Farmers as Producers of Clean Water:
*Getting Incentive Payments Right**

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Outline

Introduction Why this? Why now? Objectives? Where?

Problem How do we develop a budget for a field experiment?

Methods Estimating prices and payments.

Discussion Evaluation of prices, payments, and farmer responses.

Conclusions What is working and what needs more work.

Why this? Why now?

Currently, agricultural non-point pollution (ANP) control is primarily based on providing inputs to water quality conservation. This gets us some clean-up but it is expensive. So, ANP remains a problem and research is looking for alternatives to input-based approaches.

We propose a performance-based approach to ANP control where farmers are paid based on water quantity and quality.

Overall research objectives

(1) Derive and assess a pricing formula based on water quantity and quality that provides an appropriate incentive for farmers to implement best management practices (BMPs) to conserve surface water resources;

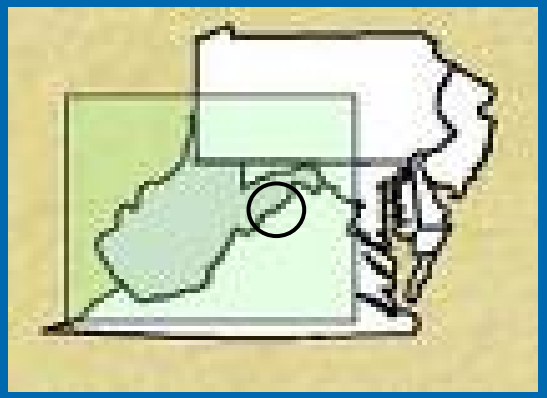
(2) Given the availability of incentive payments, assess changes in farmer attitudes and behavior towards BMPs that protect and conserve water resources relative to the traditional cost share approach;

(3) Monitor changes in water quality and quantity in response to performance-based economic incentives and compare to monitoring in other watersheds where these incentives are not offered; and

(4) Compare the cost effectiveness of water quality improvements for incentive payments relative to the traditional cost share approach.

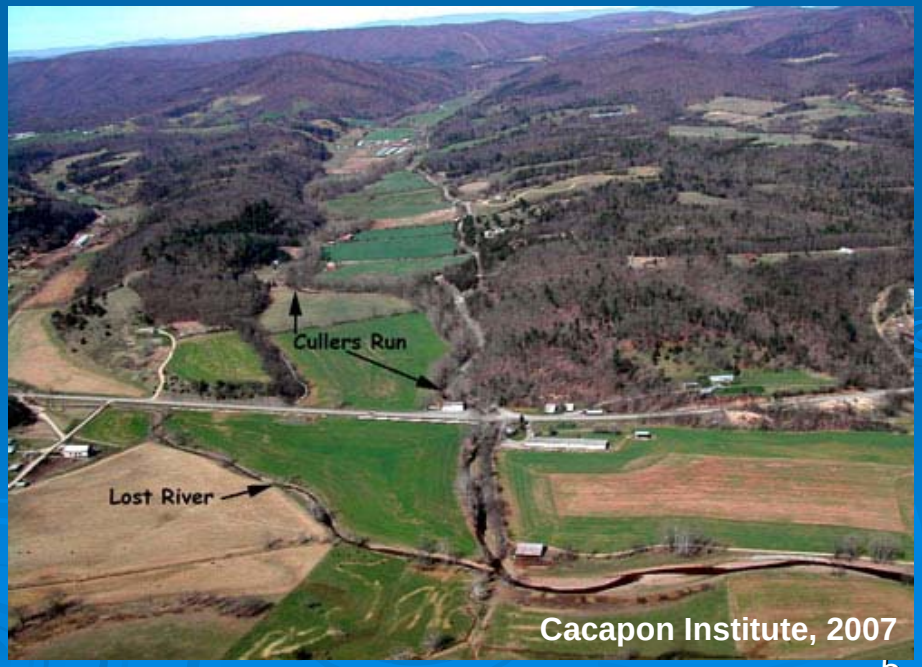
Where can we do a field experiment?

We selected a watershed impacted by agriculture yet small enough to manage a field experiment potentially involving all farmers in the watershed.



