References

Jayakaran, A., D. Mecklenburg, A. D. Ward, L. C. Brown, and A. Weekes (2005). Formation of Fluvial Benches in headwater Channels in the Midwestern Region of the USA. International Agricultural Engineering Journal, 14(4):193-208.

Jayakaran, A. D. and A.D. Ward (2007). Geometry of Inset Channels and the Sediment Composition of Fluvial Benches in Agricultural Drainage Systems in Ohio Journal of Soil and Water Conservation. 62(4):296-307.

Powell, G.E., A.D. Ward, D.E. Mecklenburg, A.D. Jayakaran (2007). Two-stage channel systems Part 1: A practical approach for sizing agricultural ditches. Journal of Soil and Water Conservation. 62(4):277-286.

Powell, G.E., A.D. Ward, D.E. Mecklenburg, J. Draper and W. Word (2007). Two-stage channel systems Part 2: Case Studies. Journal of Soil and Water Conservation. 62(4):287-296.

Powell, E., D. Mecklenburg, and A. D. Ward (2006). Evaluating channel-forming discharges: A study of large rivers in Ohio. Transactions of the American Society of Agricultural and Biological Engineering. 49(1): 35−46.

USDA-NRCS (2007). National Engineering Handbook Part 654 Stream Restoration Design. Chapter 10 Two-Stage Channel Design. Part 654 Stream Restoration Design National Engineering Handbook.

Ward, A. D., A. D. Jayakaran, D. E. Mecklenburg, G. Erick Powell, J. Witter (2008). Two-Stage Channel Geometry: Active Floodplain Requirements. Encyclopedia of Water Science 2nd Edition, Stanley Trimble (editor), Taylor & Francis, CRC Press.

Miami Conservancy District

38 E. Monument Ave.
Dayton, Ohio 45402

Phone: (937) 223-1271
Fax: (937) 223-4730

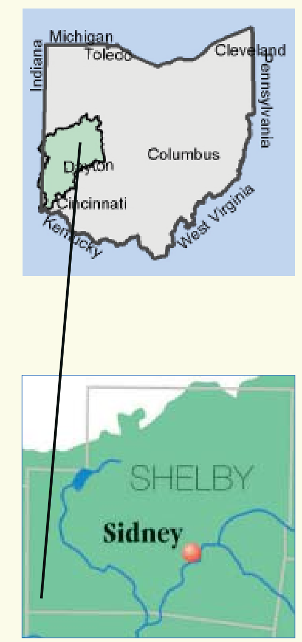
www.miamiconservancy.org

Getting Better Water Quality from an Agricultural Ditch

Miami Conservancy District

PROJECT DESCRIPTION

An innovative two-stage channel design was installed in Shelby County, Ohio in Southwest Ohio. This project demonstrates that agriculture channels can be sized to satisy requirements to convey discharge from agricultural lands and improve water quality downstream. The project was made possible by funds from The Miami Conservancy District (MCD) and a U.S. Environmental Protection Agency (USEPA) Targeted Watershed grant.



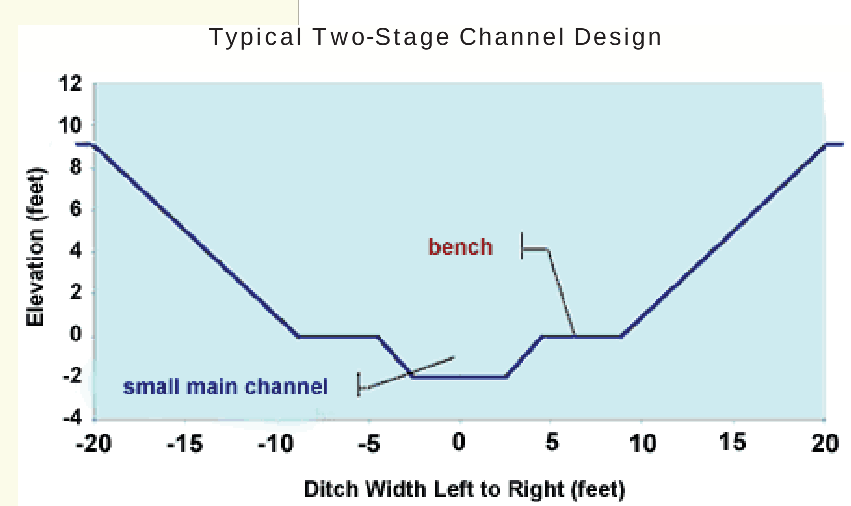
Project Details

The project focused on modifying 3,100 feet of Klase Ditch - which flows to the Loramie Creek and then to the Great Miami River - from a traditional V-shaped channel into a two-stage channel. The channel was planned, constructed and evaluated in order to measure the performance of the innovative two-stage channel design.

