Connecting Academy Expertise to Community Need to Maximize the Use of a Former Community Golf Course with a Focus on Flood Storage Potential

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Introduction

Public golf course closures have exceeded openings since 2006 (Figure 1). Because of their extent, green cover, and location in proximity to urban areas, course closures create an opportunity to reevaluate the ecohydrological services they provide. A recently-closed municipal course, the former Snyder Park Golf Course (SPGS), in Springfield, OH, at the confluence of two streams, Mad River and its tributary Buck Creek, provides a case in point (Figure 2). The former course, opened in 1920, was designed using extant floodplain and channel features preserved following channelization and levee construction on Mad River and Buck Creek in response to the historic 1913 flood. Two 30-in culverts historically provided an outlet to Mad River for a tile, pond, and channel system designed to drain standing water from the golf course. Following closure, flapper gates on Mad River were inactivated, reversing flow and hydrologically reconnecting the river to its floodplain under flood conditions. In this study, we estimated the volume of stormflow stored on the former SPGS using estimated culvert flow and the extent of flooding.

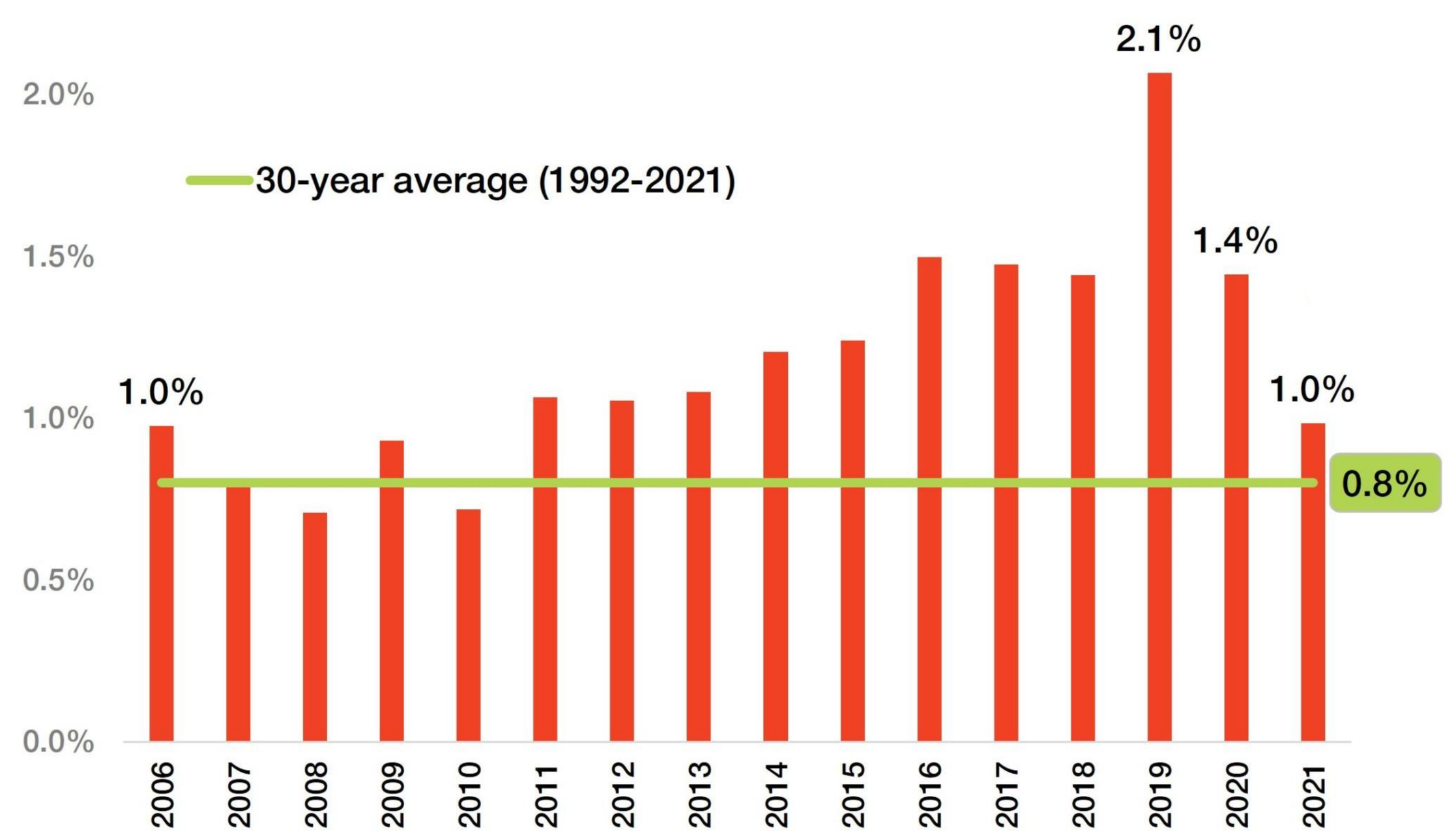
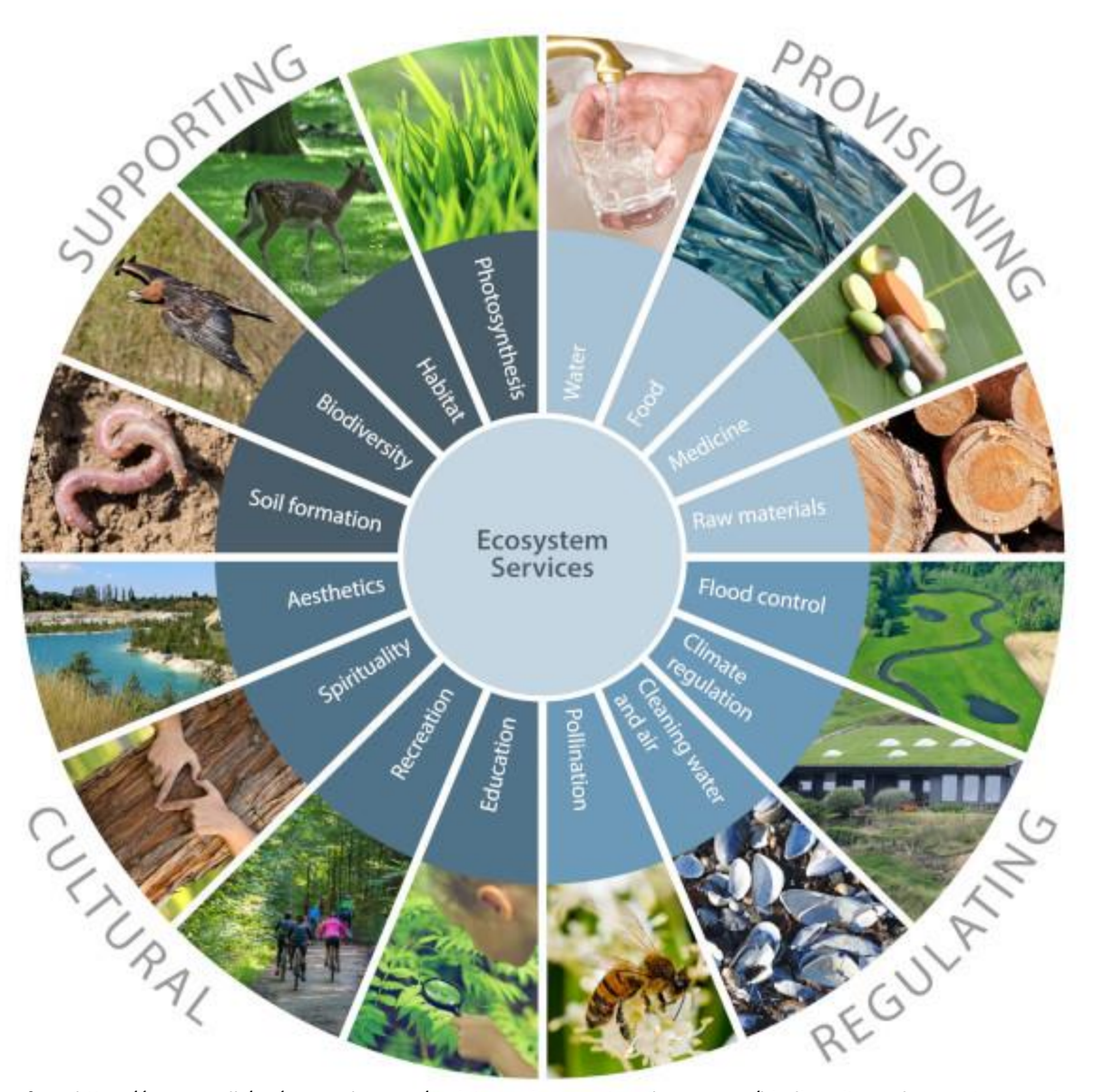