<u>The Selected Watershed:</u>

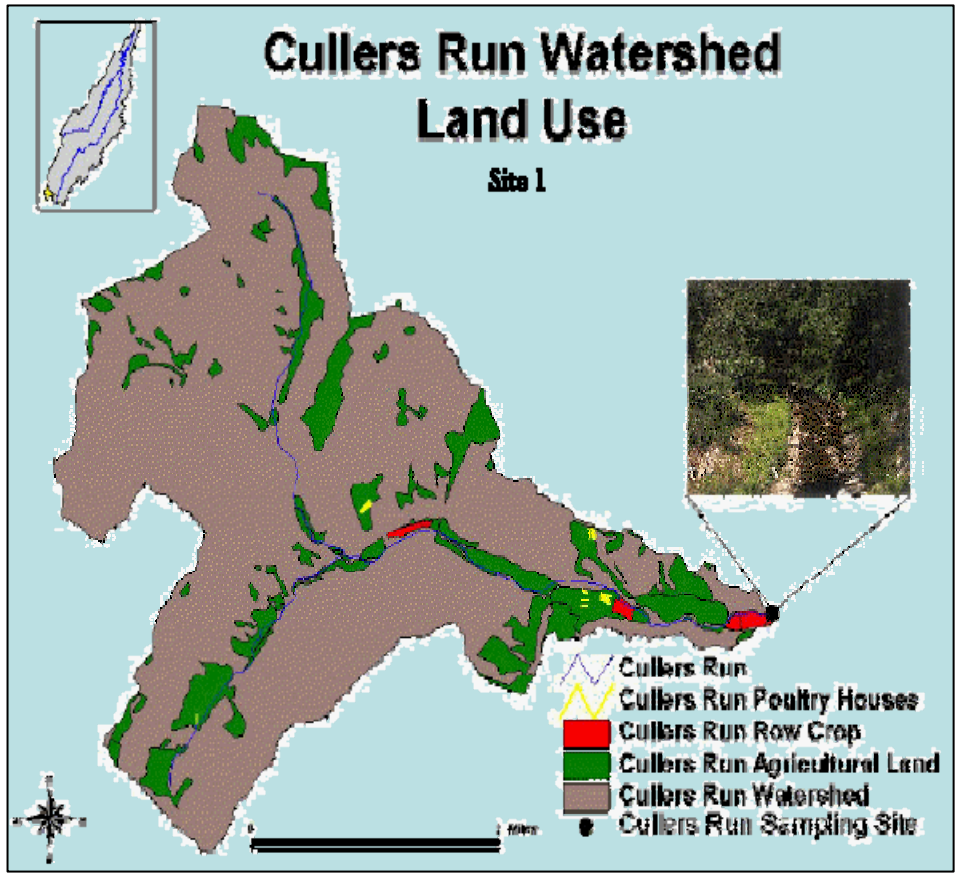
- Cullers Run
- A stream tributary of the Lost River in the eastern panhandle region of West Virginia
- Contains 2,978 hectares in West Virginia's largest poultry production county.



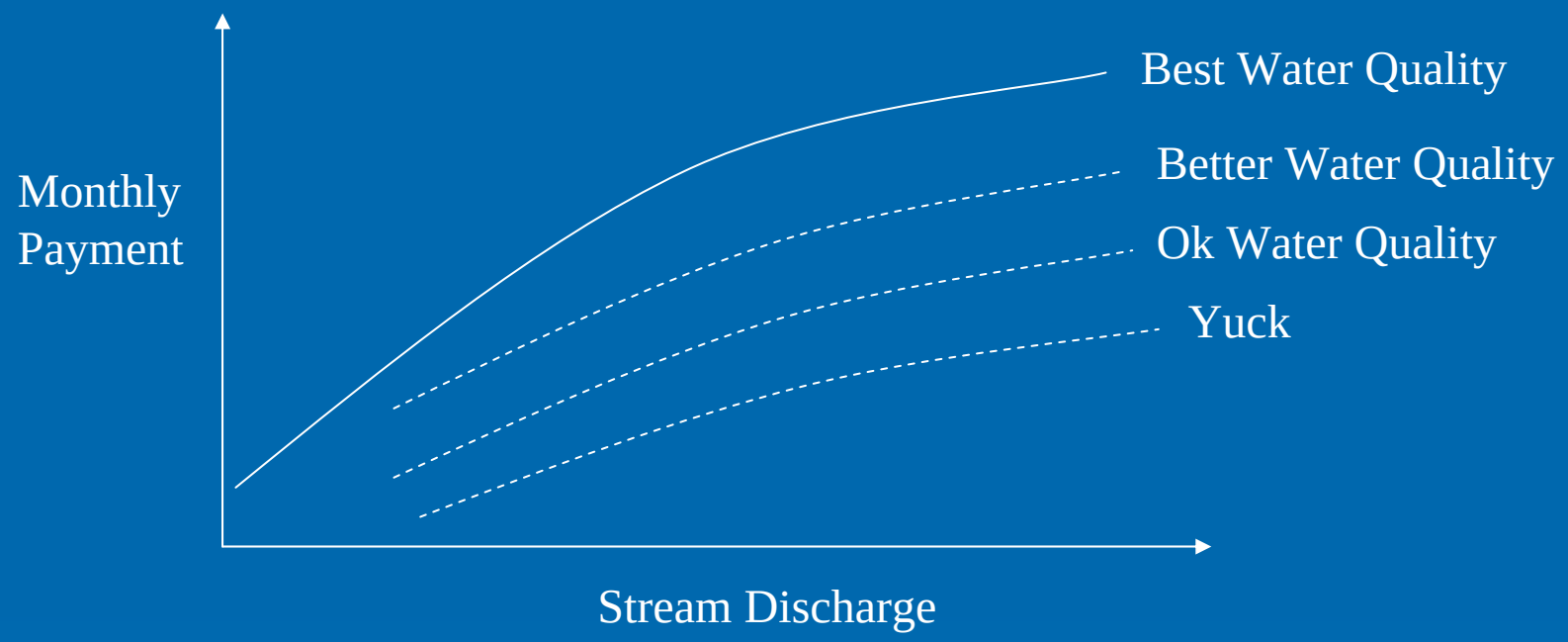
Cacapon Institute, 2007

Study Area

- Sixteen percent of the watershed is devoted to agriculture, mostly pasture or hay land.
- There are approximately twelve poultry houses conducting intensive poultry production in the watershed.
- Most agricultural fertilizer use in the watershed is provided by poultry litter.