To modify Klase Ditch into a two-stage channel, 11,565 cubic yards of earth was moved to widen the sides, and a bench was added above the low flow channel. All of the earth moved from the ditch was reused at the site or in the ajacent farm fields. Because the existing small main channel was stable, it was left undisturbed. This reduced the amount of sediment disturbance and construction cost. Water quality data was collected before, during, and after construction. After construction the average width of the base is 32 feet and the top of the ditch is 60 feet.

Partners

MCD led the project working closely with the landowners Art and Scott Ayres, The Ohio State University (OSU), the Shelby Soil and Water Conservation District (SWCD), and the Loramie Valley Alliance. Dr. Andy Ward provided assistance with sizing the two-stage geometry and personnel at OSU conducted pre-consstruction monitoring. MCD's engineering staff designed the project and supervised the construction, and MCD's program staff conducted the rest of the water quality monitoring. The Shelby SWCD staff provided expert advice throughout the project.



The Challenge

Highly modified channels drain extensive portions of productive agricultural land in Ohio. Although these modified channels function properly, they are detrimental to water quality and habitat, and require frequent maintenance to drain runoff effectively. Ditch maintenance removes woody vegetation, weeds, and sediment; and restores a V-shape to the channel.

Nature's solution: floodplains

Floodplains are a critical part of a natural stream system. Floodplains help slow and spread the energy of high flows and create a balance in sediment transport and storage. It is not possible or realistic to restore agricultural ditches to a natural stream design. However, the characteristics of floodplains can be incorporated into a ditch design to provide the maximum amount of drainage along with the ability to slow flows and settle out sediments.

Benefits

Benefits of a two-stage channel over a conventional ditch include both improved drainage function and ecological function. Designed properly, the two-stage channel will increase ditch stability by slowing water flow. The channel design also reduces the need for frequent ditch maintenance saving labor and money.

Benefits continued.

Two-stage channels improve water quality by reducing sediment and nutrients (such as phosphorus and nitrogen) that are transported from ditch to stream to river. Sediment and nutrients are decreased when finer silts deposit on the benches and coarser material forms the low flow channel. Vegetation, such as grasses, growing on the benches provides bank stability, quality cover, shade for habitat, and nutrient uptake.

Lessons Learned

Construction was delayed because of an unusually rainy season. By the time construction was completed, it was too cold for the vegetation to establish. The following year, the vegetation grew well.

Periodically, the automated samplers did not function properly so there are some small gaps in the data. Following the first year of construction, several of the rock-lined tile outlets failed. These outlets were re-constructed and smaller rocks were replaced with larger-sized rocks to keep the outlets stable.

On a positive note, there was a large rain event immediately following construction and, although the disturbed banks did not yet have established vegetation, there was little or no soil loss. The benches and sloping sides allowed the floodwaters to drain effectively without the erosive flows in a traditional V-shaped channel.

Costs

To construct the channel, a competitive bid process was used to identify a contractor. Costs for construction were approximately $132,000. The costs of lab analysis and equipment maintenance for two years of water quality sampling was approximately $26,000. The project also paid the landowner for future maintenance needs and the value of the land that was taken out of crop production. Personnel at OSU conducted a geomorphology survey, assisted with sizing the two-stage geometry, and supported the pre-construction water quality monitoring and laboratory analysis through grants from the U.S. Department of Agriculture and other sources. MCD donated the value of staff time for engineering, project management, and second and third year of water quality monitoring collection.

Klase Ditch prior to redesign. Note the v-shaped channel.

During construction 11,565 cubic yards of material was removed.

The two-stage ditch immediately following construction. Note the stability of the low flow channel.

The second year following construction the channel is stable and well-vegetated.

Water Quality results

Water quality data was collected using two in-stream automated samplers. One was installed upstream and one downstream of the two-stage channel construction. The samplers collected 100ml of water from the channel every three hours. Once every two weeks, the samples were sent to a water quality analysis lab for evaluation. The samples were tested for the parameters listed below. Flow data also was collected at each sampler. Water quality data was collected from April to August in the years 2005 through 2007.