Figure 1. Annual U.S. golf course closures have exceeded new course openings since 2006, averaging 0.8 % of total supply, in 18-hole equivalents, over the last 30 years (modified from National Golf Foundation, https://www.ngf.org/course-closures-continued-to-decline-in-2021/). Closed golf courses are mostly repurposed for residential and commercial real estate but some are converted for agricultural or recreational uses.



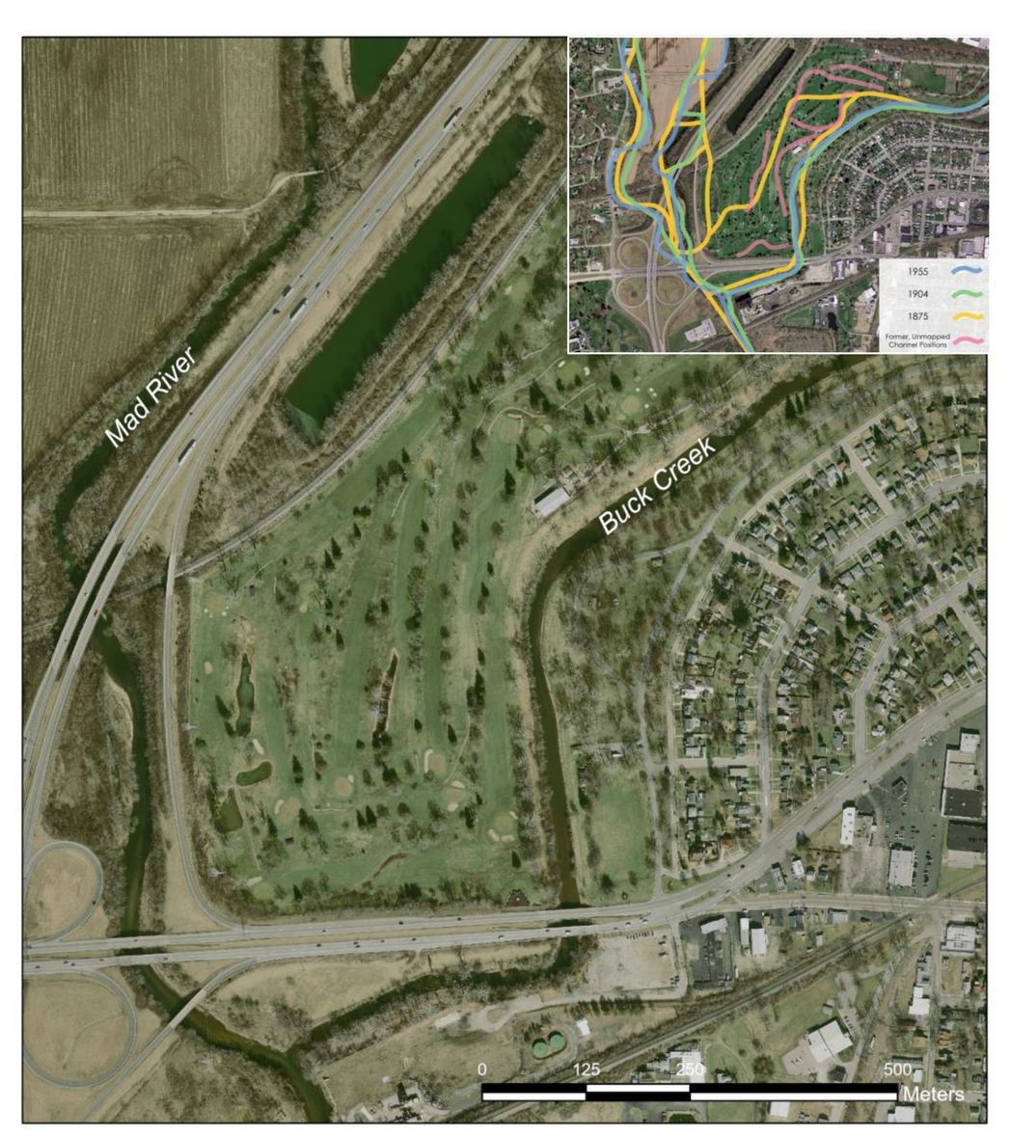


Figure 2. SPGC was an 18-hole golf course covering 88 acres at the confluence of Buck Creek and Mad River. It is mapped as the Westland soil series, a hydric soil that formed under conditions of saturation from flooding or ponding. Elevation of the property decreases towards the confluence. Following closure in 2014, the higher elevations were developed into community gardens, but the lower elevations, with periodic flooding, were left fallow. The inset shows former positions of Buck Creek and Mad River based on old maps and current topography. Geology and environmental science students and faculty have worked in partnership with National Trail Parks and Recreation district to better understand the ecosystem services this area could provide the Springfield community and its natural environment.

