

2013 Investigation of Flint Ridge Cave Surface Catchment

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Abstract

In 2013 several reasons arose to justify re-examination of the surface catchment for Flint Ridge Cave in southwest Austin. The recent availability of the 2013 LIDAR aerial data allows a high-resolution examination of surface topography. On October 12, 2013, a major rain event left well-defined flood debris drift lines. Surface drainage paths were clearly defined using these drift lines. Verification and refinement of the surface catchment are timely since the Texas Department of Transportation is preparing for construction of State Highway 45 Southwest adjacent to Flint Ridge Cave. On October 15, 2013, a field examination of Flint Ridge Cave sinkhole and its surface catchment to the west was conducted by Watershed Protection Department hydrogeologists Scott Hiers, David Johns, and Nico Hauwert. The 2013 investigation found the Flint Ridge Cave surface catchment to be about 250 feet wider than interpreted by Hauwert (2009) under the proposed SH45 SW right-of-way (ROW) closest to the cave entrance. However, the surface catchment area shown by Hauwert (2009) to extend west of SH45 SW appears to primarily flow through a drainage channel to Bear Creek, although it may flow to Flint Ridge under some flood conditions. On the north and east sides the 2013 interpretation follows the Hauwert (2009) interpretation closely. This effort did not investigate the subsurface catchment area for the cave.

Introduction

The surface catchment of a cave is the land surface that directs runoff to the cave entrance. The subsurface catchment area is the land surface area that provides water to cave drips and cave streams through infiltration of rainfall and runoff into the subsurface. Defining the subsurface catchment area to Flint Ridge Cave requires tracing and extensive effort beyond the scope of this surface catchment delineation. The subsurface catchment area is assumed to include the cave footprint, but can potentially extend thousands of feet beyond, depending on the flow rate, location, and characteristics of cave drips or cave stream, as well as factors such as geologic characteristics and local strata dip (Hauwert and Cowan 2013).

The surface catchment for Flint Ridge Cave has been described several times over the past 23 years (Table 1). It was first described as a 0.75 acre area in an Environmental Impact Statement by Texas Department of Transportation in 1989 (Figure 1). The surface catchment was interpreted to be contained entirely within the sinkhole rim. In 2000, George Veni & Associates mapped a surface catchment area of 37 acres (Figure 1). Hauwert (2009) used field-collected global positioning system (GPS) points of observed catchment divides and drainages, rain event observations, and professionally surveyed topography to define a surface catchment area of 69 acres (Figures 1 and 2). The current investigation performed by the City of Austin Watershed Protection Department (WPD) utilized LIDAR topographic data and ground observations of debris patterns to refine the cave surface catchment area.

Table 1. Summary of Surface Catchment Interpretations for Flint Ridge Cave. WPD reflects results from the recent investigation described by this report.

Area	Area		Source
	(square feet)	(acres)	
Total Surface Catchment	32,700	0.75	TxDOT (1989)
Total Surface Catchment	1,629,264	37.4	Veni (2000)
Total Surface Catchment	3,026,364	69.5	Hauwert (2009)
Primary Surface Catchment	2,519,600	57.8	WPD (2013)
Potential Surface Catchment	575,918	13.2	WPD (2013)
Unverified Potential Surface Catchment	64,890	1.5	WPD (2013)

