

An Evaluation of Livestock Spring Developments as Potential Sources of Thermal Stress to Surface Waters



**Delaware County Soil and Water Conservation District
Walton, New York**

March 2017

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EXECUTIVE SUMMARY

Small springs are common to the hilly terrain of Delaware County. While spring water use was more important to landowners in the past, springs remain useful sources for providing water to livestock in pastures. In this capacity, some confusion exists about whether such uses may or may not contribute to thermal pollution of surface waters.

This report examines temperature characteristics of springs in their natural setting, describes typical spring development design methods and materials and the effects such developments have in a variety of field situations. Spring developments collect and temporarily store a portion of spring water discharge close to its point of origin, then redirect a portion of this downslope to its point of final consumption away from surface waters. There is no contact between the water directed towards livestock and surface waters. In fact, the principal reason springs are developed by conservation agencies is to ensure an effective buffer of vegetated soil is maintained between livestock and surface waters. Research studies confirm that limiting livestock access to streams significantly reduces pollution from manure-borne nutrients and pathogens while also minimizing sediments from eroded stream banks. The net result is a positive effect to the environment; thus spring developments remain a useful tool towards meeting county, watershed, state-wide and national water quality improvement goals.

INTRODUCTION

Small, naturally occurring springs are more common on Delaware County farmlands than in most other parts of New York State. The majority of these are ephemeral, producing no visible flow during the late summer and early fall, while others reliably produce between one and three gallons per minute of relatively clean, cold water even during dry spells. Whether reliable or ephemeral, such springs are frequented by wildlife and often contribute to the origin of streams in uplands. Springs have been valued as domestic and municipal water supplies to early settlers and later residents and for cooling milk in the early days of the dairy industry. Back when horses were much more common, a Delaware County landowner who maintained a watering trough along a public road could receive a reduced tax levy for his trouble, a practice that continued into the mid-1920's (Raitt, 1993). These could be simple arrangements with spring flow being directed through a wooden pipe to a trough that overflowed toward the nearest stream.

By comparison, modern spring developments are more carefully designed and constructed, enabling conservation agencies to help farmers limit livestock access to riparian corridors and other surface waters. However, some confusion may exist among those unfamiliar with springs in agricultural landscapes or with spring development methods, specifically about whether such uses may contribute to thermal pollution of surface waters.

Front cover photo: A livestock watering facility overlooking the Ouleout Creek Valley in the Town of Franklin. Note nearby fencing that excludes cattle from riparian buffer area. Spring developments provide alternative water sources that improve water quality by keeping livestock out of streams. Photo by K. Buel



