Incorporating Natural Stream Morphologies in Ditch Restoration Work

By: Nicole Granger
Wetland Project Coordinator
Central Massachusetts Mosquito Control Project

The Old Ways

Dig It Wider And Deeper, aka...When Good Ditches Go Bad!

The old philosophy of water management work was to take stagnated ditches and dig them deep and wide. The thought was that the ditches were going to silt in again, and the vegetation was going to grow back and re-block the stream. By digging the ditches deep and wide, the amount of maintenance needed in the future should be decreased, because it should take longer for the ditches to degrade again. WRONG! Though the intentions of this philosophy are good, the results are often failed projects that require extensive maintenance in the future. The Orchard Ln project was last done ini 1993. The ditch was dug too wide, and as a result, the ditch has continued to widen. As a result of the widening, the banks are starting to errode, and water is beginning to pool in neighbor's backyards. The outlet culvert is 50% silted in, and it is time to re-dredge the ditch. A restoration project is going to be implemented to reduce the width of the channel, and increase the sinuosity of the channel in hopes that the stream can re-stabalize.

It is visibly clear that the width of the ditch is wider than necessary for the amount of water flowing into the culvert. The restoration job will decrease the width, stabalize the bank, and try to re-connect a flood plain.

Severe widening of the same ditch, caused by dredging the ditch too wide.

Old McDonald Had A Farm, And On This Farm He Had A Ditch

Many of the ditch systems in Central MA are reminiscent of an earlier time, and can be traced to agricultural practices. Dealing with old, unmaintainted agricultural ditches is rather common in upland water management work. They are often silted in, overgrown with vegetation, and causing water to back-up all over the place! They can be easily identified on any aerial map, because they are straight, and often "grid-like." No one could ever mistake these ditches for something natural, and their manufactured geometries are the precise reason why these ditches create immense drainage problems. These ditches become incised, widened, blocked, flooded, and in the long-term exacerbate all of the drainage problems that they were designed to allieviate. Agricultural ditches are often prime candidates for restoration work. There is enough land available to reconstruct a healthy stream geomoetry, however the mindset on agricultural land is that "straight is better." Sinuous streams would decrease the area of field that can be hayed. As a result, many of the streams need to be re-dredged every few years in order to keep them functional. The streams shown above are from a farm in Chelmsford, and are re-dredged approximately every five years. If they are not maintained, the fields flood and breed large populations of mosquitoes!

Agricultural ditch in Chelmsford.

Another section of agricultural ditch

An All Too Familiar Picture

The Dean Rd. project was done at the request of the Town of Marlborough. The contractor who constructed the drainage system in the area created several problems which will require a long-term maintenance plan for the area. The ditch profile is very straight, and maintains good pitch which promotes a high energy flow. Downstream, the developer created a rock waterfall, which he felt provided an aesthetic enhancement to the ditch. While the waterfall may be visually appealing, it is functionally awkward. The size of the rock is excessive in comparison to the stream discharge. In addition, several inches of roadway sand are washed into the stream each spring. The excessive sediment loads, straight stream geometry, and poorly designed waterfall spell disaster for the long-term sustainability of this ditch system. The straight stream geometry prevents the dissipation of energy, and the high energy flows are capable of carrying larger amounts of sediment. However, once the water hits the rock waterfall, there is an immediate dissipation of energy. As the flow velocity decreases, the sediment drops out and is deposited behind the waterfall. Over time, the sand builds up along the entire lenght of ditch, and needs to be re-dug. Unfortunately, this ditch is located in private yards, and a stream restoration project is not feasible. As a result, this stream will likely need to be re-dredged every few years in order to reduce breeding habitat, and prevent flood damage.

Look At The Size Of That Culvert! Let's Widen The Ditch!

