FIELD STUDY FOR EVALUATING EFFLUENT AND GROUNDWATER USE REDUCTION IN CATFISH PONDS

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ABSTRACT

A hydrological management strategy designed to reduce the volume of effluent discharge and groundwater use in catfish ponds was modeled by Cathcart et al. (1999). The modeled system uses deepened "production/storage" ponds to hold and reuse rainwater in lieu of groundwater in conventional production ponds. Model predictions suggested that this approach may reduce effluent discharge and groundwater use by up to 70 %. The approach is currently being implemented in a 3 year field study to test the assumptions of the model. Seven 1-acre ponds located at the Delta Research and Extension Center (DREC) in Stoneville, MS. have been modified for this purpose. Tested configurations include 3 production ponds linked to 1 production/storage pond; 1 production pond linked to 1 production/storage pond; and a control pond. Effluent volume data from each pond system are being collected using a 30 cm H-flume connected to each of the production/storage ponds and a pressure transducer for flume depth readings. Equations for known depth/volumetric flow rate relationships of a 30 cm H-flume are being used to calculate effluent volumes. The systems have been calibrated and installed and data is being collected. When required, the volume of groundwater added will be calculated by measuring depth changes in the ponds. After collecting data for effluent produced and groundwater used, the field data will be compared to model predictions for the same conditions. If predicted and observed performance agree reasonably well, the authors feel that this approach will be a viable alternative for producers in the face of increasingly stringent requirements by regulating agencies.

INTRODUCTION

Growing concern over the effect of non-point pollution in waterways has become an issue in all sectors of the agricultural economy. The catfish industry in the southeast has shared this concern. Water is discharged from catfish ponds when precipitation causes the water level in a pond to increase above the maximum depth or when producers prepare to harvest. Additionally, most catfish ponds in the southeast use groundwater aquifers for their make-up water needs. Due to the increase of user demand on certain aquifers, producers would like to have management options available to reduce reliance on groundwater.

Work by Pote and Wax (1993) helped producers to address both of these issues. Their "6/3 scheme" advised producers to avoid adding groundwater until the pond water depth had declined by 15 cm (6 in.) and then only filling back 7.5 cm (3 in.). By implementing a water management approach that avoids ever completely filling a pond with groundwater, a producer always has the capacity to capture and store rainwater, thus decreasing both effluent release and groundwater use.

Cathcart et al. (1999) attempted to take this approach a step further. They suggested that catfish ponds be modified so that overflow due to precipitation be routed to a specified pond rather than out of the ponds into receiving waters. The specified pond, referred to as a "production/storage" pond, would be substantially deepened to provide additional storage capacity over and above that which was provided by the "6/3 scheme" (Figure 1). During periods of high precipitation, the excess storage would be filled, reducing the quantity of discharge that would otherwise occur. During dry periods, the excess storage would be used to refill the linked ponds prior to resorting to groundwater. In this way, both effluent discharge and groundwater use would decrease.

This approach was evaluated using a mathematical model to predict groundwater use and effluent discharge for a variety of pond configurations and management options. Using a 26 year record of precipitation and evaporation, the model predicted that effluent discharge and groundwater use could be decreased by up to 70 percent, depending upon the depth of the production/storage pond and the number of ponds linked together.

The next step after modeling was to implement this management approach in production ponds. This would allow the comparison of predicted and observed performance as well as potentially detect unforeseen consequences of modifying conventional pond management. The authors received a grant during summer, 1999, from the Southern Regional Aquaculture Center to support a 3 year test of the approach. This paper describes the research ponds, the pond modifications used, and the monitoring system that has been put in place to measure effluent discharge and groundwater use for this study.

METHODS AND MATERIALS

Seven 0.4 ha research ponds at DREC are being used to test the approach. The two configurations that are being tested are illustrated in Figure 2. In one configuration, 3 conventional production ponds have been linked to 1 production/storage pond that was deepened by 60 cm (3:1 system). A second configuration has 1 production pond linked to 1 production/storage pond that was deepened by 30 cm (1:1 system). One pond is being used as a control.

The 7 research ponds were drained, allowed to dry, and then carefully surveyed to establish shapes, volumes, bank depths, etc. The 2 production/storage ponds were then deepened as per specifications and resurveyed. Pipes to drain production and production/storage ponds were installed through the pond banks. The pipes used to drain production ponds into production/storage ponds are 15 cm pvc mounted to drain depths in excess of 1.25 m (Figure 1). Pipes used to drain production/storage ponds and the control pond are 15 cm pvc as well. The elevation of the opening to these drain pipes is the culture depth of the pond plus the supplemental storage depth, if any (Figure 3).

The pipe diameters were chosen on the basis of an additional model that was written to estimate outflow rates for the ponds. This was done to ensure that 15 cm pipes were adequate to prevent bank overflows at the ponds. One hundred year design storms were used in the model. Flow rates through the pipes were estimated using weir, oriface, and full pipe flow assumptions to ensure that predicted flow rates were reasonably accurate. This model, based on 15 cm diameter pipes, predicted only modest depth increases in the ponds even after severe rain events.