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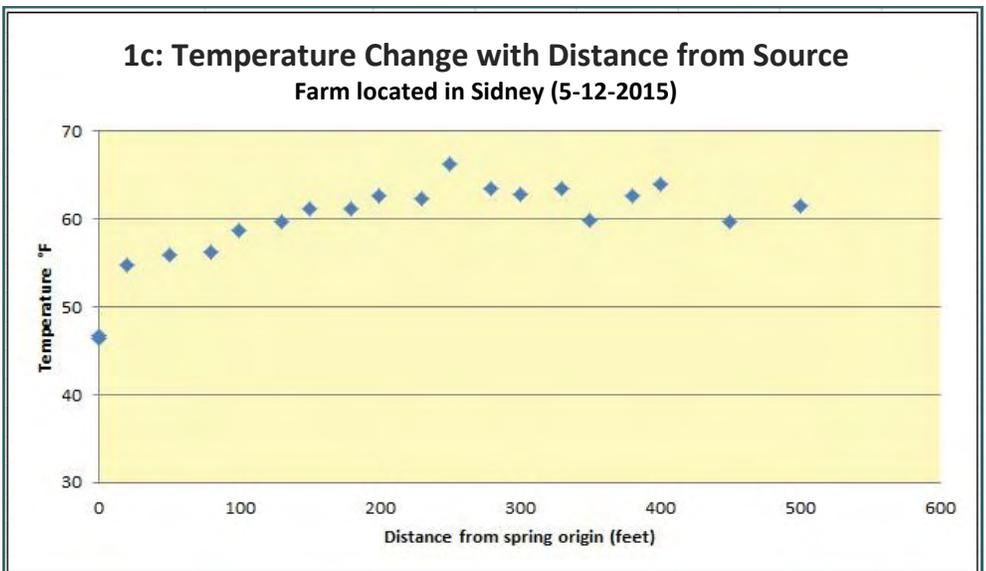
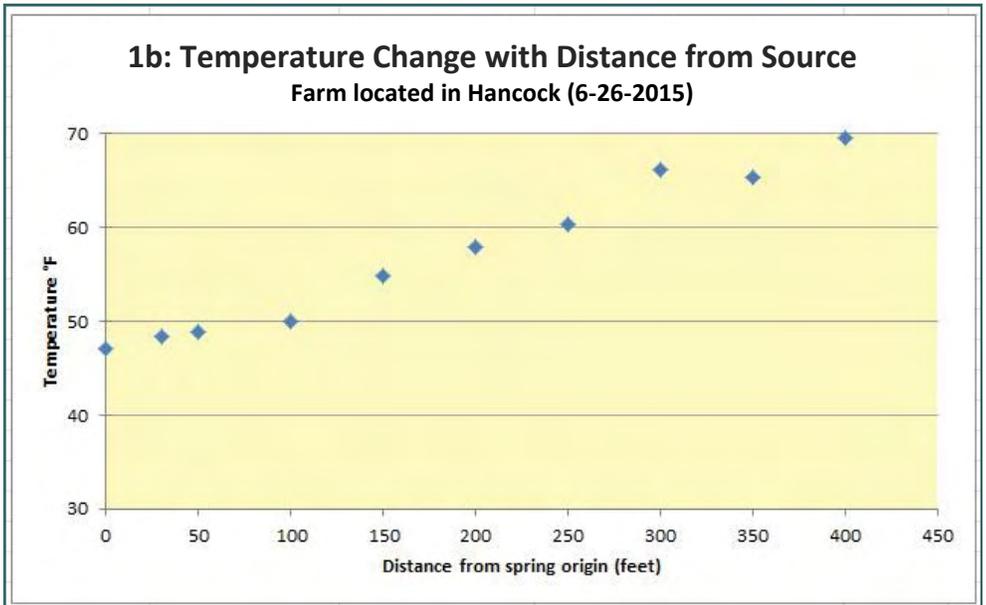
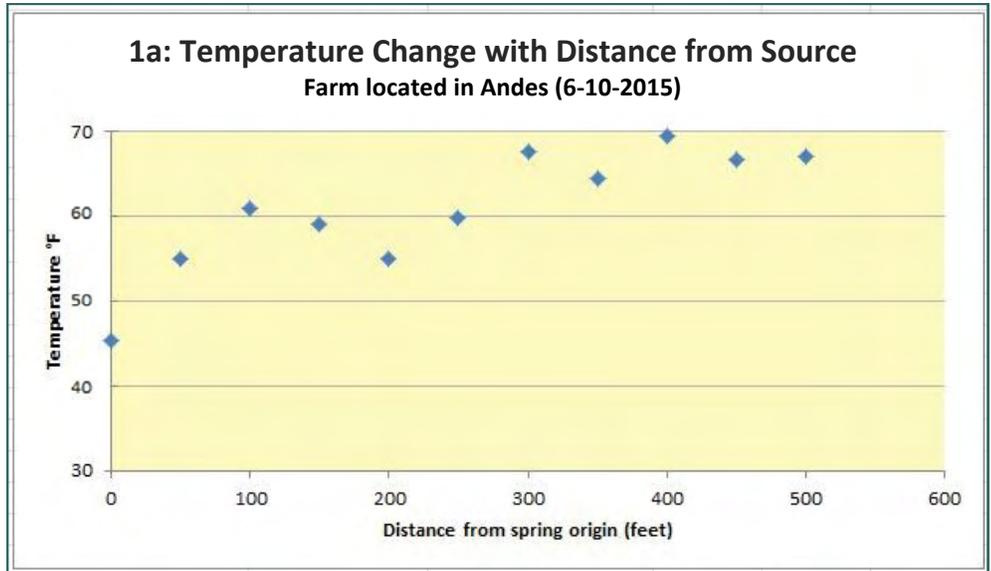
Funding provided by the DCSWCD and Watershed Agricultural Council