The Intuition



Payments need to:

- assist in motivating farmers to participate in the experiment,
- provide an incentive to abate,
- be seen as fair, and
- sensibly reflect environmental conditions.

Problem Statement

But to conduct a field experiment, we need to estimate payments with enough accuracy to:

- give researchers the budgetary information they would need, and
- let farmers evaluate the desirability of participating.

Put differently, we had to be able to answer farmers when they ask: “So how much money are we talking about?”

Payment Formula

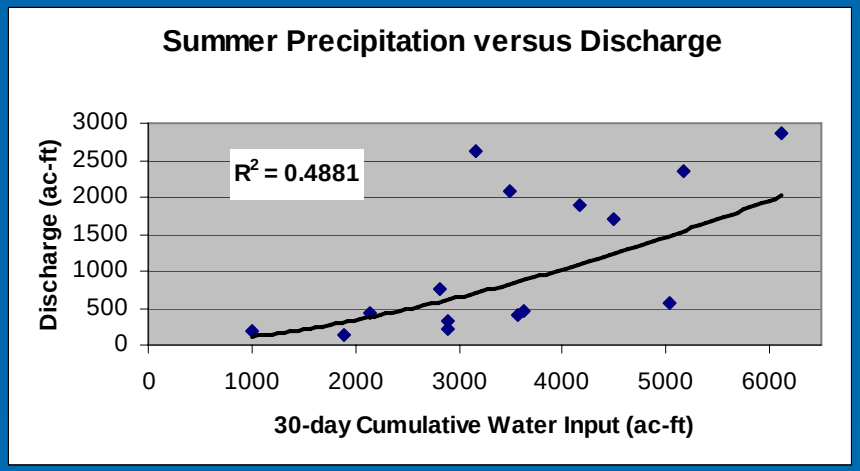
Watershed Payment = volume * unit price *adjustment factor

- Units are in acre-feet.
- The adjustment factor incorporates water quality changes.

Step 1: Volume Estimation

We used:

- 32 months of 30-day cumulative regional rainfall data,
- corresponding mean monthly flow data from Waites Run as measured by the USGS, and
- Excel "best fit" equations that maximized R^2.

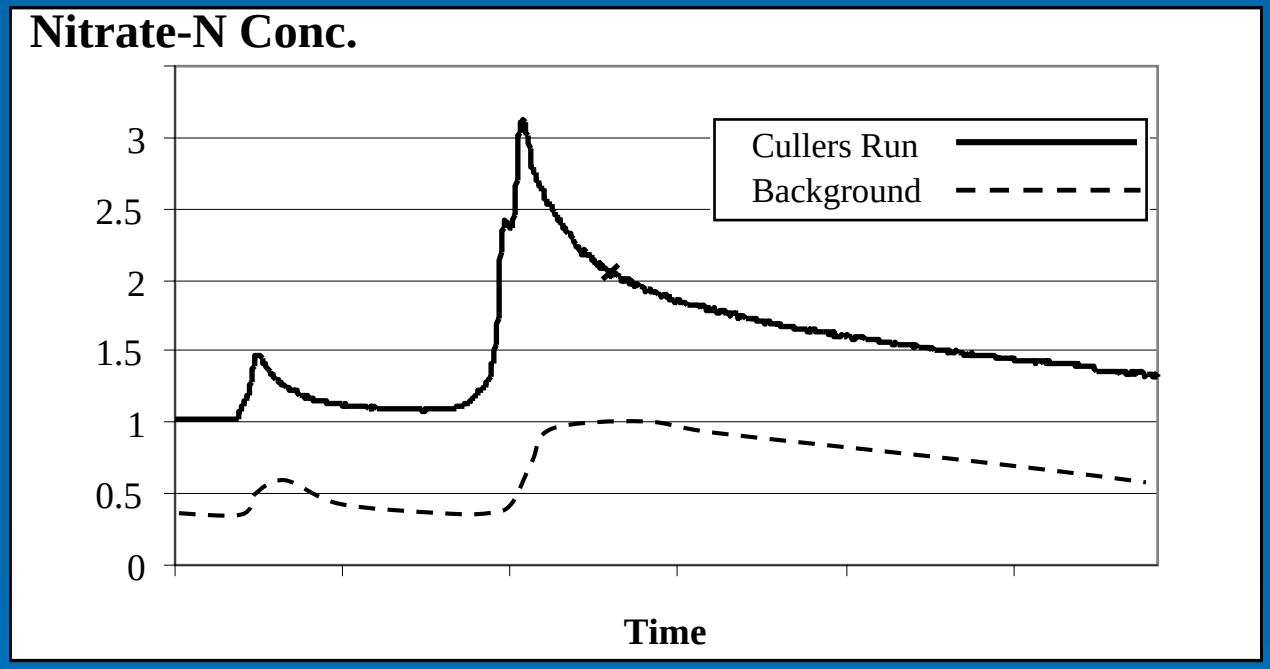


$$(2)\quad \text{acre-ft/month} = 8.778 \times (\text{rainfall}) \times (\text{watershed acres})^{0.6635} \quad (R^2 = 0.42)$$

$$(3)\quad \text{acre-ft/month} = 0.0018 \times (\text{rainfall}) \times (\text{watershed acres})^{1.6008} \quad (R^2 = 0.48)$$

Step 2: Quality Adjustment

We assume Cullers Run nitrate-N load has two components:



Because this would add noise to the economic incentive we use a ratio of nitrate-N in a "natural" stream over that in Cullers Run as our adjustment factor.

