Incorporating Natural Stream Morphologies in Ditch Restoration Work

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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 would silt in over time, and the vegetation would grow back and cause blockages in the stream. Bu digging the ditches deep and wide, the amount of maintenance needed in the future would 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 in 1993. The ditch was dug too wide and too deep, an has resulted in an unstable stream morphology that continues to widen. The results of the stream widening are eroding banks and pooling of water. 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 to increase the sinuosity of the stream in hopes that the system can restabilize.

The width of the ditch is wider than necessary for the amount of water flowing into the culvert

Rendering of the proposed project. The restoration job will decrease the width, stabilize the bank, and try to re-connect the flood plain.

Old MacDonald 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, un-maintained agricultural ditches is rather common in upland water management work. They are often silted in, overgrown with vegetation, and cause water to back-up and pool. They can be easily identified on any aerial map because they are straight and often "grid-like". No one would 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 alleviate. Agricultural ditches are often prime candidates for restoration work. There is enough land available to reconstruct a healthy stream geometry, however the mindset on agricultural land is that "straight is better". Sinuous stream would decrease the area of the field that could be efficiently hayed. Often times natural meandering streams are re-routed in straight geometries that border the field. The streams shown below 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

Aerial of property from Mass. GIS. Note the straightness of the ditch system.

An All Too Familiar Picture

The Dean Rd. Project was completed at the request of the City of Marlborough. The contractor responsible for the construction of the drainage system created several problems which will require a ling-term maintenance plan for the area. The ditch profile is straight and maintains a good pitch, which promotes a high energy flow. Downstream the developer created a rock waterfall, which he felt created an aesthetic enhancement to the ditch. While the waterfall may be visually appealing, it creates operational deficiencies. The waterfall is constructed from rock slabs which are incongruous in size in comparison to the stream discharge. In addition, several inches of road sand are washed into the stream each spring. The excessive sediment loads, straight stream geometry , and poorly designed waterfall spell disaster for the long-tern sustainability of the ditch system. The straight stream geometry prevents the dissipation of energy, and the high energy flows area 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 length of the ditch, and needs to be re-dug. Unfortunately, the 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.

Photo of ditch prior to maintenance

Photo of ditch after dredging.

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 generally the 50 or 100 year storm event. However, the average annual discharge of the stream is significantly less. Digging the ditch to accommodate the size of the culvert and not the annual flow can cause long term degradation. As a result, the stream can widen, shallow, incise, and become a maintenance nightmare! The shallow stagnant water will become a perfect haven for mosquitoes, effectively negating any positive intentions of the original project.

Outlet culvert to the ditch. The two side culverts were buried, and were discovered during excavation. Notice there is only a trickle of water from the large culvert. Stains on the pipe show the original level of sediment accumulation.

The ditch was dug to the width of the culvert. Notice how the water pools in the ditch because it is too wide for the capacity and velocity of flow from the culvert.

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.

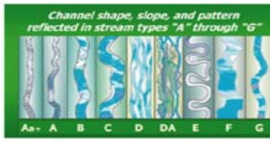
Stream Restoration is defined as:

" 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

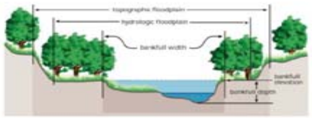
There are two main principles that need to be considered in order to understand the flow path of water. Water will flow the path of least resistance, and simultaneously try to maximize the dissipation of energy. These two forces oppose each other, as the path of least resistance will minimize the dissipation 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).

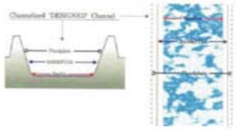
Processes That Shape Streams

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

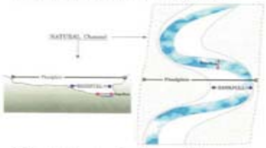


Application to Ditch Maintenance

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.

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 was 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 mimic 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 erosion of the banks. However, by mimicking the natural sinuosity of the existing ditch, and by maintaining the connection to the floodplain, the result of the project should be a self-sustaining drainage system the will require minimal maintenance in the future.

Brushed stream banks of downstream channel show natural sinuosity of stream.

Hand dug portion of upstream channel mimics natural downstream morphology.

Case Study 2: Mahoney Ln., Northbridge, MA

The Mahoney Lane project included the dredging of a large wetland area that had formed from a silted in farm pond. The wetland area was reconstructed 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 sinuosity was recreated n order to promote a sustainable system, and to prevent any negative impacts to the healthy stream, such as incising or widening.

Pristine section of ditch with natural sinuosity and visible connection to the floodplain.

Mimicking sinuosity and preserving connection to floodplain 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 a redefinition of a severely degraded ditch system. Water is constantly flowing into the system, originating as ground water discharge 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 had resulted in an unstable, widening system. In the summer months, the area is overgrown with vegetation which further impeded flow, promotes flooding, and results in mosquito breeding. The goal of this project is to restabilize 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 to reconnect it to a floodplain to promote stream health and sustainability.

Site was a widening stream with undefined banks. There was no connection to the floodplain.

Create a channel with a connection to its floodplain. Incorporate meanders to promote dissipation of energy.

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