Water Resources Research Institute

Annual Technical Report

FY 2000

Introduction

The Alabama Water Resources Research Institute (AWRRI) is an inter-disciplinary, multi-campus research and outreach center, located at Auburn University, charged with stimulating and coordinating research and information dissemination on water. Over the years, our mission has expanded from an early focus on State Water Quality to one that encompasses virtually all water relater issues.

The Institute is responsible for water research coordination and administration activities that extend beyond Auburn University to all state and private universities in Alabama. The Institute does not undertake research directly, but supports an annual portfolio of projects on different phases of water research through our competitive grants program.

Using a multi-disciplinary approach to problems, and building on the established base of off-campus linkages with the University of Alabama System, Historic Black Colleges and Universities, and the University of South Alabama, the Institute works to expand its current level of activity to coordinate and conduct basic and applied research and disseminate information on broad water resources issues. This research is conducted by faculty and students within a departmental structure of each campus of those universities who successfully compete in the awards process.

Research Program

Basic Information

Title:	Implementation of Methods to Enhance the Evaluation of the Effectiveness of Current BMPs in Controlling Stormwater Discharges from Small Construction Sites in the Valley and Ridge Physiographic Region and the Development of Metrics to Access the Effects of Discharge on Stream Communities
Project Number:	SGUAB-02AL
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Sediments, Water Quality, Ecology
Descriptors:	Erosion Control, Construction, Sediments, Bioassessment
Lead Institute:	Water Resources Research Institute
Principal Investigators:	Ken R, Marion, Robert A. Angus, Melinda M. Lalor

Publication

1. No publications at this time.

Implementation of methods to enhance the evaluation of the effectiveness of current BMPs in controlling stormwater discharges from small construction sites in the Valley and Ridge physiographic region and the development of metrics to assess the effects of discharge on stream communities

Interim Progress Report

Ken Marion, Robert Angus and Melinda Lalor

University of Alabama at Birmingham

May 8, 2001

Research Problem

As population expansion and increasing development occur in the Southeast, stormwater runoff from construction sites has become an increasingly major contributor to siltation input into our streams and rivers. While large construction projects represent single major potential pollution sources and are usually more visible, smaller construction sites (usually future home sites <5 acres) are both more numerous and are less likely to employ adequate erosion control best management practices (BMPs). By far the most common BMPs employed at such sites are plastic silt fences and hay bales. Although factors controlling erosion processes are well known, few scientific studies have been performed to evaluate the effectiveness (or lack of it) in the field of such BMPs, especially as affected by physical site and rainfall characteristics. This is especially true for the more upland and hilly terrain regions of Alabama and the Southeast. Information on the effectiveness of such BMPs in hilly terrain situations and the factors influencing the effectiveness is needed to assist in the selection of appropriate BMPs and the design of future erosion controls. Such information would be directly useful to federal, state and local regulatory agencies charged with the protection of aquatic environments. Additionally, in order to adequately evaluate the effectiveness of silt fence erosion control, assessments of the runoff on receiving streams or drainages are needed. Although a number of bioassessment metrics are available and commonly used, some metrics are more responsive to some stressors than others and are known to vary between physiographic regions. There is a critical need to develop or refine such metrics so that they are more sensitive biocriteria from which a more refined discrimination can be made between the level of impairment between sites. Such improved metrics will assist in the selection and design of improved erosion control devices.

Research Objectives

The major objectives of this research are (1) to assess the effectiveness of silt fences in controlling sedimentation runoff during heavy rainfall events in hilly terrain areas of the southeast, and (2) to develop or refine biological metrics that are sensitive indicators of siltation impacts on aquatic communities.