WATER TEMPERATURE

Groundwater temperatures in 63 wells and 44 springs in Delaware County were found to range from 32° to 60° F with a reported mean of 45° F (Soren, 1963, recorded in late fall and winter months of 1949); Perlmutter and others (1957) reported a range of 46° to 48° F. More recent studies of 55 springs have found a mean of 48.8° F and a median of 49° F, when the most common sampling dates were in late June (unpublished data, Delaware County SWCD). Spring discharge temperatures tend to vary seasonally, a few degrees lower than average in late winter through mid-spring months and higher in late summer through early fall, due to the influence of soil temperature variations on these shallow groundwater sources. The most reliable springs tend to maintain more even temperatures throughout the year while temperatures of more ephemeral springs fluctuate across the full reported range of 32° to 60° F (unpublished data, DCSWCD).

Spring discharge temperatures described above refer to measurements taken at the origins of flow that are at the highest elevation to which a spring source can be traced, often issuing from a slight depression in the landscape. During the growing season, roughly late April through early October, spring discharge has been found to be coldest at its point of origin. As discharge travels downslope in a fairly well defined flow path, known locally as a spring run, its temperature tends to rise with distance from its origin (**figures 1a-c**) until some maximum is reached (unpublished data, DCSWCD). Supplemental small seeps along spring runs can drop temperatures a few degrees for some distance, the water warming again with continued flow distance downslope.

Figures 1a-c: Rising temperatures of spring discharge (as overland flow) with increasing distance from point of origin, from three sites in Delaware County.



MEASUREMENT LOCATIONS

Figures 2a-c show typical temperature measurement locations and methods as used in evaluating springs for potential development and for this study. This pattern of heat gain with distance from point of origin appears common to all local springs that have significant overland flow before merging into wetlands or surface waters. (Although not confirmed with measurements, in cold winter months the latent heat of discharged groundwater would likely be lost with distance from a spring's origin, rather than gained as during summer.)



Figure 2a: Temperature measurement at native spring source, which tends to originate from base of a boulder, bedrock ledge or tree. Digital thermometer was calibrated and has reported precision to ± 0.1 degree F.



Figure 2b: Measurements were recorded within spring run after pacing roughly 25-ft intervals from point of origin to lowest available point of flow.