Step 3: Price Estimation

With estimates of volume and quality, to estimate prices that would induce BMP implementation, we built an economic optimization (GAMS) model with the following simple objective function and constraints:

$$\text{Max Net Income} = \left(\text{Ag Income}\right) + \left(\text{Water Income}\right)$$

s.t. contraints on acreage, land use shifts, and non-negativity.

where…

$$\text{Ag Income} = \sum_i \left[\left(\text{Net revenue of land use } i \text{ per acre}\right) \times \left(\text{Acres land use } i\right)\right]$$

$$\text{WI} = (\text{ac-ft of water}) \times \left(\frac{\text{Price}}{\text{ac-ft}}\right) \times \left(\frac{\text{Average nitrate-N load Waites Run}}{\sum_i \left[\left(\frac{\text{Lbs. nitrate-N}}{\text{acre landuse } i}\right) \times (\text{acres landuse } i)\right] \times \left(\frac{e^{0.3188 \times \text{rainfall level}}}{e^{0.3188 \times \text{ave. monthly rainfall}}}\right)}\right)$$

BMP Inducing Prices

Water Price Summary			
May through September		October through April	
Cullers Run Stream Discharge (ac-ft)	Dollars per Acre-Foot	Cullers Run Stream Discharge (ac-ft)	Dollars per Acre-Foot
Up to 320	18	Up to 740	8
321-800	8	Over 740	5
Over 800	5		

Single versus Multiple Water Prices

- A single water price at every discharge level that induces BMP implementation could result in too high of payments at high discharges and too low of payments at low discharges.
- We chose to compute abatement inducing prices by season and discharge level to avoid over/under paying farmers.

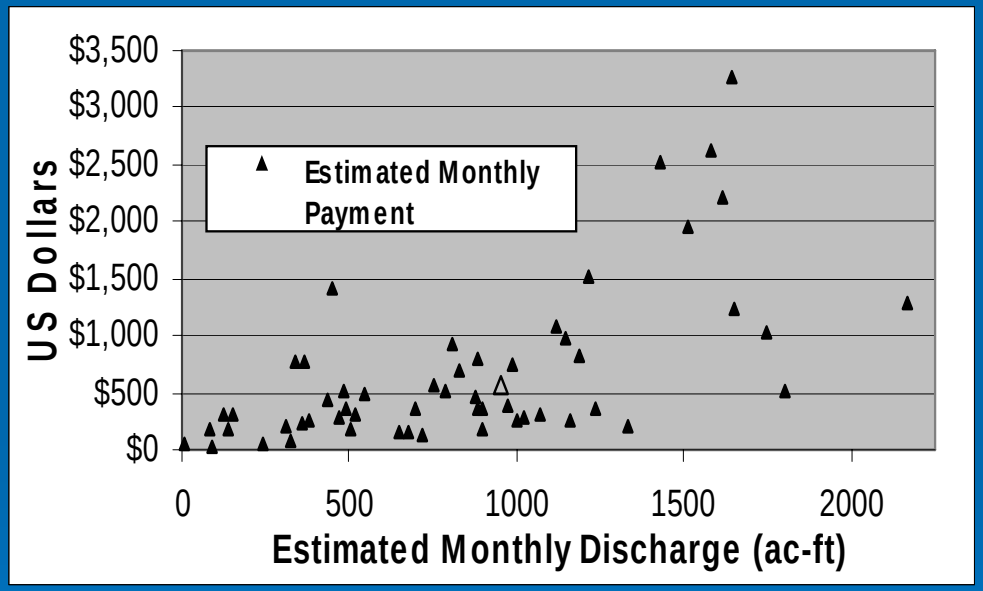
Evaluation Methods for the Payment Formula