Methods

The study sites are in the upper reaches of the Cahaba River basin in north central Alabama. The effectiveness of in–place erosion control devices (silt fences) is being evaluated at small construction sites. Stormwater runoff samples are being collected to investigate the relationship between the quality and quantity of the runoff and physical site characteristics. Stormwater runoff samples escaping from the silt fences are being collected during “intense” (≥1 inch/hr) rain events. The runoff samples are being analyzed at the UAB Environmental Engineering Laboratory for turbidity (using a nephelometer), particle size distribution (using a Coulter counter), and total solids (dissolved solids and suspended solids, using methods 2540B and

2540C in Standard Methods for Examination of Water and Wastewater; NSTM, 1998). These data are entered into a computer database for statistical analysis.

Six tributary or upper mainstream sites are being studied to investigate the effects of sedimentation input from upstream construction sites on both habitat quality and the biological "health" of the aquatic ecosystem (using benthic macroinvertebrates and fish). Two of the sites have a heavy sediment load, two have been moderately impacted, and two (reference sites) have had little or no sediment input. Each site is assessed in the spring, after the period of winter rains (to evaluate immediate effects), and again the following late summer or early fall (to evaluate delayed effects).

An evaluation of habitat quality is an important component of the assessment of the ecological integrity of a site. We are using EPA–recommended procedures for high gradient streams, as outlined in the "Revision to Rapid Bioassessment Protocols for Use in Streams and Rivers" to assess the habitat quality at our study sites. This procedure quantifies the degree of impaction at each site and permits the making of comparisons between sites.

Preliminary Results

Effectiveness of Silt Fences - With our current data set, we have made comparisons between runoff collected immediately below silt fences and water collected nearby but not below a silt fence (Fig. 1, Table 1). Silt fences are better than nothing at all. Significant reduction ($p < 0.05$, t-test) was seen in numbers of small (<5 μm) and total particles per ml. Reductions were seen for numbers of large (<5 μm) particles, turbidity (NTU) and total suspended solids. These differences were not quite as great, but would be significant at $\alpha = 0.10$. However, for every variable measured, the values of samples taken below silt fences were significantly higher ($p < 0.001$) than samples collected from undisturbed vegetated control sites.

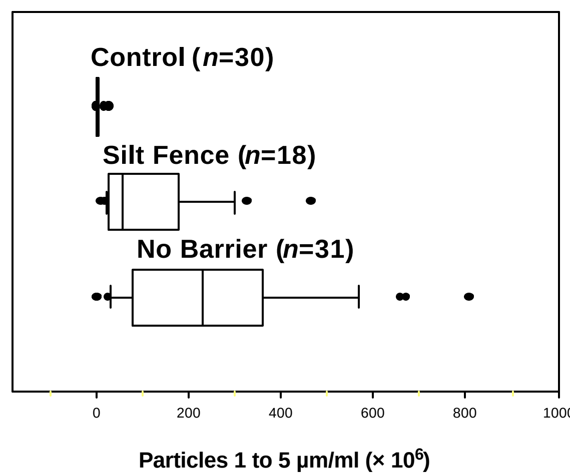

Figure 1. Counts of small particles in grab samples of water taken in vegetated, undisturbed areas (Control), immediately below silt fences (Silt Fence), and in disturbed areas with no silt fences (No Barrier).

These data indicate that silt fences are only partially effective at preventing the runoff of silt. Surprisingly, the amount of silt in runoff (as measured with the variables mentioned above) was not significantly correlated with slope of the site, amount or intensity of rainfall (although we only studied "intense" rainfalls). This may reflect the fact that we only sampled "intense" (>1 inch/hour) rainfall events. Data from ongoing studies will permit us to explore possible correlations with site and rainfall characteristics with greater statistical power.

	No Barrier	Fence	Control
Total Particles	2.53×10^8	1.59×10^8	4.13×10^6
Small Particles	2.49×10^8	1.15×10^8	3.98×10^6
Large Particles	4.61×10^6	2.97×10^6	1.54×10^5
TSS	7,741.3	3,645.0	255.7

Table 1. Mean values of particle counts and total suspended solids (TSS) in grab samples taken during >1"/hr rain events in unvegetated control sites, below silt fences, and in disturbed areas with no barrier. In each row, the mean for the Control is significantly lower than for the other cells in the same row ($p << 0.001$). Values in cells separated by dotted lines would be significantly different at α=0.1 (p = 0.06, t tests on log transformed data).