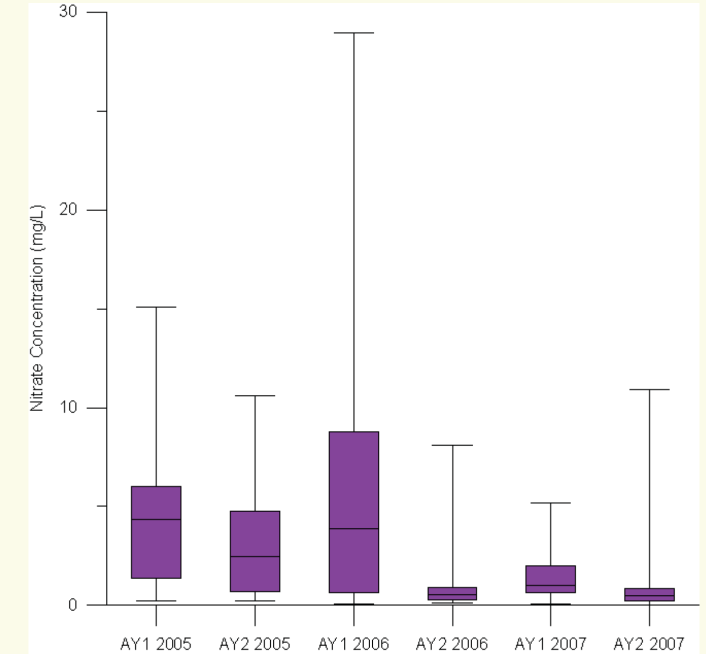
Test Parameters

- Ammonia (NH3)
- Nitrite (NO2)
- Nitrate (NO3)
- Sulfate (SO4)
- Chlorine (Cl)
- Silicon Dioxide (SIO2)
- Total Kjehdahl Nitrogen (TKN)
- Total Phosphorus (TP)
- Conductivity
- Suspended Solids (SS)
- Flouride (F)
- Soluble Reactive Phosphorus (SRP)

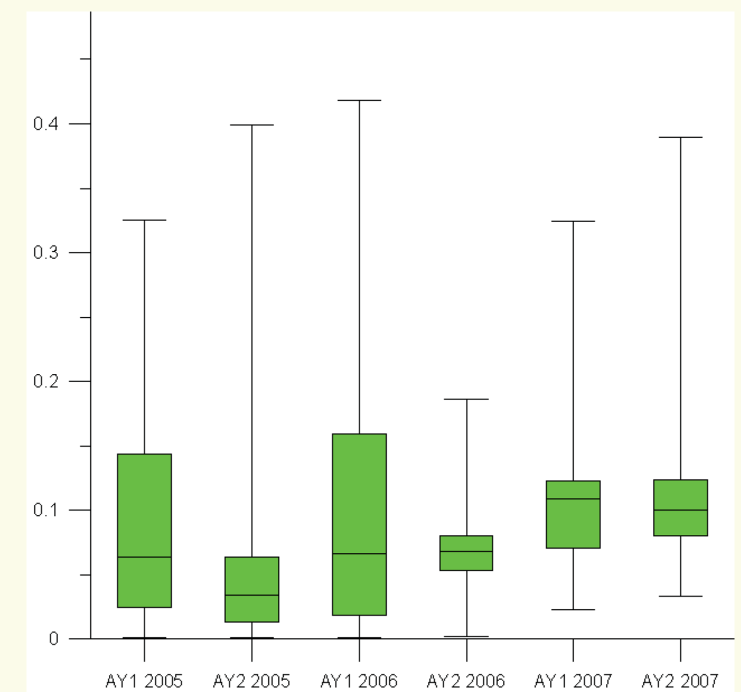
These two charts illustrate the differences in water quality concentrations above and below the 3100 foot section of Klase Ditch under construction. AY1 is data collected at the automated sampler located upstream of the channel construction. AY2 is data collected downstream.

MCD staff installing the water quality sampling equipment in the Klase Ditch upstream of the construction.

Nitrate concentrations in Klase Ditch for 2005-2007



SRP concentrations in Klase Ditch for 2005-2007



The boxes represent the range of concentration values. The horizontal line in the box is the median - half the samples were above that value, and half were below. Note that during 2006 and 2007, nitrate concentrations are lower at the AY2 than the pre-construction levels of 2005.

Also note that SRP values are slightly higher. The data collected in 2007 reflects that the ditch had not yet fully recovered from the sediment disturbance during construction. The trends will reverse as the vegetation matures and the channel reaches an equilibrium with the new shape.