Figure 3. Because the lower elevations of the former SPGC frequently flood, most of our study has focused on surface and ground water, the frequency and duration of flooding, and the flood storage capacity of the area. The extent of flooding from Mad River for two flood events examined in this study are illustrated, inundating 13 and 17 ac, respectively. Flooding occurs when the Mad River is at a stage higher than the elevation of the course such that it back floods through culverts that had traditionally been used to drain the former golf course.

Flood Storage Potential

Figure 4. Flooding in March 2020 covered approximately 18 ac of the former SPGC. Buck Creek is separated from the course by a levee. Though flooding occurs when Buck Creek is high because of permeable sand and gravel outwash underlying the levee, extensive flooding such as shown here occurs through two 30-inch conduits connecting SPGC to the Mad River. During exceptionally high flow, flooding extends further onto the former SPCG along abandoned channels of Buck Creek from the time of channelization (inset).

Figure 5. a) Flap gates on the Mad River side limited flow from Mad River during floods while allowing for drainage of flow from the golf course. The culverts are submerged during the flow event shown. The inset shows the housing for one of the leveloggers during low flow. With the flap gates open, the Mad River is essentially hydrologically reconnected to its former floodplain. b) Submerged culverts on the former SPGC side would have drained the course during operation but now allow flow onto the course. A second levelogger on the SPGC side is used to measure the difference in head between Mad River and the course.

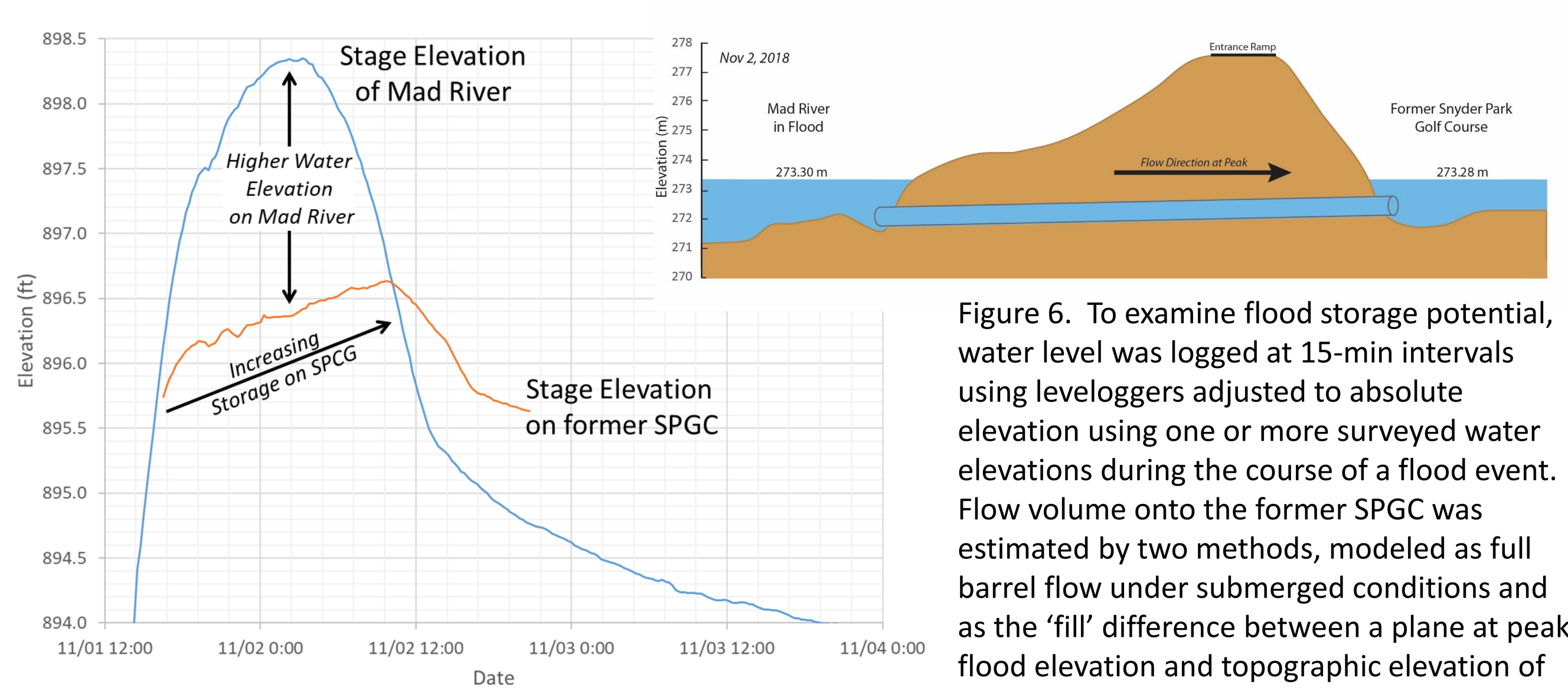


Figure 6. To examine flood storage potential, water level was logged at 15-min intervals using leveloggers adjusted to absolute elevation using one or more surveyed water elevations during the course of a flood event. Flow volume onto the former SPGC was estimated by two methods, modeled as full barrel flow under submerged conditions and as the 'fill' difference between a plane at peak flood elevation and topographic elevation of the course using GIS.