Development of Biological Metrics Sensitive to Sedimentation Effects

Fish - Preliminary analysis of the fish biota indicates that various metrics used to evaluate the biological integrity of the fish community (IBI) are altered in the most sedimented streams (Shades and Patton Creeks). In these streams the proportion and biomass of darters is lower (or nonexistent), the proportion and biomass of sunfish is higher, the Shannon-Weiner diversity index is lower, and the number of tolerant species higher. The trends are most clear when the two most sediment-impacted streams (Shades and Patton) are compared to the least sediment-impacted stream (upper Cahaba at Hewitt-Trussville High School). These streams also show the most contrast in overall habitat assessment scores via EPA Rapid Bioassessment Protocol. Correlations with degree of sedimentation impacts are less clear when all six of our sampling streams are factored in. Pinchgut, Little Cahaba Creek and Cahaba Valley Creek vary widely in both fish metrics and sediment depth and impact and show weaker correlations. Additional data should strengthen and clarify our results. However, a number of fish groups show a relationship in abundance in the extent of sediment impact. Examples of two such groups are shown in Figure 2. In addition, the fish data we have gathered for the first two years of this project will contribute toward the creation of a revised IBI (index of biotic integrity) appropriate for southeastern streams impacted by sedimentation

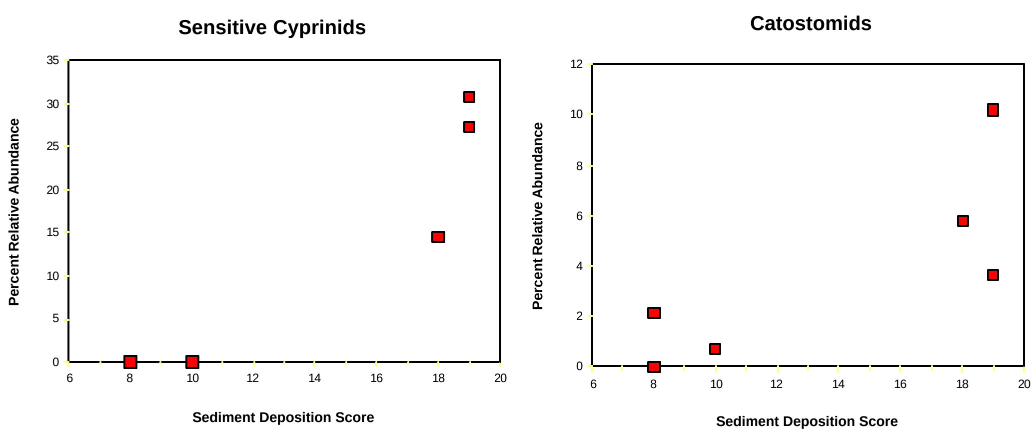

Figure 2. Relationship between sediment deposition (high scores represent low deposition levels) and abundance of disturbance-sensitive minnows (cyprinids) and suckers (catostomids).

Benthic Macroinvertebrates - Several macroinvertebrate metrics (Sorenson's Community Similarity index, Shannon-Weiner diversity index, EPT index, % chironomids, Jaccard Coefficient, and Hilsenhoff Biotic index) reach their highest or lowest point in the two streams with the most sediment load. Although Spearman Rank Correlations of each of these metrics for all streams studied with several measures of sedimentation load show few statistically significant relationships at the 0.05 level, *p* values approach this level, indicating definite trends. The EPT index (number of mayfly, stonefly and caddis fly genera) and the Hilsenhoff Biotic index (HBI) show promise as metrics sensitive to sedimentation. Figure 3 illustrates the relationship of these metrics to measures of sedimentation. The HBI and the EPT index also show positive correlations to several other measures of disturbance, such as percent of the watershed altered by development. Further studies will determine whether the associations, which currently approach significance at the $\alpha=0.05$ level, turn out to be significant when the sample sizes are increased. In addition, we expect that a fine sediment biotic index (FSBI), specifically designed to respond to silt stress, will out-perform any of the currently existing metrics as an indicator of silt effects on macroinvertebrate communities.