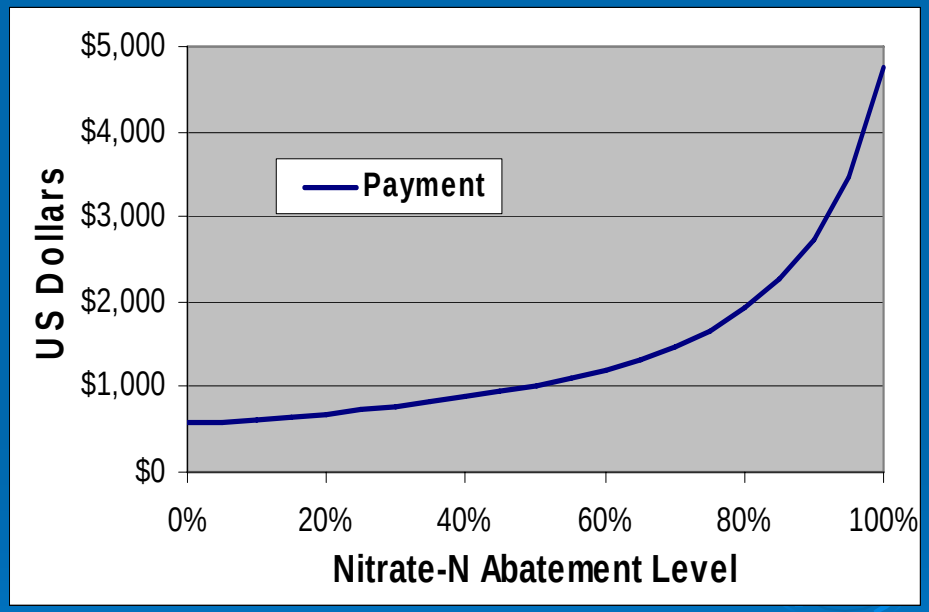
- Simulate payments and payment components based on past data.
- Compare estimated with actual payment levels.
- Examine participation and abatement decisions by farmers.

Evaluating Simulated Payments

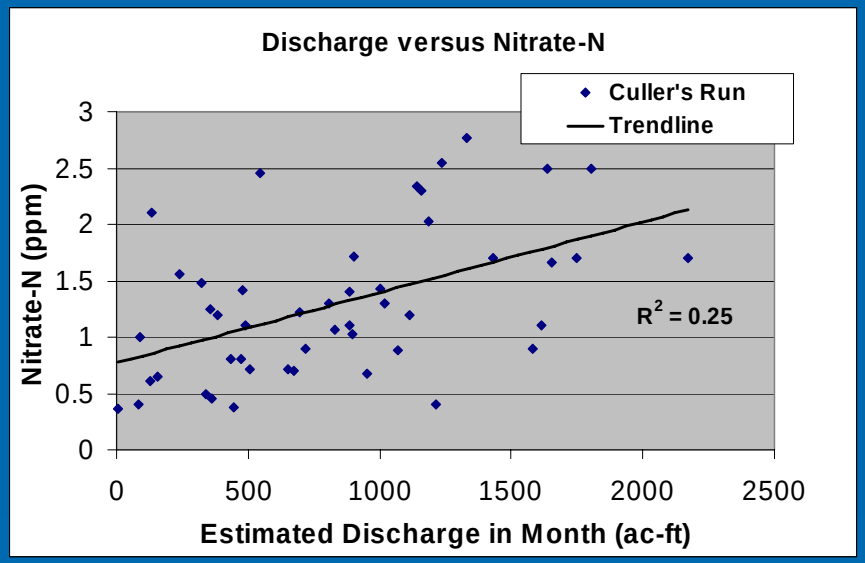
- The annual total payment averaged $7,721 (range: $4,593 to $9,400) based on 4 years of estimated monthly payments.
- A 25% reduction in nitrate-N gave an average payment of $9,595 annually (range: $5,898 to $11,480).
- Abatement payment function is convex.