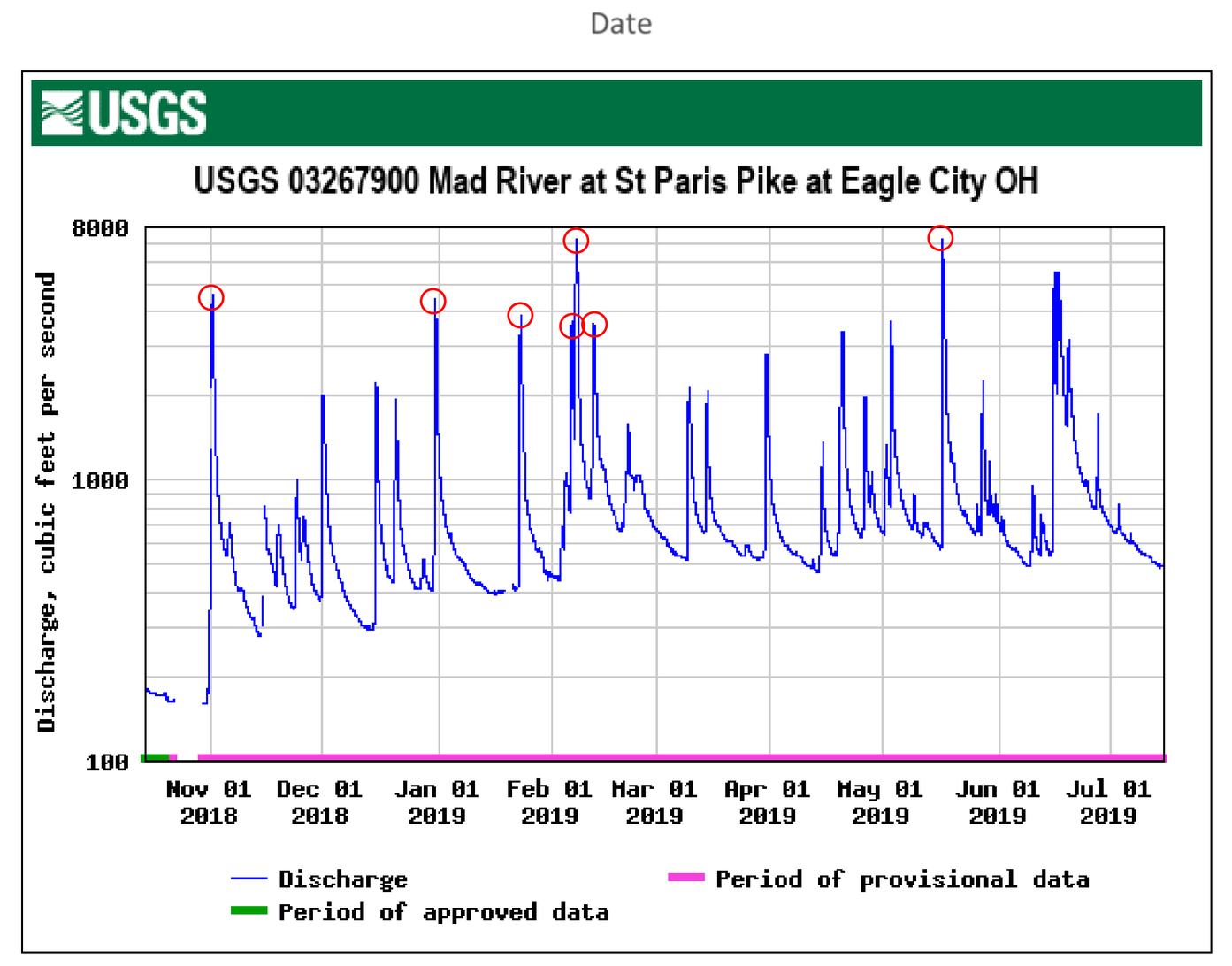


Figure 7. From November, 2018, through June, 2019, 11 stormflow events occurred on Mad River at St. Paris Pike with peak discharges in excess of 3000 ft³/s, the approximate flow magnitude necessary for the culverts connecting Mad River to the former SPGC to backflow onto the course. Seven events, two of which exceeded floods with a return period of more than 5 years, were selected for study of flood storage potential.

Table 1. Flood flow volumes from seven flood events in 2018-2019 was modeled using culvert flow and GIS models. Based on culvert flow modeling, 1.3-3.6M ft^3 of stormflow from Mad River is stored on the former SPGC. This represents storage of 0.4 to 2.1 percent of stormflow for the respective events and, relative to peak discharges, storage of 5.0 to 8.4 minutes of peak flow.

					Estimated Volume Stored (ft^3)	
Date	Peak Discharge[1] (ft^3/s)	Peak Storage[2] (min)	Total Stormflow[3] (ft^3)	% of Stormflow Stored	Culvert Flow Model[4]	GIS[5]
Nov 1-2, 2018	4610	7.5	345,455,712	0.6	2,094,271	1,760,202
Dec 31, 2018 – Jan 1, 2019	4450	5.0	362,755,584	0.4	1,341,695	n.m.[6]
Jan 23-24, 2019	3930	5.7	65,167,200	2.1	1,356,046	n.m.
Feb 6-7, 2018	3700	5.9	--	--	1,310,543	n.m.
Feb 7-8, 2019	7300	7.5	727,200,288	0.5	3,292,912	3,656,367
Feb 12-13, 2019	3660	6.5	307,584,000	0.5	1,489,969	n.m.
May 17, 2019	7240	8.4	461,116,800	0.8	3,653,126	3,659,427

Notes:
1. Values and calculations are based on the USGS gage on Mad River at St Paris Pike at Eagle City OH (03267900).
2. The time, in minutes, of the hydrograph for which flood water would have been stored at peak flood, is based on the nomograph estimate of total volume stored.
3. The duration over which the peak flood is stored. The area under the hydrograph curve in Figure 7 represents the volume of flood stored.
4. Total stormflow calculations are based on hydrograph separation using Web-based Hydrograph Analysis Tool (WHAT): https://engineering.purdue.edu/mapserve/WHAT/.
5. Total stored stormflow through two 30-in culverts calculated based on full barrel flow with a submerged flow condition (Schall and others, 2012).
5. Calculated using the Cut Fill tool in ArcMap, based on the volume difference between current topography and observed high-water levels surveyed on the former Snyder Park Golf Course. High-water levels were not observed for all events. They are marked n.m. – not measured.