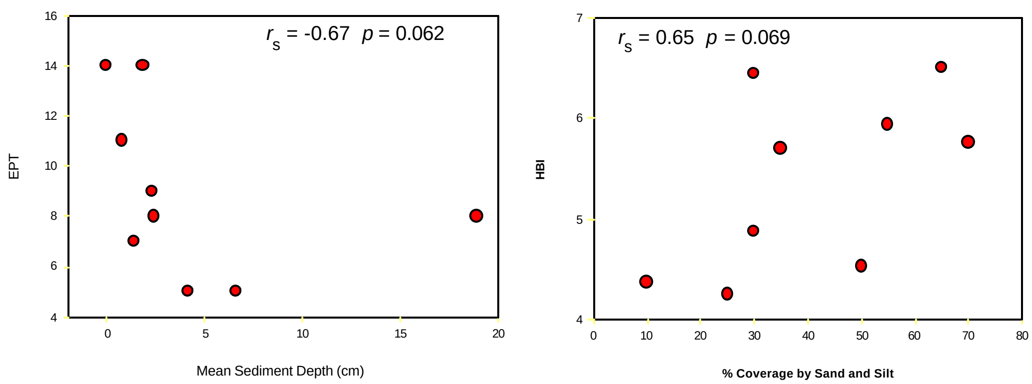

Figure 3. The relationship between two macroinvertebrate metrics with measures of sedimentation.

Publications and Presentations Since Last Report

Angus, R. and K. Marion. An evaluation of the effectiveness of current BMPs in controlling stormwater discharges from small construction sites and developing metrics to assess the effects of discharge on stream communities. Presented at the Annual Water Resources Conference Symposium, Gulf Shores, AL, September 2000.

Angus, R., K. Marion and M. Lalor. The effectiveness of silt fences in controlling stormwater discharges from small construction sites and the effects of siltation on stream communities. Presented at the Alabama Fisheries Association Meeting, Eufaula, AL, February, 2001.

Owens, J.S., R.A. Angus and K.R. Marion. Evaluation of sediment-sensitive biotic indices. Poster presented at the Alabama Academy of Science meeting, Auburn, AL, March 2001. (Abstract to be published in summer 2001).

Owens, J.S., R.A. Angus and K.R. Marion. A refinement of sediment-sensitive aquatic macroinvertebrate metrics. Poster presented at the Association of Southeastern Biologists meeting, New Orleans, LA, April 2001. (Abstract to be published in summer 2001).

Marion, K., R. Angus and M. Lalor. The urbanizing of a river: the search for functional indicators of change. Seminar presented at Dauphin Island Sea Lab, May 2001.

Students Supported Since Last Report

Direct Partial Stipend – Janna Owens; M.S. candidate in Biology; biological aspects of project are main thrust of dissertation research.

Direct Partial Stipend – Jennifer Harper; M.S. candidate in Civil Engineering; sedimentation aspects of project are main thrust of dissertation research.

Educational experience was provided to 14 Biology undergraduates (32 semester hours total registered under BY 397 – Undergraduate Research in Biology); students assisted in field collections, sample sorting, and preliminary specimen identification. One M.S. candidate in Biology is also working on aspects of the project.