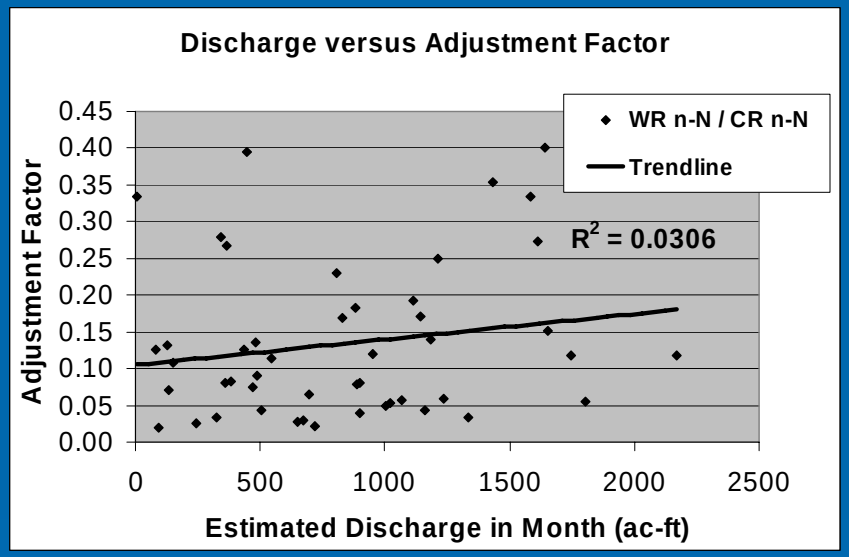
Simulated payments over 4 years of data





Evaluating Simulated Adjustment Factors



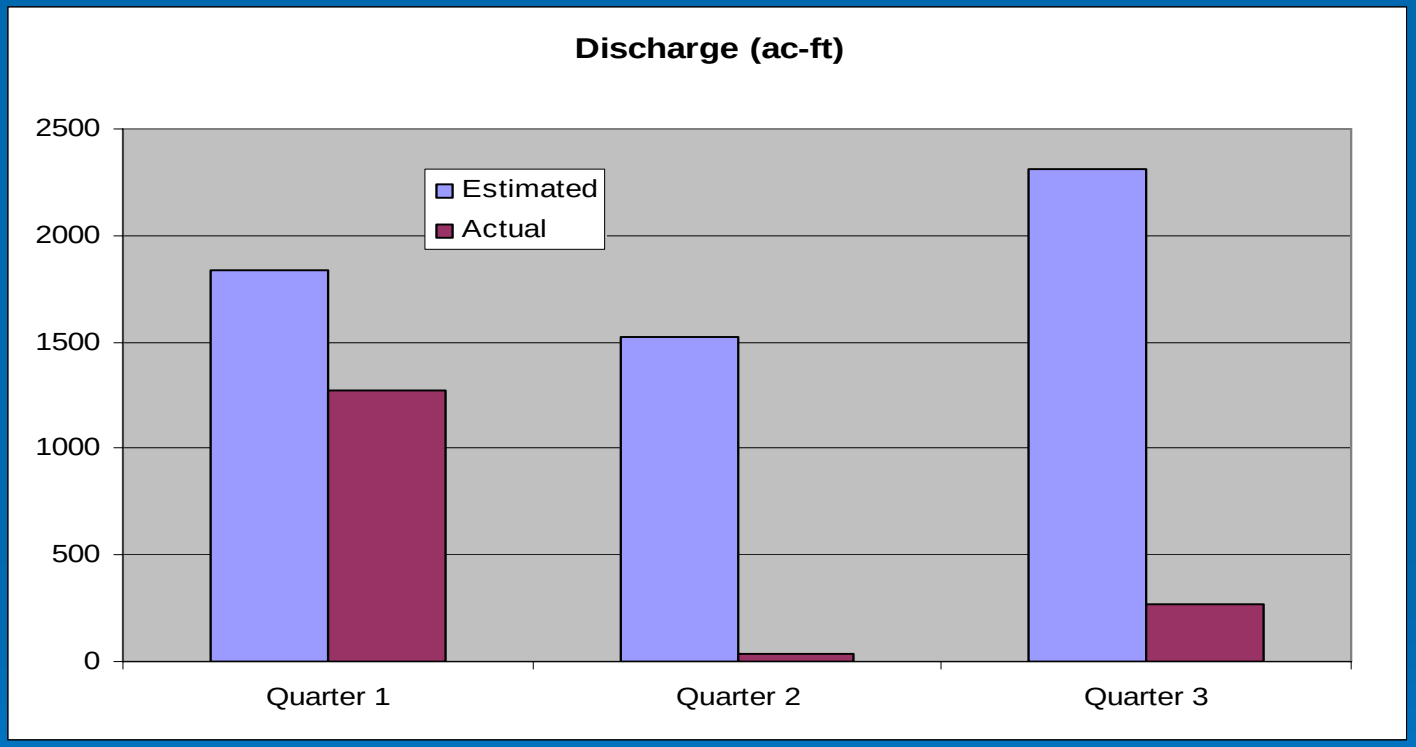


Adjustment factor reduces connection between discharge and nitrate-N ($R^2 = 0.25$, $p<0.001$ versus $R^2 = 0.03$, $p<0.23$)