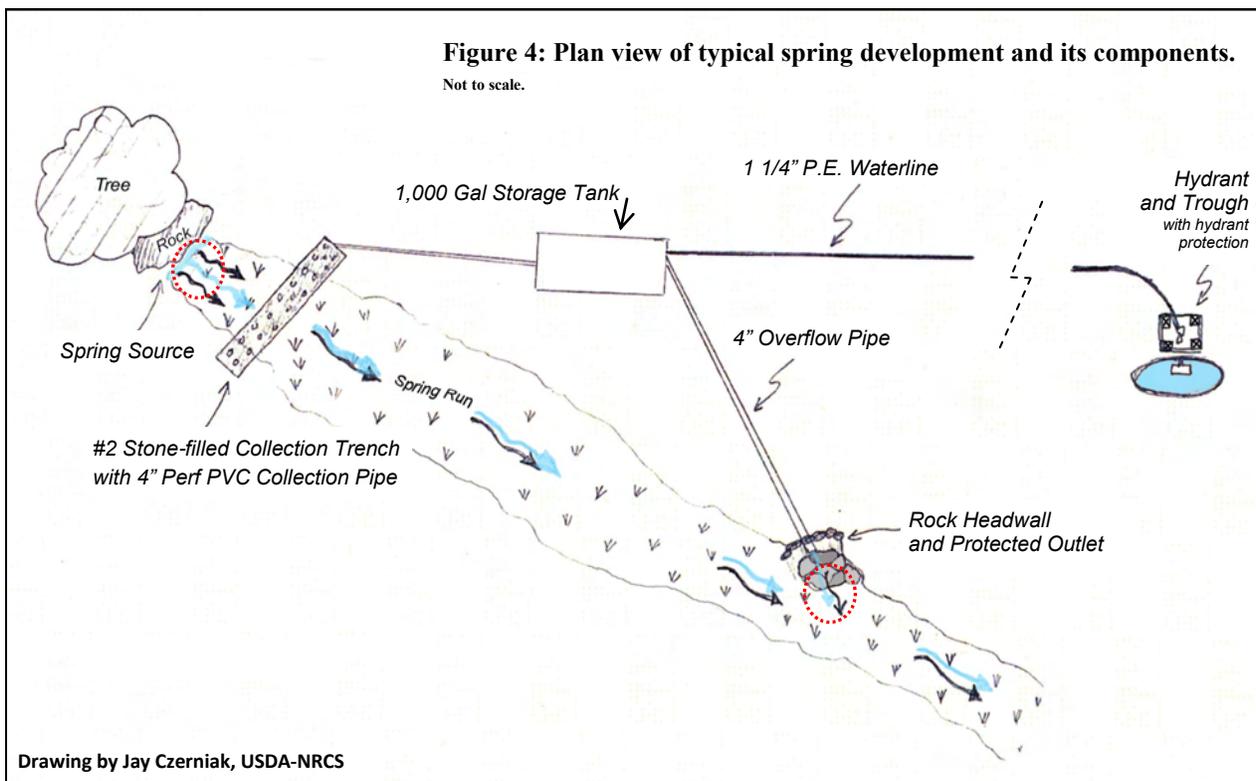
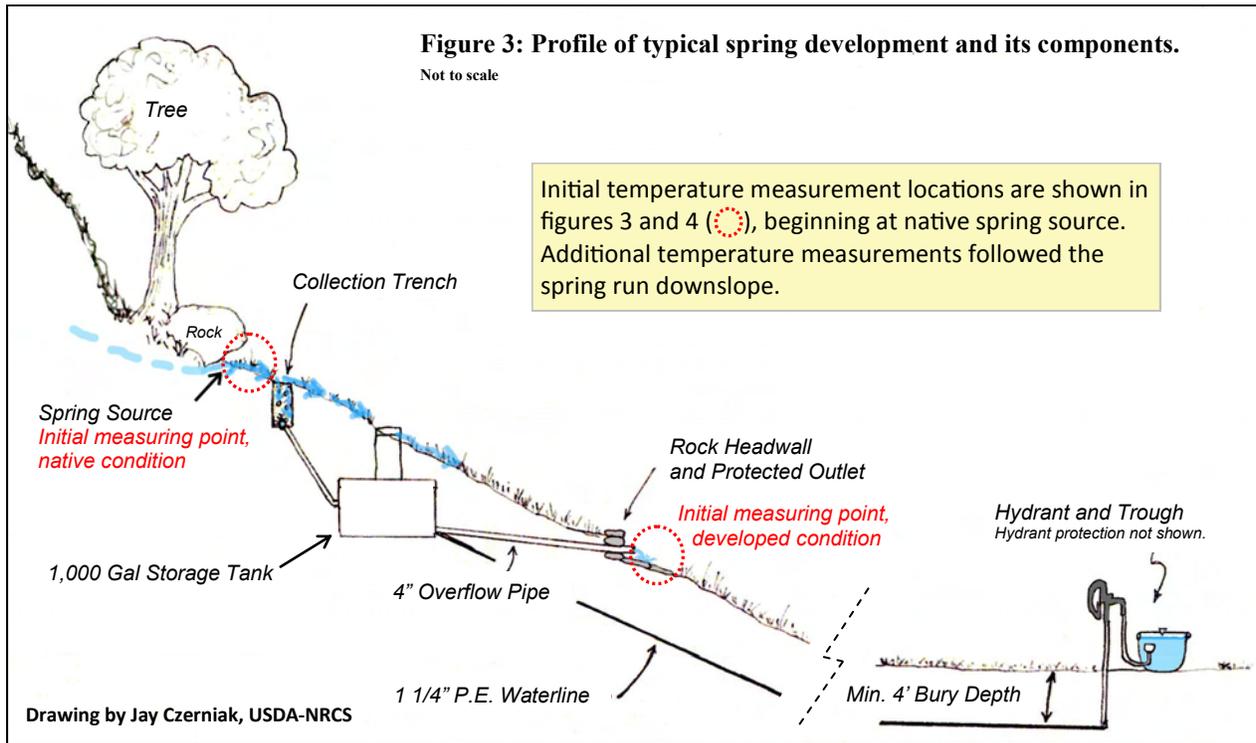


Figure 2c: Outflow from hydrant represents the lowest sampling point in spring development system.