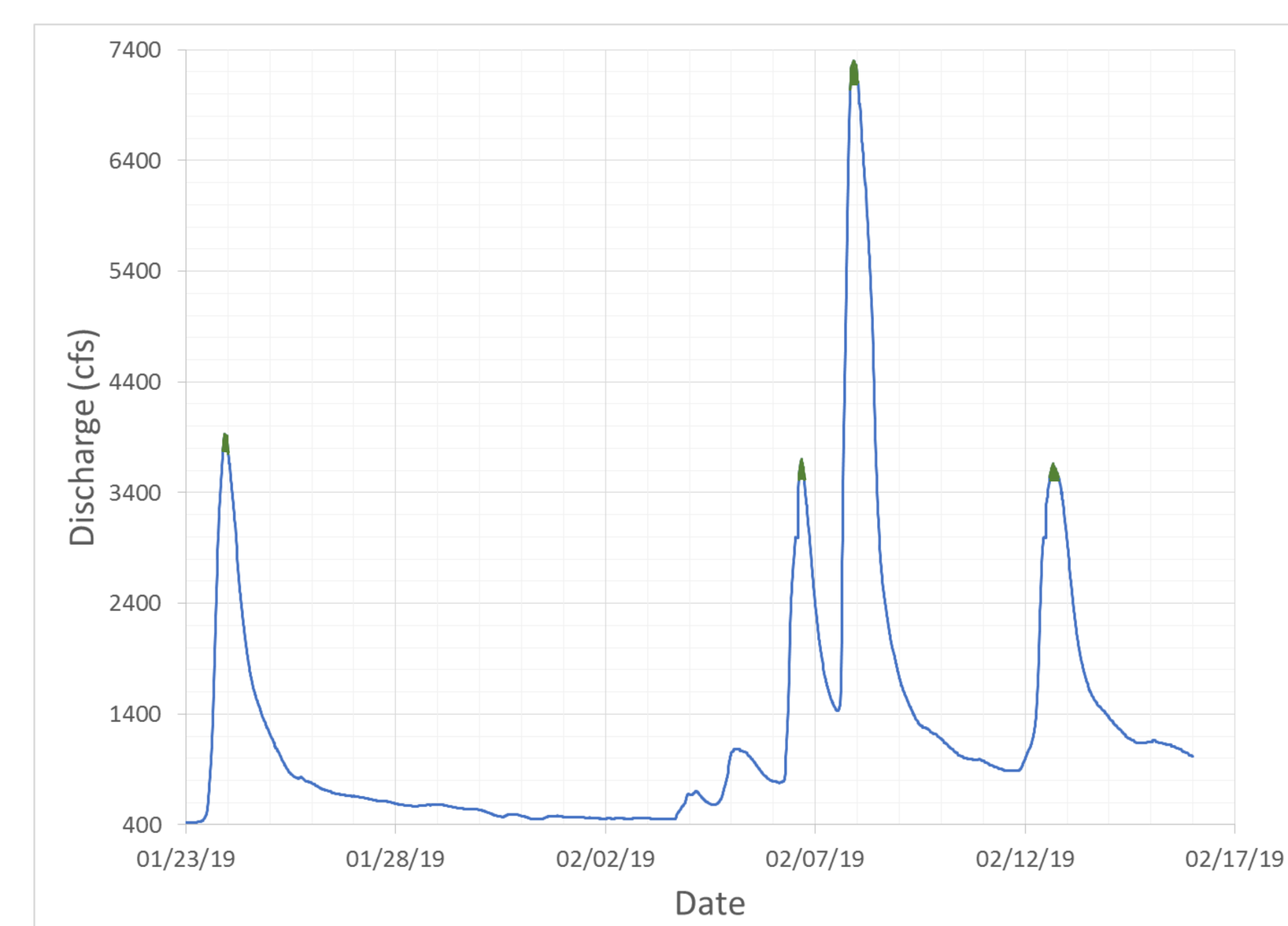


Figure 8. One method to illustrate the storage potential of the former SPGC is to graphically plot the stored volume as a proportion of total streamflow as the "area under the hydrograph curve," which represents volume (i.e., from the hydrograph, volume/time * time = volume). By equating the storage volume to an area under the curve, an alternative sense of the magnitude of storage is provided. Four stormflow events are illustrated in this way with the green area graphically equivalent to the stored volume for each.