Prior to refilling the 7 ponds, depth staffs were installed in each. These are used to monitor pond depth and, in conjunction with the survey data, pond volume as well. They will also be used to ensure careful adherence to the "6/3 scheme" when ponds require refilling.

Discharge from each production/storage and control pond is routed through 30 cm H flumes (Figure 4) mounted on the outer bank of each of the 3 ponds that allow discharge to receiving waters (Tracom). Pressure sensors (Global Water, WL300) mounted in contiguous still wells are used to monitor water depth in the flumes. Additionally, pressure sensors in still wells mounted in the 3 ponds are used to provide a supplementary measure of the depth of those ponds. Each pair of sensors is connected to a data logger (Campbell CR-10) to record measurements of flow rate. The sensors are scanned at 5 minute intervals. These systems (flume, sensor, and logger) were tested and calibrated prior to installation using facilities at the Agricultural and Biological Engineering building at Mississippi State University.

Pond modifications and installation of hardware were accomplished during the fall and early winter of 1999. Ponds were filled with water and data collection began during January, 2000. Ponds were stocked with fish at commercial rates during March, 2000.

Data collection for this project will consist of the discharge measurements using the systems described above, water elevation in the ponds (bi-weekly and whenever water is transferred), standard water quality measurements (chlorophyll a, ammonia, nitrite, and solids bi-weekly), and routine observation of fish health as per standard catfish culture practice. The water depth observations will be used to determine the volume of groundwater added to ponds after stored water is depleted and will determine when pumping is complete. Monitoring of water quality and fish health will be used to detect unforeseen consequences of this water management approach.

Precipitation and class A evaporation data are being recorded daily approximately 0.4 km from the experimental site.

As mentioned, the primary purposes of this study are to compare observed pond discharge and groundwater use to model predictions and to make sure that unforeseen problems with this management approach are surmountable. If model predictions are reasonably accurate and fish health and growth rate are not adversely affected, then this approach can be presented to the catfish producers as a viable alternative to conventional practices.

RESULTS AND DISCUSSION

During the period January to early April, 2000, monitoring of pond discharges has continued with minimal problems. One data logger was damaged, apparently during a thunderstorm. It has since been replaced. All other components appear to be working satisfactorily.

Heavy rains during late March and early April provided a rigorous field test of both the drainage capacity of the installed pipes and the flume/sensor/logger monitoring systems.

Figure 5 shows representative data for the period April 1 to April 4, 2000. Ponds were very close to full on April 1, prior to the beginning of the rain. Over the next 3 days, approximately 7 cm of rain fell. The graph of discharge rate has roughly the shape that one might expect. The instability during peak rates reflects the extreme sensitivity of the volumetric flow rate to small variations in flume water height at high flows. The general shape of the curve is reasonably consistent, however, through this period. The long "tail" following the end of the rain is characteristic of such systems, as decreasing pressure head leads to steadily decreasing flow rates. Total discharge for the rain event can be determined by integrating this curve.

The predictions of performance by the model described above were based on 26 years of meteorological data. These data included very dry and very wet years as well as a spectrum of intermediate values. A difficulty associated with the form of field validation described here is the uncertainty of the weather. Three years of essentially the same conditions (all wet, all dry, or all of a similar intermediate character) will provide a limited comparison. On the other hand, the model is really quite simple, based upon fairly basic geometrical and volumetric relationships. We believe that flaws in the model or the approach, if found, will be conceptual and readily apparent. Because of the simplicity of the model, we believe that good agreement between predictions and measured performance even in a limited validation may extend to conditions outside of the validation limits as well.

ACKNOWLEDGEMENTS

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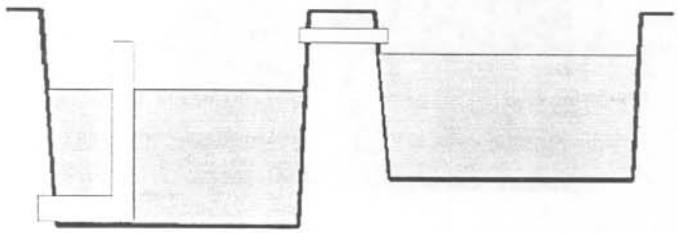

Figure 1. Drawing of the proposed system showing a linked production (right) and production/storage pond.