Basic Information

Title:	Reducing NPS Pollution From On-Site Sewage Disposal Systems Through Improved Soil Assessment
Project Number:	SGAGS-03AL
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Water Quality, Waste Water
Descriptors:	Water Quality, soil-water relationships, septic tanks
Lead Institute:	Auburn University
Principal Investigators:	, Joey Nathan Shaw

Publication

Reducing NPS Pollution From On-site Sewage Disposal Systems Through Improved Soil Assessment

Dr. Joey Shaw
Department of Agronomy and Soils
Auburn University

Research Problems

On-site sewage disposal systems (OSDS) have been targeted as the leading source of pollution introduction into surface water and groundwater in many regions. It has been estimated that close to 50% of the people of Alabama use OSDS as their method of domestic waste disposal for single-family dwellings. When properly installed in suitable soil, these systems provide a safe and efficient disposal method for domestic waste. Unfortunately, it is apparent in certain regions of the state that a large portion of these systems is failing, and failure numbers seem to be increasing. OSDS failure manifests itself in several ways, including: 1) backing up of effluent to the soil surface (termed surfacing), and 2) leaching of untreated effluent to groundwater. With either situation, deterioration of groundwater and/or surface water quality occurs due to the off-site movement of nutrients, household chemicals, and in some cases, pathogens. In this researcher s opinion, deterioration of water quality due to OSDS failure is the largest threat to water resources in Alabama. Failures of OSDS mainly occur because the systems are installed in soils that are unsuitable due to poor drainage characteristics and/or the presence of a seasonal high water table (SHWT), which forbids additional hydraulic loading. Health Department personnel and soil scientists typically use features in soil (termed *redoximorphic features*) to predict the depth to a SHWT and make proper interpretation of soil suitability to hold a functioning OSDS. However, in certain sandy soils (classified in Arenic and Grossarenic subgroups), assessment of redoximorphic features is problematic due to the nature of the sandy materials. These types of soils are termed problem soils . In these soils, it is difficult to predict the height of the SHWT, which sometimes results in erroneous assessment for OSDS suitability. Little research exists that correlates soil redoximorphic features with water table dynamics for these soils.

These concerns have prompted interest from soil scientists at Auburn University and the Alabama Department of Public Health to develop guidelines to better assess the drainage class of certain sandy soils in the Coastal Plain of Alabama. These soils are common, approximately 25% of Baldwin County in Lower Alabama is composed of these types of soils, and OSDS failures are occurring in this region. These soils possess thigh sandy eluvial (0.5 to 1.5 m thick) horizons overlying argillic (clay-rich) horizons of reduced permeability. Past studies have shown that lateral gradients of flow associated with subsurface horizons occur in some of these soils, but uncertainties exist about the degree of *perched* water above the clay-rich horizons and the status of the SHWT. Many of these soils in lower topographical positions also possess *true* groundwater (related to regional water tables) for significant periods of the year. Because of the problematic morphology and because these soils inherently have limited abilities to sorb and renovate pollutants (e.g. from on-site sewage effluent) in the sandy eluvial horizons, accelerated deterioration of water quality often occurs due to the erroneous interpretations of soil drainage class. This study proposed to assess the drainage class and water table dynamics of these soils.

Research Objectives

The objectives of this study are to: 1) correlate the depth and duration of seasonal water tables in extremely sandy soils of the Coastal Plain of Alabama with certain redoximorphic features, and 2) establish relations that can be used by soil scientists and health department personnel for estimating depths to SHWT for making better assessments of OSDS suitability.

Materials and Methods

We evaluated the relationship between SHWT and redoximorphic features in Arenic and Grossarenic soil subgroups. Arenic subgroups possess a sandy eluvial layer that extends from the mineral surface down to 50-100 cm, and Grossarenic subgroups have a sandy eluvial layer that extends >100 cm, both of which overly an argillic horizon (Soil Survey Staff, 1997). Three transects were established in Barbour County, Alabama. These sites were chosen to be representative sandy Coastal Plain catenas. The three sites include the Midway Plantation Site (MP) and the Grant sites 1 and 2 (G1 & G2).
Soils at all sites possess sandy eluvial horizons overlying argillic horizons of various depths. MP soils consisted of very deep sands (Aquic Hapludult, Grossarenic Paleudult, and Typic Quartzipsamment). Soils at the Grant sites consist of Arenic Plinthaquic, Plinthaquic, and Arenic Paleudults.