Photos by L. Underwood

SPRING DEVELOPMENTS—DESIGN

Existing springs and their runs have long been useful drinking water sources for pastured livestock, especially if they are reliable during both wet and dry times of the year. Various methods and materials have been used to capture, store and redirect spring discharge to livestock watering locations by gravity alone. A typical design used by the DCSWCD, USDA-NRCS and NY City Watershed Agricultural Program is shown in **figures 3 and 4**. The typical primary components start with one or more 10 ft-long gravel-filled trenches that contain a perforated 4-inch PVC plastic collection pipe installed close to the spring discharge point of origin. This trench collects a portion of discharge that is then directed through solid-wall PVC plastic pipe to a buried, 1000-gallon, pre-cast concrete storage tank.



SPRING DEVELOPMENTS—STORAGE TANK

The storage tank usually has one inlet as described above and two outlets, all below ground to protect water from freezing and from contamination by surface runoff. As detailed in **figure 5**, at the tank's maximum design fill elevation, a standpipe directs any excess inflow towards an overflow outlet that also serves as a tank cleanout and may include a manually operated valve; this flow is conveyed through PVC pipe to a day-lighted outlet downslope where it rejoins the spring run. Stored spring water enters the inlet end of the out-bound supply pipeline through a section of perforated inlet pipe that sits ± 8 inches off the floor of the storage tank. After passing through the wall of the tank, pipe diameter is reduced down to 1½" black polyethylene supply pipe, usually buried below 4 feet deep for frost protection, which continues on for hundreds or thousands of feet to the livestock watering facility(s).