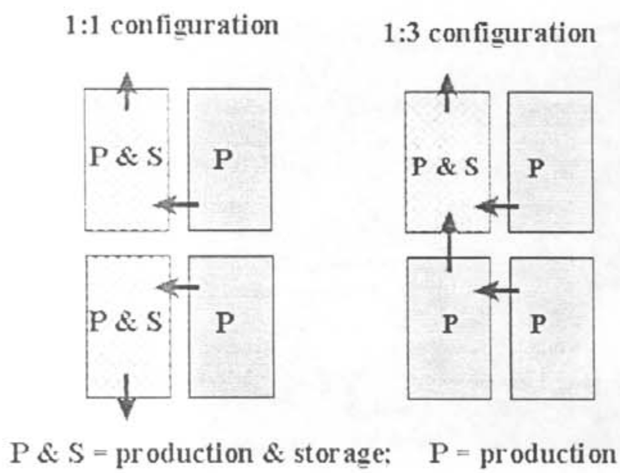

Figure 2. Two pond configurations simulated in the model and being tested in the field study.

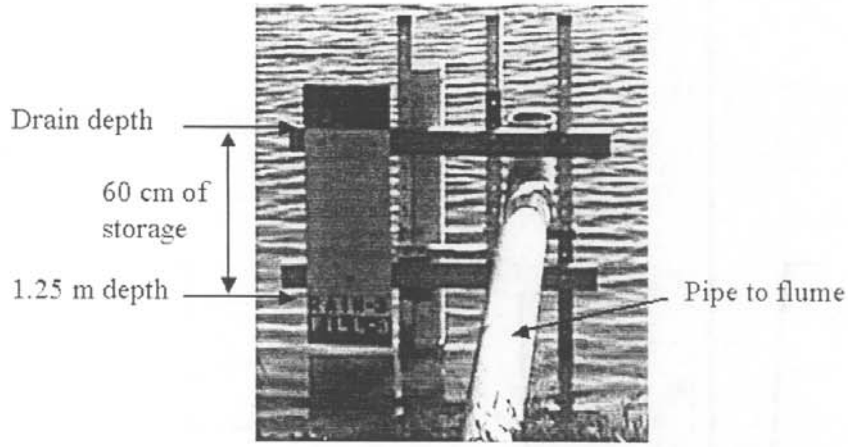

Figure 3. This picture of a production/storage pond shows the 1.25 m "culture depth" plus the 60 cm of supplemental storage due to the deepening of the pond.

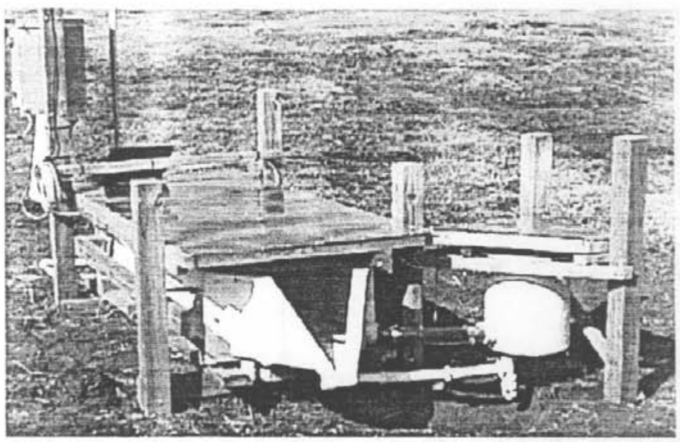

Figure 4. Flume, pressure transducer (in still well) and data logger system used to measure effluent discharge from the production/storage and control ponds.

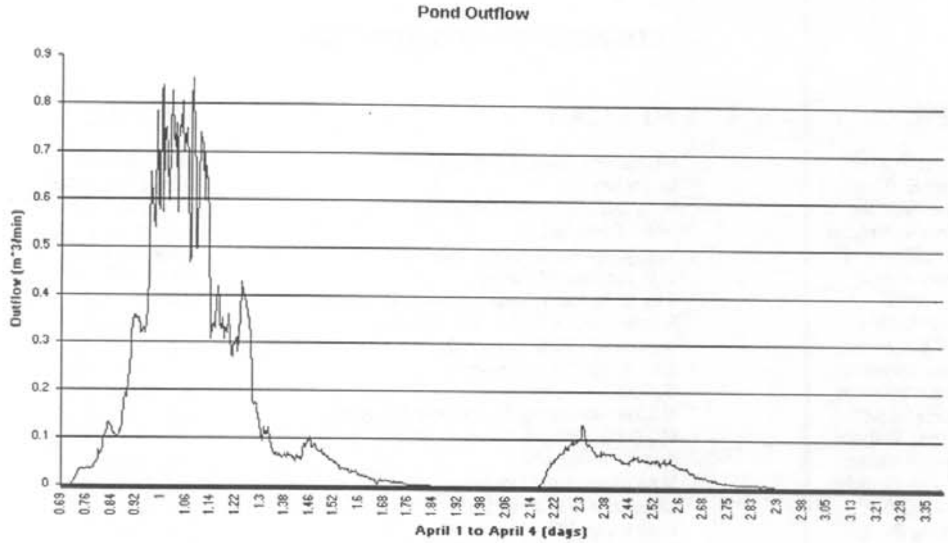

Figure 5. Effluent discharge from the control pond during the period April 1 to April 4, 2000.