A total of nine nests are being monitored. A nest consists of two piezometers, one well, and ten redox probes placed at depths relative to soil morphology. Three nests at MP (MP1, MP2, & MP3), three at G1 (G11, G12, & G13), and three at G2 (G21, G22, & G23). An electronic tipping bucket rain gauge, a Campbell Scientific CR10X data logger, and soil and air thermocouples are centrally located at each site. The CR10X data loggers are equipped with Campbell Scientific AM416 multiplexers to increase the number of channels available for monitoring.

Piezometers were used to evaluate the potentiometric surface of water tables in soils at specific depths. Piezometers were constructed of 12-inch PVC pipe and perforated using a 3/8-inch drill bit. Piezometers were perforated 15 cm from the bottom in 2.5 cm increments, and covered with a thin permeable cloth to prevent sloughing and deposition of soil within the pipe. For this evaluation, one piezometer was placed just above the argillic horizon in the sandy eluvial horizon, and the other was located within the argillic horizon.

Wells were constructed of 1½-inch PVC pipe and perforated using a 3/8-inch drill bit. The well pipes are continuously perforated from 20 cm below the surface to a depth of approximately 175 cm in 15 cm increments, and thus give a composite view of the free water surface. Differences in water levels between wells and piezometers can help differentiate zones of perching in the soil.

Water columns within each piezometer and well are monitored using Druck model CS-420 pressure transducers. The two lower nests on each landscape are electronically monitored (MP2, MP3, G12, G13, G22, & G23) while the upper nest (MP1, G11, & G21) is manually monitored. A CR10X data logger records data on thirty-minute intervals. The data consists of the height of the water column in four piezometers and two wells, air and soil temperature, and rainfall. Individual data loggers and other peripheral devices are located at all three transects.

Redox probes are manually monitored as per techniques described by Patrick et al. (1996). The probes were constructed of 10 gauge copper wire with platinum tips, attached using lead-free solder. All copper and solder is covered by a rubber or epoxy coating. The probes were calibrated using a pH buffered, (pH 4 and pH7) quinhydrone solution of known pe. A saturated calomel electrode was used as a reference electrode. Redox probes were placed at depths corresponding to piezometer placement.

Standard Soil Survey techniques were used to describe and sample soils, with Standard Soil Survey techniques v
redoximorphicredoximorphic features. Soil physical and chemical properties including particle size distribut
excexchangeexchange capacity (pH 7), and organic carbon content were measured by horizon. Selective extraction
dithionite,dithionite, ammonium oxalate, and sodium pyrophosphate techniques) was usedithionite, ammonium
oxideoxide forms. Mineralogical analyses were conducted usingMineralogical analyses were conducted using
rayray diffraction (XRD). Saturated hydraulic conductivity (K_{sat}) of selected horizons was evaluated using a
Compact Constant Head Permeameter (Amoozegar, 1989).

Results

Soils on the lower landscape position (MP3) tended to be saturated more often than soils upslope. MP1 exhibited SHWT for short periods at depths that exhibit redox features. Perching of water tables above argillic horizons does not appear to be occurring at this site.

Initially, the SHWT was observed at MP2 at a depth of 170 cm in June of 2000. On July 6, 2000, no SHWT was present in any of the MP nests. The SHWT was absent from nests until November 2000. At this time the SHWT was observed in MP2 and MP3 nests at varying depths and was still present as of May 7, 2001.

Redox potentials at each MP nest were observed to be within the range required to reduce Fe species beginning in January 2001. Also, redox potentials decreased as duration of saturation increased.