It is common to come across ditches that have improperly sized culverts. The size of the culvert is based upon the design storm, which is usually the 50 or 100 year flood event. However, the average discharge of the stream is significantly less. Digging the ditch to accomodate the size of the culvert, and not the natural width of the stream can cause long term degradation, where the stream shallows, widens, and becomes a maintenance nightmare! The shallow stagnant water will become a perfect haven for mosquitoes, effectively negating any positive aims of the oringinal project.

There is a small trickle of water coming from the large culvert (culvert at bottom of photo).

Water pools in the bottom of ditch becuase it is too wide for the amount of water flowing.

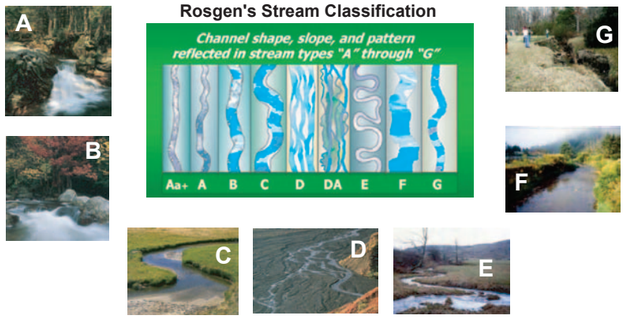
The Difference Between Ditch Maintenance, and Stream Restoration

Ditch maintenance is the main aspect of the Central Mass. Mosquito Cotrol Projects' water management program. The goal of the program is to reduce or elliminate stagnant mosquito breeding sites by removing obstructions from degraded ditch systems. This can be accomplished by cutting overgrown brush that is blocking the flow of water, raking blockages from streams, digging small ditches by hand, or using a low-pressure excavator to dredge the ditch. Ditches have typically been dug in a way that removed any type of obstruction or soil deposit in order to create a channel that flowed freely. This practice disregards the natural processes that occur in all channels, and the functions that stream structures play in the long-term stability of the stream.

Stream Restoration is defined as:
" the establishment of the dimension, pattern, and profile of the appropriate, stable stream type in order to restore its physical and biological function"(1)
In order to determine what the stable dimention, pattern, and profile of the ditch should be, there

Factors That Affect Formation Of Stream Morphologies

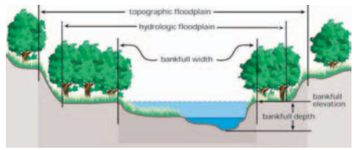
There are two main principles that need to be considered in order to understand the flow path of water. Water will flow the path of least resistance, and simultaneously try to maximize the dissipation of energy. These two forces oppose each other, as the path of least restistance will minimize the dissipation of energy. Streams will therefore form in patterns, or morphologies, that will satisfy these two forces.



A stream's flow pattern is determined by its watershed, the slope, velocity of flow, sediment load, sediment size, resistance to flow, and the bed material. These parameters also affect the stream's state of stability. All stable streams have a direct connection to their floodplain. If there are any changes in sediment load, watershed, or slope, it will have a negative impact on stream stability. Unstable streams will start to incise and widen in an attempt to redevelop a stable connection to a new floodplain. The patterns that arise from the hydrologic and stability factors have been summarized in Rosgen's Stream Classification. Stable stream types include step pool morphologies, commonly know as rapids (B type), sinuous streams with point bars (C Type), and meandering streams (E type). Valley streams with steep slopes and waterfalls (A Type) can also be stable if the bed material is competant enough, such as bedrock or bolders. Unstable stream types include braided streams (D Type), widening streams with erroding banks (F Type), and steep incising streams (G Type).

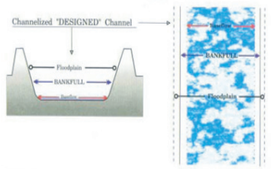
Processes That Shape Streams

The dominant process that shapes streams is the bankfull event. The bankfull event occurs approximately once every 1.5 years, and is the flood event that transports the most sediment over the long-term. The bankfull stage is defined as the point in which the flow that fills the active channel begins to spread out over the stream's floodplain. Becuase the bankfull stage is considered the effective discharge for the stream, it is used as the design discharge for the stream restoration project.