Hydrogeology

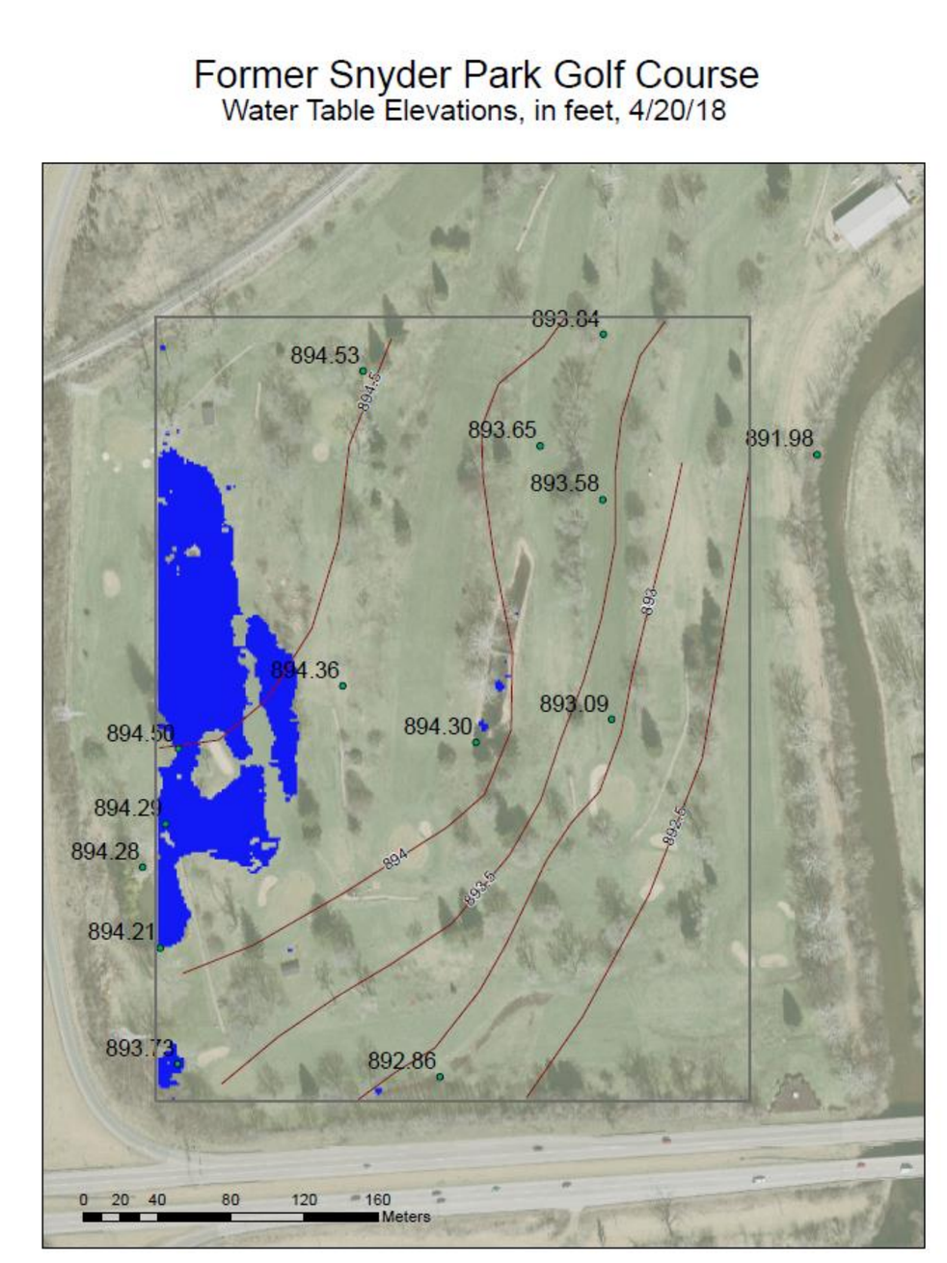


Figure 9. The former SPGC is above a buried valley aquifer composed of sand and gravel outwash. Monitoring wells and natural observation points were used to monitor ground water levels. Depending on season and stream stages, ground water flow is to the south- southeast. In April 2018, with some standing water, flow is to the southeast. Depth to ground water varied from 0-34 inches at the monitoring sites on the same date.

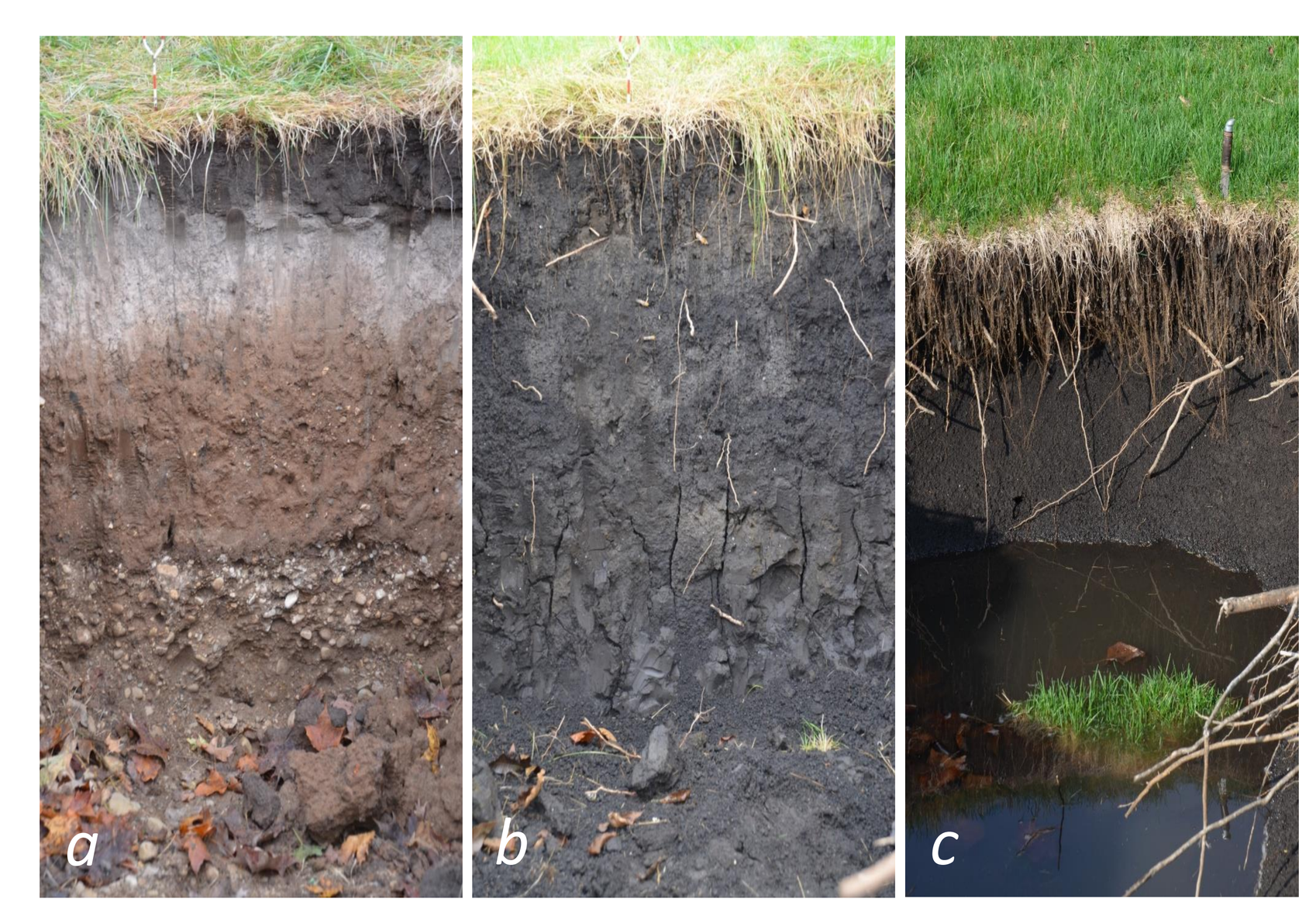


Figure 10. Two soils are present on the former SPGC, (a) Eldean and (b) Westland soil series. The Westland is classified as a hydric soil in Ohio and comprises more than 98 percent of the former course. The sand and gravel that form the parent material for the Eldean (a) underlie the entire area and form a highly-productive buried valley aquifer. (c) Because of the high hydraulic conductivity of the sand and gravel, while lower elevations of Westland soils are inundated, the water table in dry areas rises nearer the surface on Westland soils at higher elevations. Excavation of the upper part of the Westland soil would enhance storage potential and, in lower areas, restore it to its natural condition as a riparian wetland.