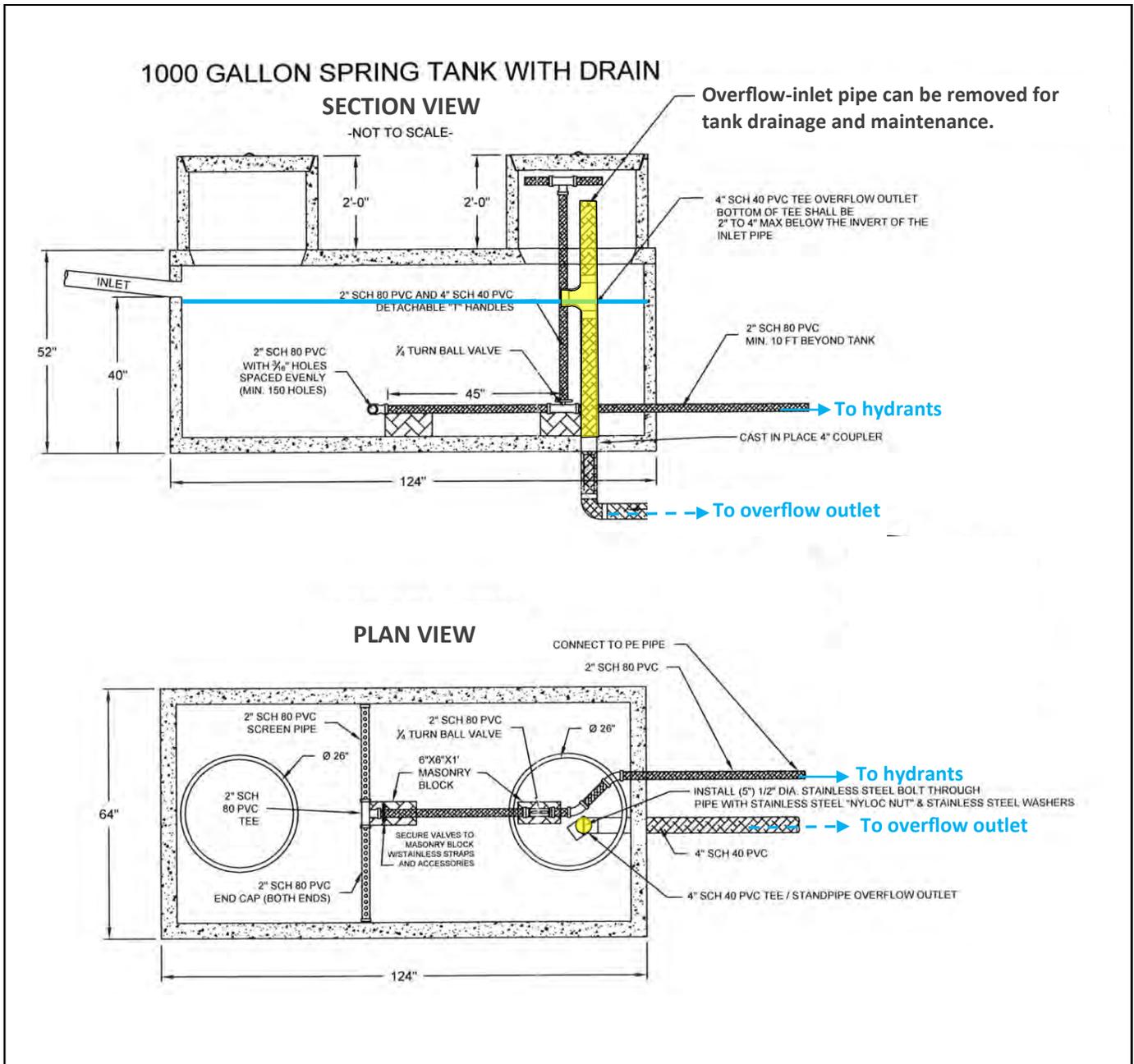


Figure 5: Holding tank and its components.

WATERING FACILITIES

Each livestock watering facility has a frost-free hydrant and hose that fills a watering trough made of either concrete or plastic. Each trough has a float mechanism that shuts off flow when the tank reaches its design depth, so as to not drain the spring development’s storage tank faster than it can be refilled. Watering facilities are located well away from surface waters, on a dry knoll if available, and the ground surface around the troughs is hardened with a gravel pad to minimize soil disturbance by animal hoof shear, subsequent surface erosion and to allow accumulated manure to be cleaned (figure 6).