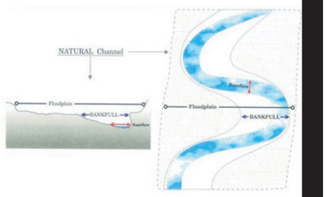


Application to Ditch Maintenance

By incorporating restoration concepts into ditch maintenance work, it is possible to create more sustainable sites, and to reduce the long term need of maintenance. Ditches can be designed and dug in stable stream shapes, and it is possible to re-connect degraded systems to a new floodplain. These designs can be developed based upon data gathered from field survey, and identification of the bankfull stage.



Common profile of old channelized ditches. Profile shows instability and lack of connection to floodplain.



Profile of a ditch using restoration concepts, incorporating natural morphologies and promoting sustainability.

Trying New Ideas

Case Study 1: Pinedale Avenue; Tewksbury, MA

The Pinedale Avenue project originated with a phone call from a local resident who was inundated with mosquitoes. The ditch system abutting her property had become overgrown with vegetation, resulting in blockages and flooded areas that provided prime mosquito breeding habitat. Because the ditch was already at its natural bottom, the project was set up as a brushing and hand cleaning job. The lower 1,500' of the ditch were well defined, however there was an undefined flooded area in the upper 100' of the ditch located between the outlet culvert and the inception of the natural ditch. A defined channel was dug by hand through the flooded area, and was designed to mimick the natural sinuosity preserved in the downstream length of the ditch. The underlying soils at the project site are medium to fine sands, and other ditch systems created in the area have resulted in incising of the channels, and errosion of the banks. However, by mimicking the natural sinuosity of the existing ditch, and by maintaining the connection to the flood plain, the result of the project should be a self-sustaining drainage system that will require minimal maintenance in the future.

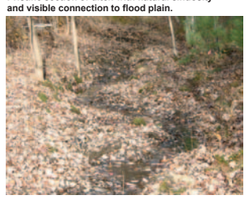
Brushed Stream Banks of downstream channel show natural sinuosity of stream.

Hand dug portion of upstream channel mimicks natural downstream morphology.

Case Study 2: Mahoney Ln., Northbridge, MA

The Mahoney Lane project included the dredgine of a large wetland area that had formed from a silted in farm pond. The wetland area was re-constructed into a 3,000 sq. ft. pond, and the associated inlet stream was dredged to form a defined channel. The majority of the ditch was classified as a shallow, wet, mucky depression. However, the upstream portion of the ditch was developed and maintained a healthy, stable stream morphology. When the undefined portion of the ditch was dug, the width and siinuosity were re-created in order to promote a sustainable system, and to prevent any negative impacts to the healty stream, such as incising, or widening.

Pristine section of ditch with natural sinuosity and visible connection to flood plain.



Mimicking sinuosity and preserving connection to flood plain in the dredged section of the stream.

Looking downstream from pristine section of stream to the dredged section of stream.

Case Study 3: Goldthwaite Rd., Northbridge, MA

The Goldthwaite Road project required re-definition of a severely degraded ditch system. Water is constantly flowing into the system, originating as ground water seepage from a man-made berm holding back a large lake less than 200' away. A culvert beneath a driveway separates the degraded ditch from a retention area. A heavy flow always pours from the culvert,and has resulted in an unstable, widening system. In the summer months, the area is overgrown with vegetation which further impedes flow, promotes flooding, and results in mosquito breeding. The goal of the project was to re-stabalize the stream and reduce the mosquito breeding habitat. In order to promote dissipation of energy, several meander bends were incorporated into the design. The ditch was dug as a connected stream with a defined flood plain to promote stream sustainability.

Side view of stream with no flood plain to contain flow. There was no connection to a flood plain.

Create a channel with a connection to its flood plain. Incorporate meanders to promote dissapation of energy.

Final view of ditch from same vantage point as "before" picture. Stream will be monitored to see if it is sustainable.