Comparing Estimated versus Actual Values

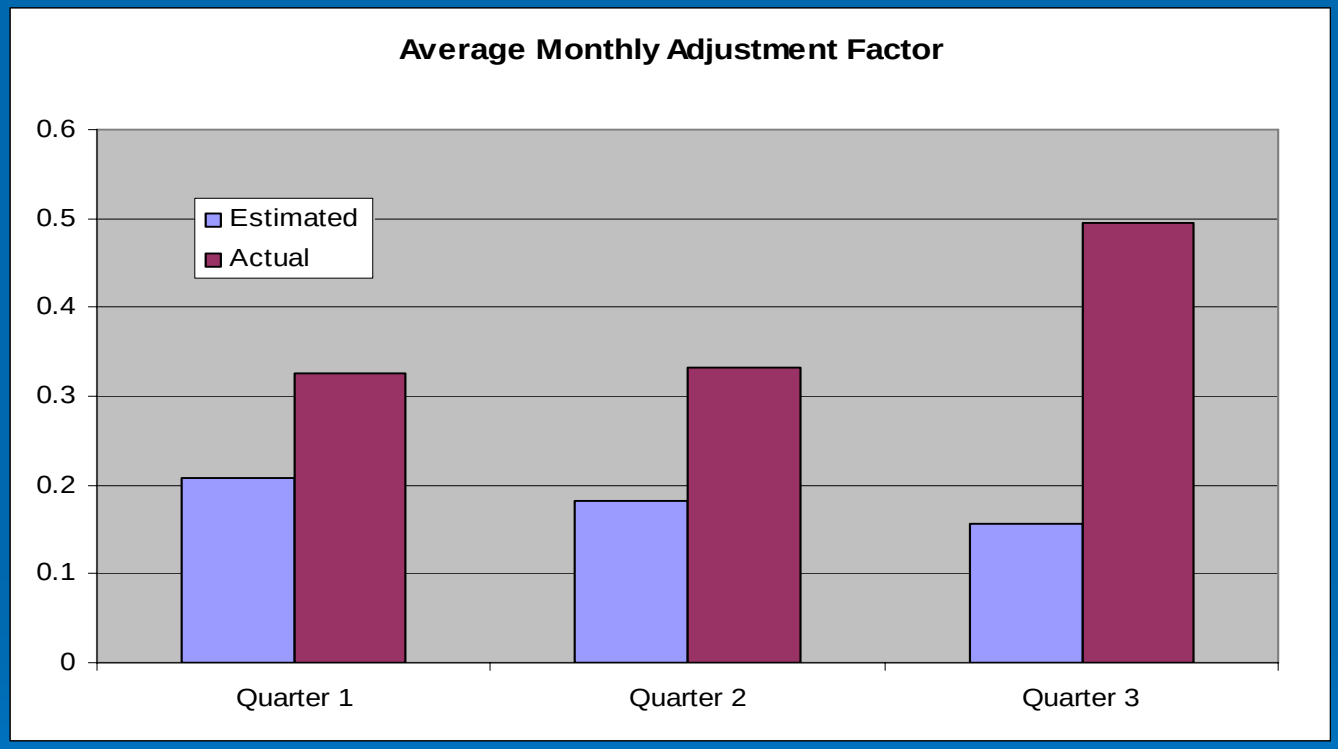
- Payments are the multiplication of water quantity (in acre-feet), price, and an adjustment factor.
- When comparing estimated versus actual, we compare quantity, adjustment factors, and payment levels.

Comparing Estimated versus Actual Discharge



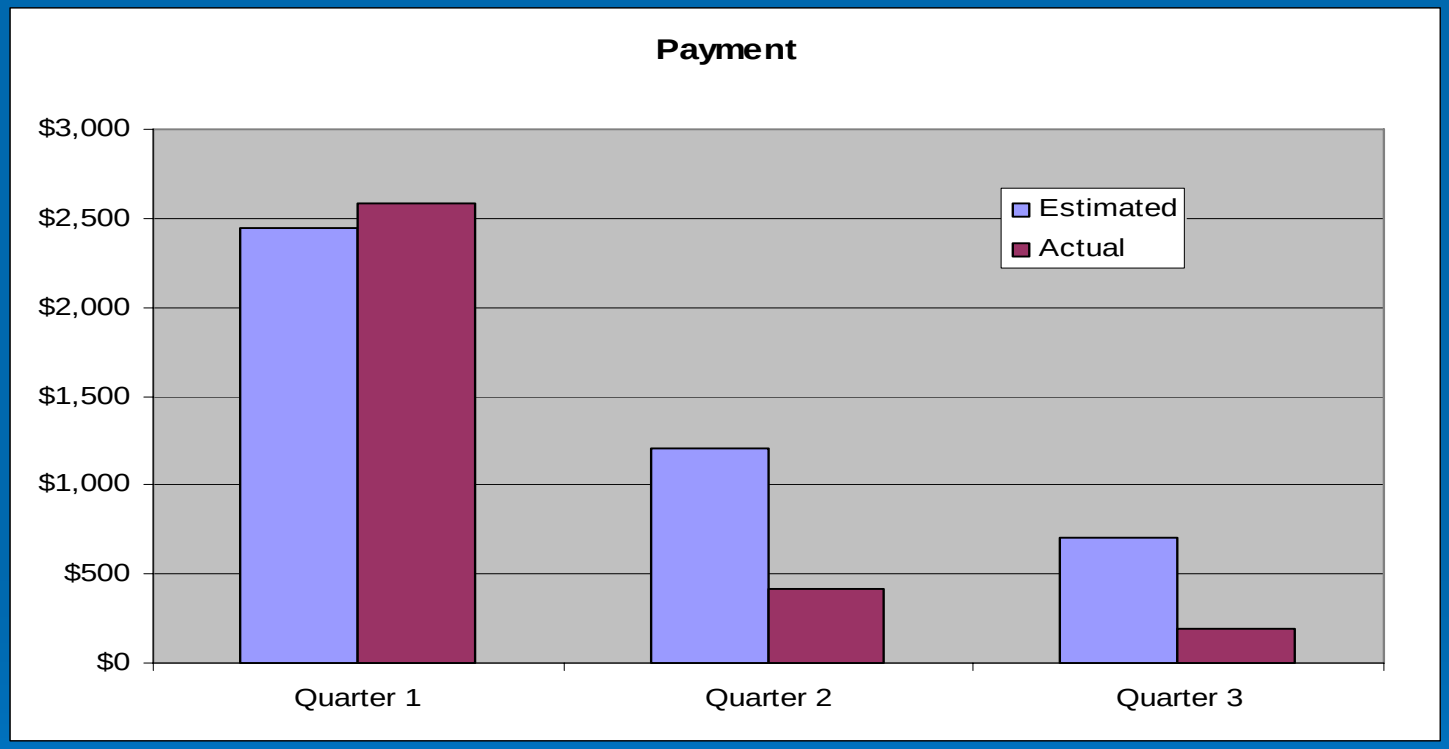
- Cullers Run stream flow was much lower than anticipated during April through December 2007.