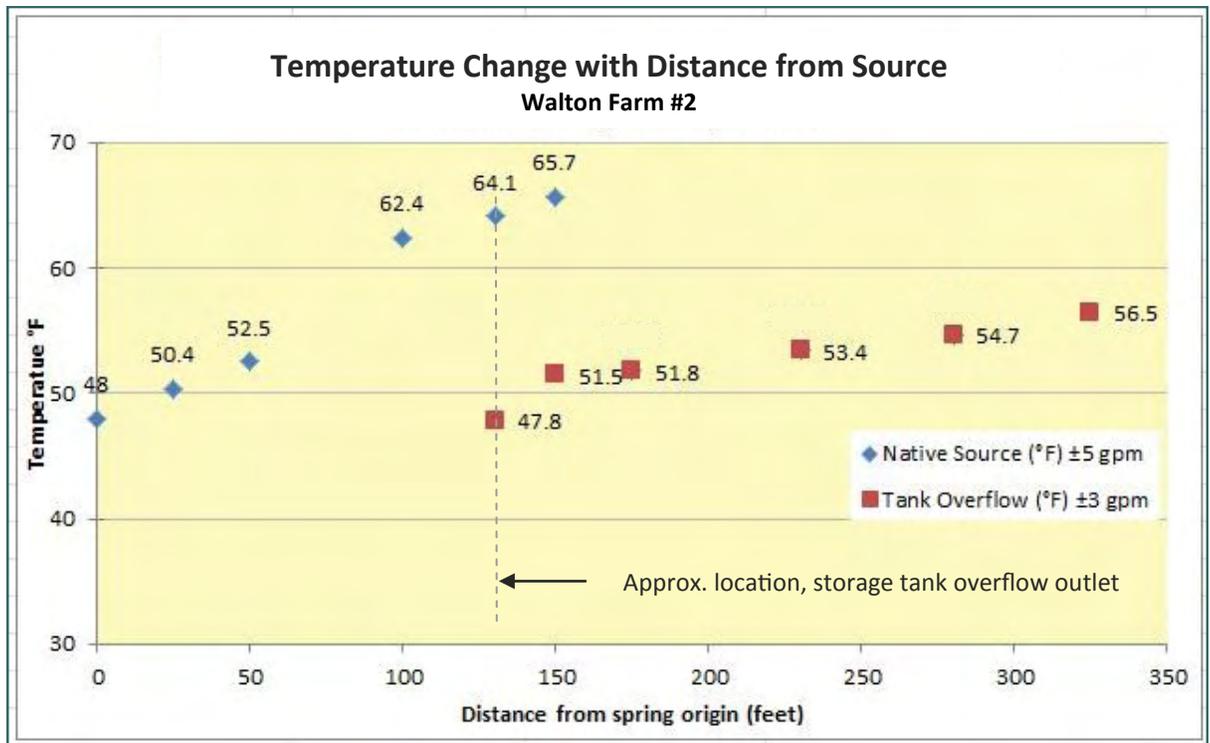


Photo by K. Buel

Figure 6: Watering facility with concrete trough installed adjacent to fencing that excludes livestock from the stream corridor.

It should be noted that water standing in the water trough may become quite warm by contact with air and direct sunlight, but it enters the tank cold as it is kept 4+ feet below ground until it reaches its point of consumption by livestock. The pipeline and other spring development components maintain spring discharge at the reduced temperatures associated with shallow groundwater for extended distances from the spring’s point of origin, farther than it would otherwise be under natural spring run conditions. This effect is described in terms of temperature in figure 7, which compares temperature increase with distance from spring source as the spring run and tank overflow occur under both native and developed conditions. Note that the temperature recorded at the point where tank overflow is returned to its native spring run, 125 feet from its origin, is 16.3 degrees colder than native surface flows at the same distance, the effect continuing downslope to the water trough inlet. Other spring developments have shown temperature patterns similar to this, although spring runs don’t always have sections where native flow and spring development outflow occur parallel to one another as shown here. Figure 8 shows combined data from all five sites sampled in this study, three of which were developed.

Figure 7: Temperature readings from native spring run and from tank overflow downslope, 6-18-2015.