Planned Future Use

Current ecosystem services provided by the former SPGC clearly include flood control, a regulating service. Other regulating services, including carbon, sediment, and nutrient storage, and supporting services like soil formation and habitat, are also provided. Though it may only be the tip of the hydrograph (i.e., Figure 8), stormflow and the sediment, carbon, and nutrients it carries are stored more locally than would be otherwise. Supporting services, including habitat and biodiversity, and cultural services, including stewardship, recreation, and particularly education abound at this site. Maintaining or augmenting these services was a high priority for National Trails Parks and Recreation District.

Figure 11. Data was provided to, and field visits were made with, EMH&T, a planning and landscape architecture firm hired by National Trail Parks and Recreation District to create a conceptual plan for the SPGC. EMH&T created the conceptual plan shown here with walking trails and wildlife observation decks in different land covers including woodland, prairie, wet meadow, and pond.

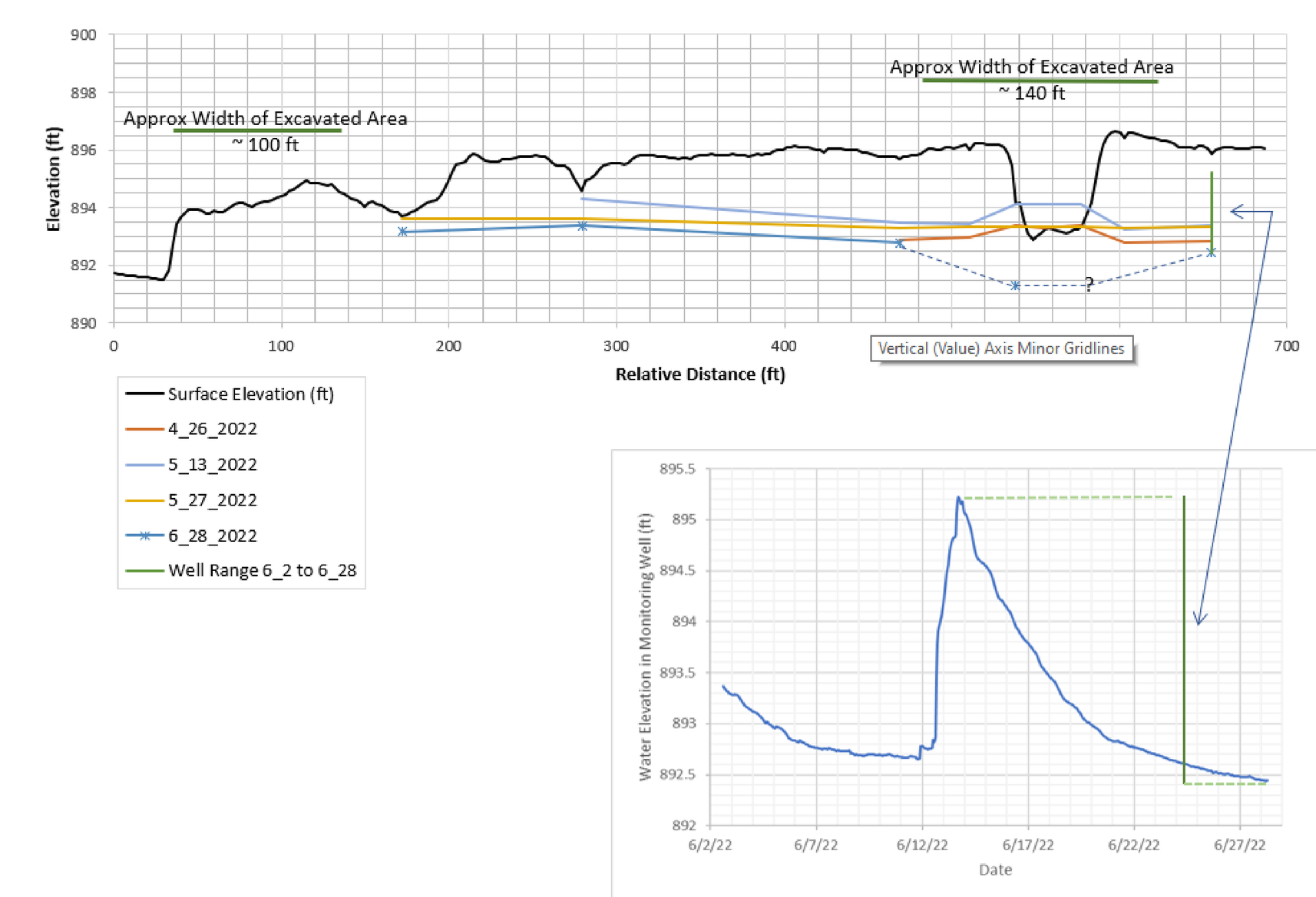


Figure 12. Implementing the conceptual plan created by EMH&T, particularly depths of excavation in the areas of planned wet meadow, required additional monitoring of ground water conditions. Successful wet meadows require saturated root zones through a significant duration of the growing season. Monitoring wells, some instrumented with leveloggers, were installed to assess changes in the water table through the spring and summer of 2022. The depth to the water table varied depeding on precipitation and flooding. The continuous hydrograph shows the range and duration of ground water elevation during a flood event.