Comparing Estimated versus Actual Adjustment Factors



- The adjustment factors were much higher than expected during April through December 2007.

Comparing Estimated versus Actual Payments



- With the exception of the first three months, payments have been lower than expected between April and December 2007.

Comparing Estimated versus Actual Values

- Total actual payments between April and December 2007 were $3,193.
- Estimated from past water quantity and quality data, payments were expected to be $4,357.
- This is a difference of about one-third less (-36%), due mostly to drought conditions.

Evaluating Farmer Response

- Farmers were able to sign a written contract to participate in the project beginning April 1, 2007.
- To date, a total of 15 farm households have signed a contract.
- This sign-up represents about one-half of the farmers who came to meetings.
- Of the total actual payments ($3,193), only $922 has been distributed to farmers.

Evaluating Farmer Response

Less than one-third of the payments have been distributed based on a farmer decided payment allocation formula:

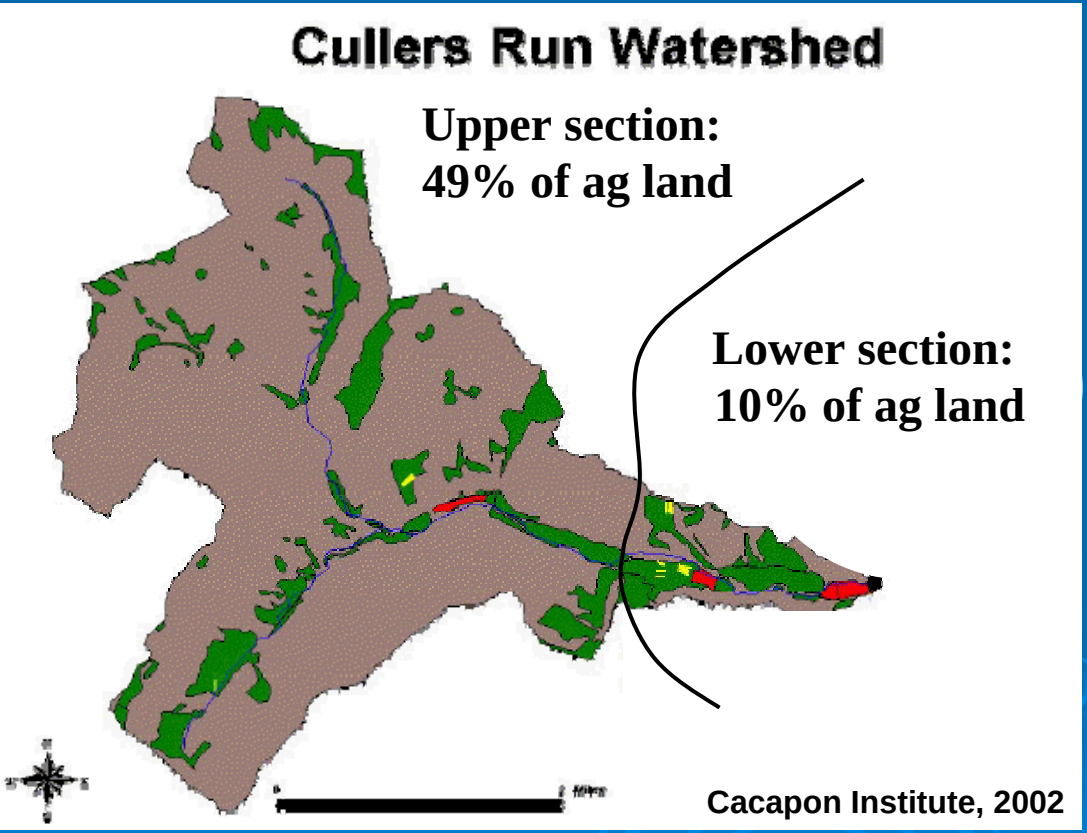
- a $50 signing bonus to each participant who signed up prior to June 1st, 2007,
- 10% of each monthly payment is to be distributed equally among all participants,
- the remaining 90% is reserved to financially assist farmers who engage in nitrate-N abatement, and
- any remaining funds at the end of the year are to be paid out as a bonus to all participants.

Evaluating Farmer Response

- Participation: 41% of ag land is within the project
- Abatement: One of three largest nitrate-N contributors based on lbs/square mile has initiated abatement.
- Participation is not even throughout watershed…

If we divide the watershed into upper and lower sections…

We see a difference in participation rates.



Conclusions

We think so far so good…

- A substantial portion of farm households and land is participating in the project.
- Farmers have shown an interest in identifying water quality problem areas and have undertaken additional abatement, although the link to the payments is uncertain.
- Participating farmers are trying to recruit nonparticipating farmers, especially in the lower section.

Conclusions

However…

- Ultimately, project success will hinge on getting lower section farmers involved.
- We will seek to better understand how participating farmers will make abatement decisions as a group.

Thank you!

Any Questions??