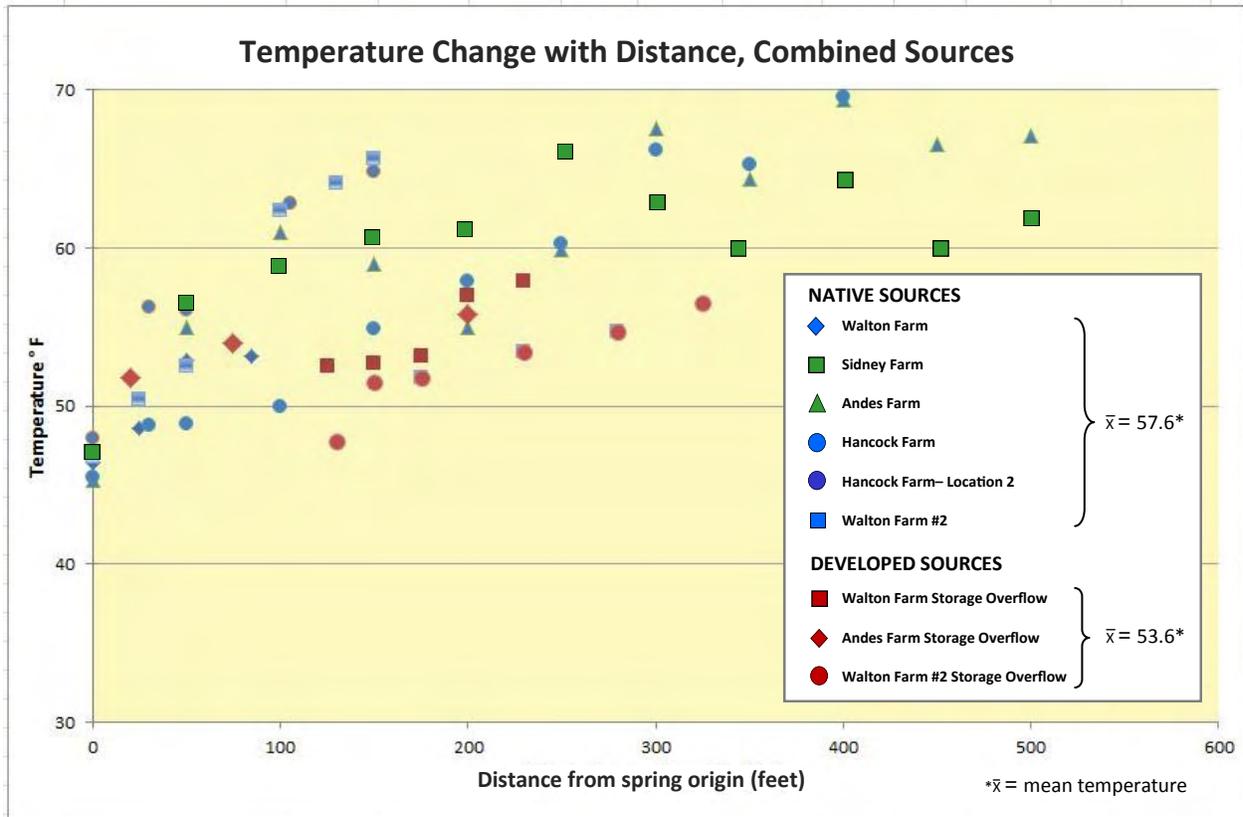


Figure 8: Combined data from six spring sites sampled during 2015. Note that storage tank overflow temperatures tend to be colder than native flows due to subsurface storage of spring discharge.

WATER USAGE

How much water might a spring development produce, and what portion of this might livestock consume? A typical Delaware County spring development that captures two gallons per minute of flow will produce 120 gallons per hour or **2880 gallons** per day.

A typical livestock farm on which a spring might be developed would be a cow-calf beef operation, where calves are produced, grown and sold from a permanent herd of mature animals. Recent Delaware County farm data (M. Kiraly, CCE of Delaware County, 2017, personal communication) finds the present average beef herd size is 34.5 animal units, one animal unit being 1,000 pounds of live-animal weight.

A cow-calf pair could be considered to have an average combined weight of 1600 lbs. and would likely consume about 15 gallons of water per day. Since 34.5 animal units is equivalent to 22 cow-calf pairs weighing 1600 lbs. per pair, they would then consume 22×15 gallons per day = **330 gallons** per day total, or slightly more than 11 percent of the spring's daily discharge. So, during the usual 6-month growing season when livestock are pastured, the major portion of spring discharge continues to flow directly through the overflowing storage tank and re-enters its native spring run.

SUMMARY

As demonstrated here, spring developments effectively extend the relatively low temperatures of groundwater to lower portions of hillsides where cattle graze and require drinking water. Because modern spring developments transport a minor portion of spring flows to a terminal point of consumption with no further runoff, they do not and physically cannot contribute to thermal stress of surface waters. Indeed, the information provided above and years of field experience by conservation technicians corroborate that the subsurface storage and delivery components of spring developments maintain cool water temperatures until reaching the point of consumption downslope.

* Means (\bar{x}) are statistically significant at $p < 0.01$ level. That is, there is less than 1% probability that the 4°F difference between the means is due to chance.

RIPARIAN BUFFERS

If one considers the universal goal of reducing pollution to surface waters from livestock operations, the true value of spring developments lies in their being an alternative water source for pastured animals. This is an important method since by giving animals an off-stream water source, livestock can be physically excluded (by fencing) from surface waters, thus keeping their manure, enteric pathogens and sediment from animal-induced streambank erosion out of streams, spring runs and other hydrologically sensitive areas. The benefits associated with riparian buffers, especially where forested, far outweigh the thermal benefits described above — to the point that they “represent the best management practice for protecting aquatic ecosystems from outside pollution by filtering out nutrients, sediments and toxic contaminants before they get to the stream.” (Stroud Water Research Center, 2016).

Using state and federal assistance through the USDA-Natural Resources Conservation Service and the USDA-Farm Service Agency, Watershed Agricultural Council, and New York State’s Agricultural Non-Point Source Grant Program, Delaware County has become a statewide leader in riparian forest buffer implementation. Riparian buffers are considered an important management practice toward meeting total maximum daily load (TMDL) goals set by the US Environmental Protection Agency, which New York State must meet to help improve water quality in the Chesapeake Bay. By prioritizing the implementation of riparian forest buffers, the DCSWCD considers spring developments an important tool that helps Delaware County meet its local water quality objectives as well as those of the Susquehanna River watershed TMDL in New York State.

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