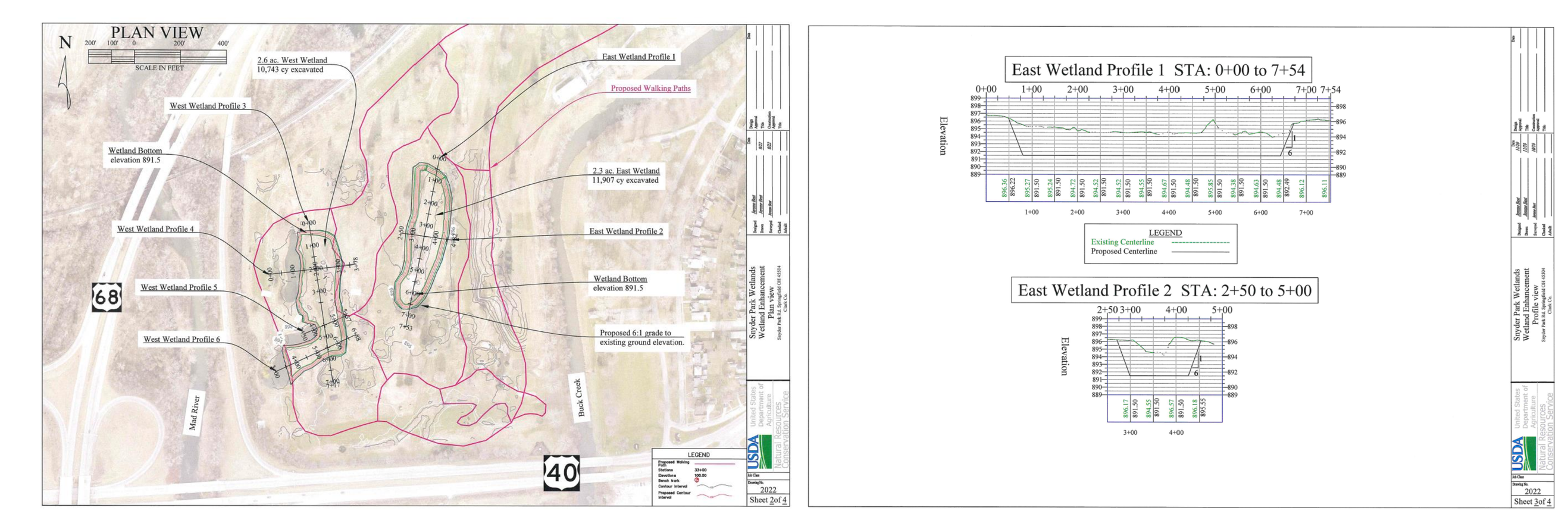
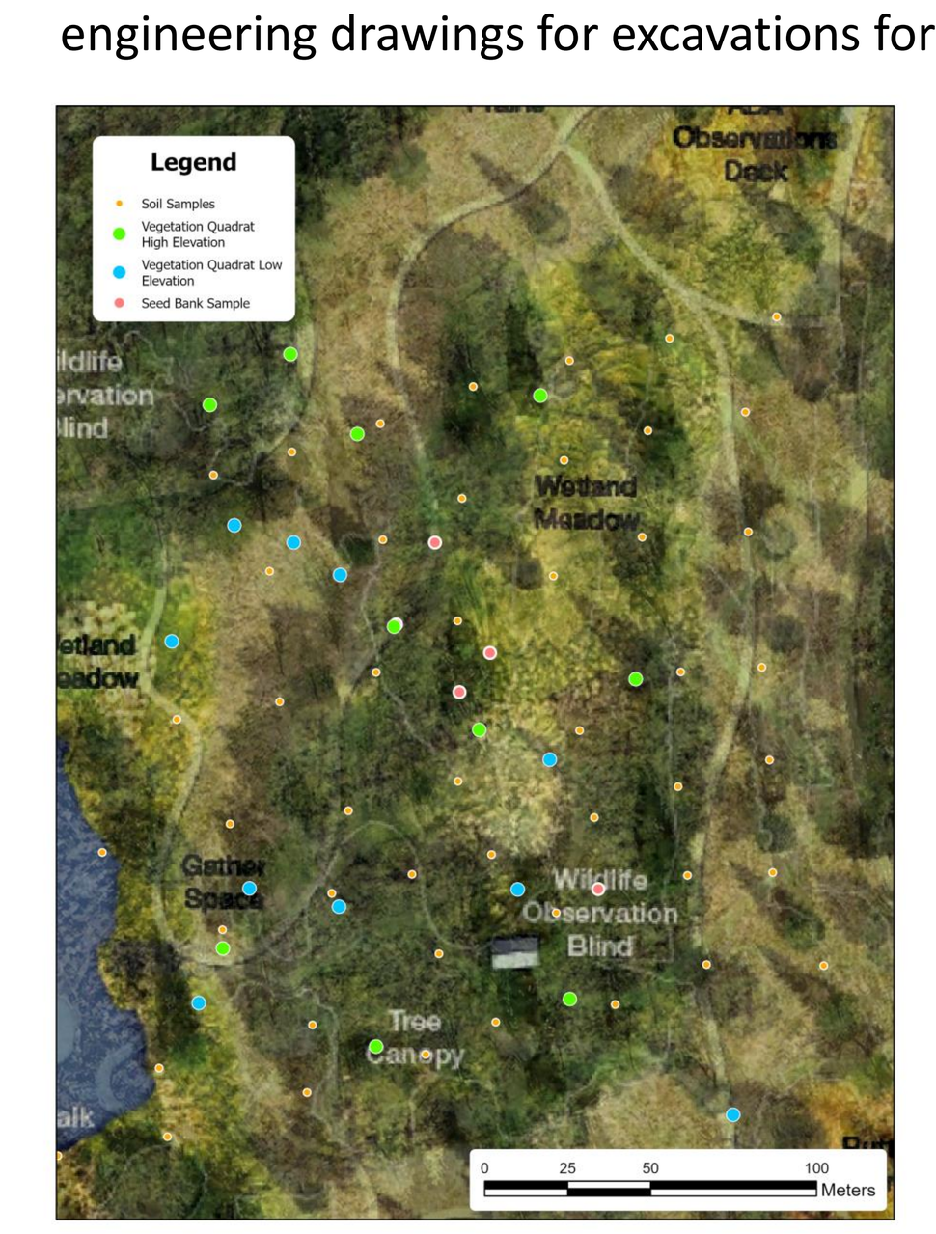


Figure 12. Based on depth to ground water, data on the depth and extent of excavations for the wet meadow and combined ponds were provided to the Clark Soil and Water Conservation District. The Distric has experience with and design authority for ponds and waterways in the county as well as connections to contractors who could complete the work. Staff at the Clark Soil and Water Conservation District completed engineering drawings for excavations for the site.



Current Status

The former SPGC is currently being prepared for excavation and re-planting. Current ground vegetation will be burned this fall and new growth in the spring will be cleared with herbicide. The timing of excavation will depend on rainfall and flooding next spring and summer so that saturated soil is not an issue. To promote flood storage, a channel will be constructed from the culverts to an adjacent pond and a former channel of Buck Creek. Former drainage on the course will be maintained during excavation to deliver water to the central wet meadow.

Figure 13. In preparation of the changes to SPGC in order to assess the benefit of restoration, soil, vegetation, and natural seed bank in the wet meadow area were sampled or analyzed in summer 2022. This information in addition to continued hydrologic and hydrogeologic measurements will insure that the site will be used for educational purposes in the future.