The SHWT at MP was observed for extended periods of time in horizons not exhibiting redox features. For example, the E3 horizon at the MP2 nest has olive yellow (2.5Y 6/6) and pale yellow (2.5Y 7/3) sands, and was saturated for approximately 130 days. Interestingly, some white (10YR 8/1) stripped sands were found in the E2 horizon directly above. The SHWT was observed above the E2 horizon in horizons without redox features for two 15-20 day periods in March and April 2001. The MP3 nest possessed a SHWT at depths above redox features for 45 days in March and April 2001. Other periods of saturation at the MP site have occurred at depths where redox features were present.

Lower landscape positions have been saturated more often than soils upslope at G1. G11 has exhibited SHWT for two very short periods (5-7 days) since monitoring began. The horizons in which saturation occurred mostly possess redox features. Perching of water tables above argillic horizons does not appear to be occurring at this site.

The G1 site was installed in late March 2000. The SHWT was observed at G1 during the month of April through early May 2000. G12 and G13 exhibited water tables at depths of approximately 174 cm and 163 cm, respectively, during this time. During the period from May 2000 until early March 2001water tables were not observed at G1. At this time the SHWT was observed in G12 and G13 nests at varying depths and was still present as of May 7, 2001.
Redox potentials have been recorded at G1 since early September 2000. Redox potentials in saturated soils at each G1 nest have been observed to be within the range required to reduce Fe species. Also, redox potentials have decreased as duration of saturation increased.

At G1 the SHWT has been observed in horizons not exhibiting redox features for extended periods of time. G12 and G13 nest had a SHWT present for a 35-37 day period in horizons where redox features were not present. In both cases, the horizons were eluvial horizons (E1 and E2) with fine sand features. Some light brownish gray (10YR 6/2) and pale brown (10YR 6/3) stripped sands were identified in the Ap and E1 horizons, respectively, at G12.

The SHWT at the G2 site was first observed in January 2001. At this time the SHWT was observed in the G22 and G23 nests and was still present as of May 7, 2001. At this site, lower landscape nests are saturated more often than the nests located higher on the landscape. The G21 nest had not shown any signs of a SHWT until mid March 2001 following a heavy rainfall event. Perching of water is not evident at this site.

Redox potentials have been recorded at G2 since early September 2000. Redox potentials at each G2 nest have been observed to be within the range required to reduce Fe species when soils are saturated. Also, redox potentials have decreased as duration of saturation increased.

At G2 the SHWT has been observed in horizons not exhibiting redox features for extended periods of time. G12 and G13 nest revealed saturation for several short 5-7 day periods in horizons where redox features were not present.

Conclusions

It is clear that dry conditions over the period of this study complicated our findings.

For these sandy soil catenas, the SHWT tended to be shallower at lower landscape positions. In general, the shallowest depth to saturation (3 cm) occurred in March 2001, corresponding to a period of significant rainfall. Although distinct argillic horizons are present in these soils, our data suggests limited perching of water.

In the lower landscape positions, the SHWT tended to occur above the depth of redoximorphic features. Saturation of soils above redoximorphic features was not observed in the soils situated in higher landscape positions. Thus, it appears that a combination of landscape position and redoximorphic feature evaluation is necessary to fully interpret SHWT depths and duration.

It appears that the SHWT is at its shallowest depths during the early spring. Several rainfall events during the winter and early spring of 2001 have resulted in significant periods of saturation at many of our nests. Our findings have confirmed that SHWTs do occur for significant periods in areas not exhibiting redoximorphic features in some Arenic and Grossarenic subgroups of soils. Extended monitoring throughout the rest of 2001 and through the spring of 2002 should allow a better prediction of the behavior of SHWTs in these soils.

Information Transfer Program

Basic Information

Title:	Annual Alabama Water Resources Conference
Start Date:	9/6/2000
End Date:	9/8/2000
Descriptors:	
Lead Institute:	Water Resources Research Institute
Principal Investigators:	Dennis H. Block

Publication

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	4	0	0	0	4
Masters	2	0	0	0	2
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	8	0	0	0	8

Notable Awards and Achievements

None

Publications from Prior Projects