Figure 1. 2013 Investigation Summary for Flint Ridge Cave Surface Catchment Area

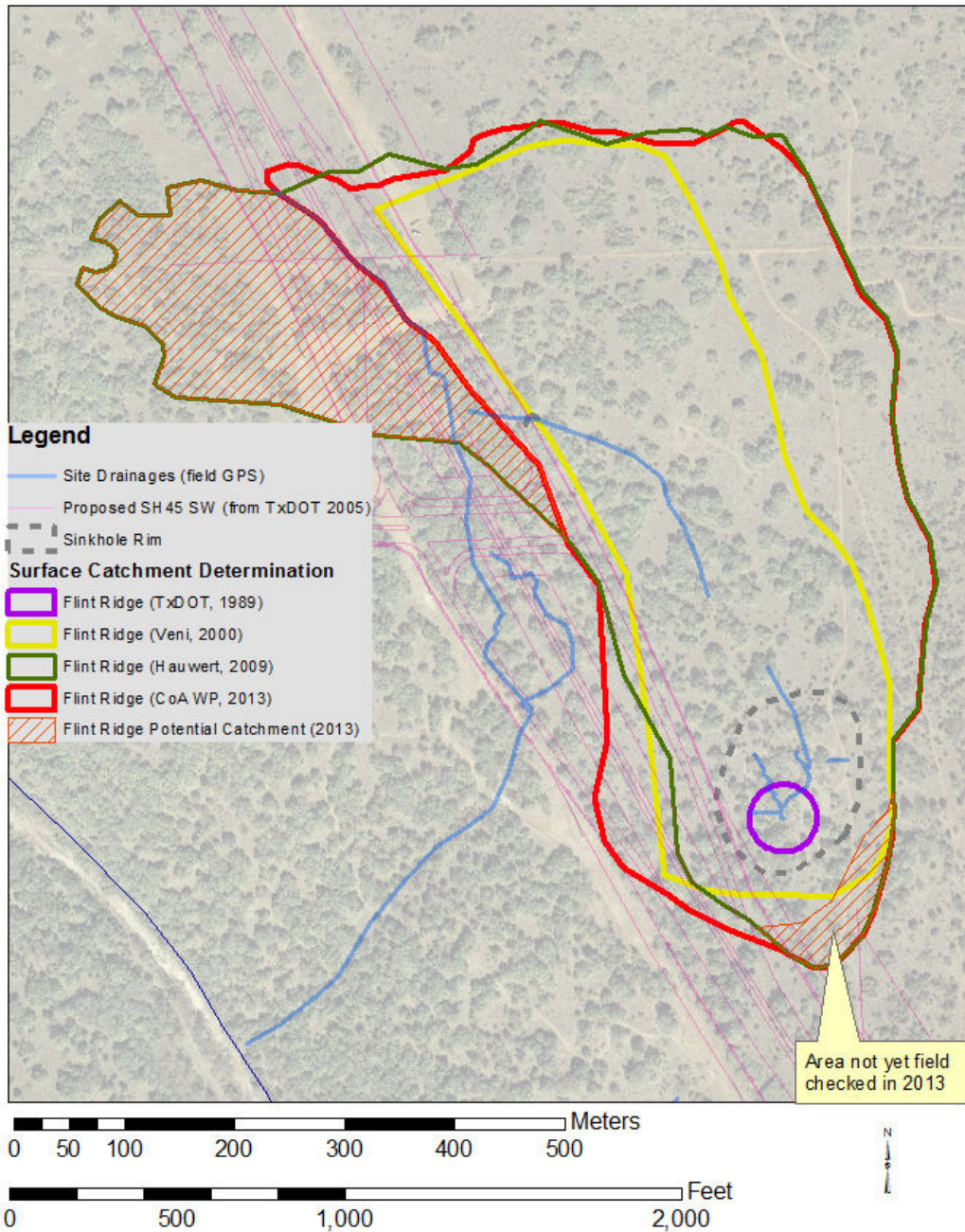
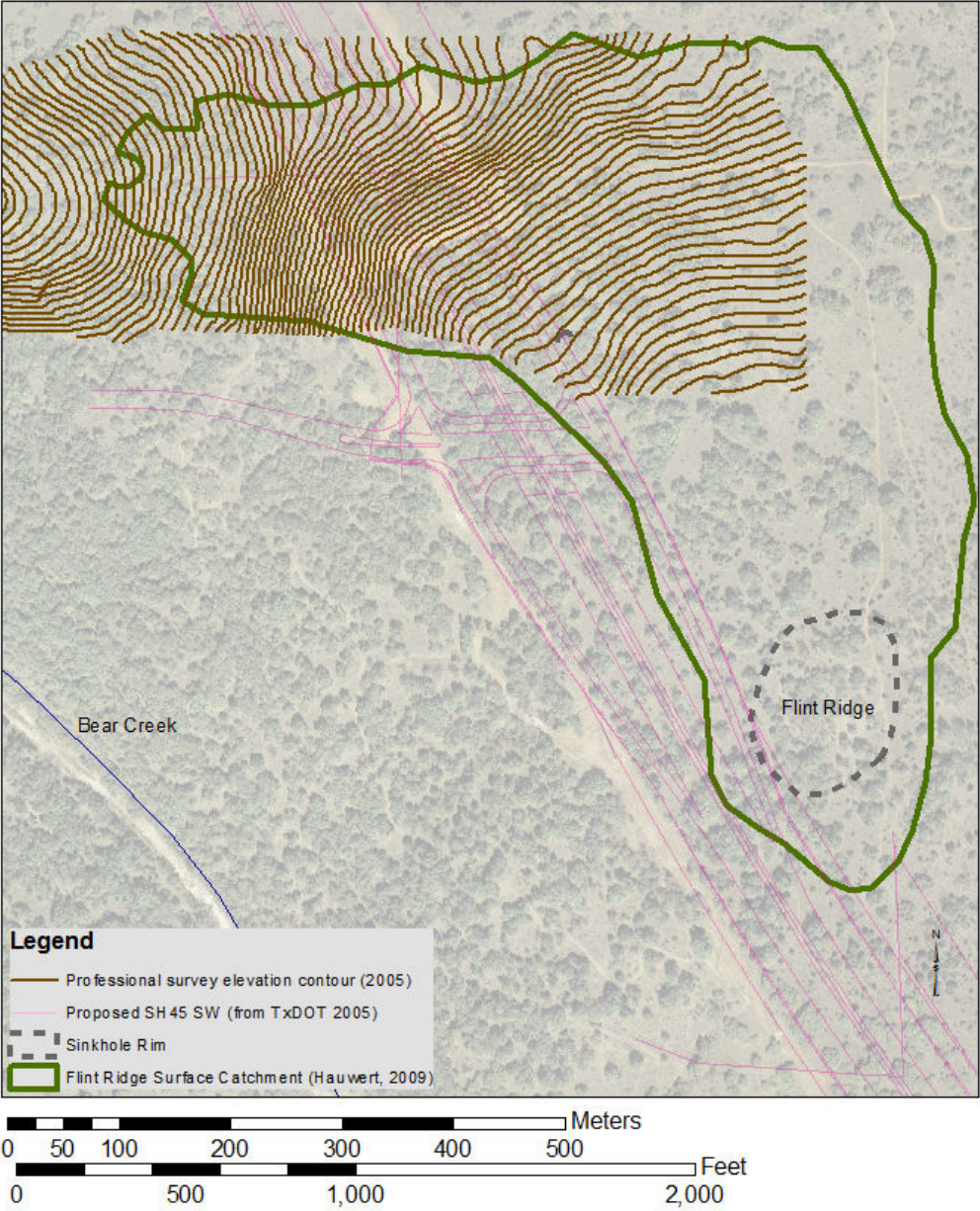


Figure 2. 2005 Survey Data and Flint Ridge Cave Surface Catchment Area Interpreted by Hauwert 2009.



Methods

LIDAR is a remote sensing aerial technology utilizing reflected laser light to measure surface elevations at high resolution. The 2013 LIDAR coverage was gridded to 1 square foot resolution by WPD geographic information systems staff (Figure 3). The topographic survey used by Hauwert (2009) has a density of approximately one point every 8,333 ft² whereas the LIDAR coverage in the Flint Ridge area has approximately one point every 3.84 ft². The resulting LIDAR topography has much denser data coverage resulting in the ability to detect more subtle topographic changes in comparison to previous manual topographic surveys. The LIDAR image illuminates a drainage to Bear Creek that parallels the western edge of the Flint Ridge surface catchment defined by Veni (2000). The drainage becomes more subtle northward where it enters the western lobe of a surface catchment area defined by Hauwert (2009) (labeled “potential catchment” in Figure 1) which is inside and west of the highway ROW.

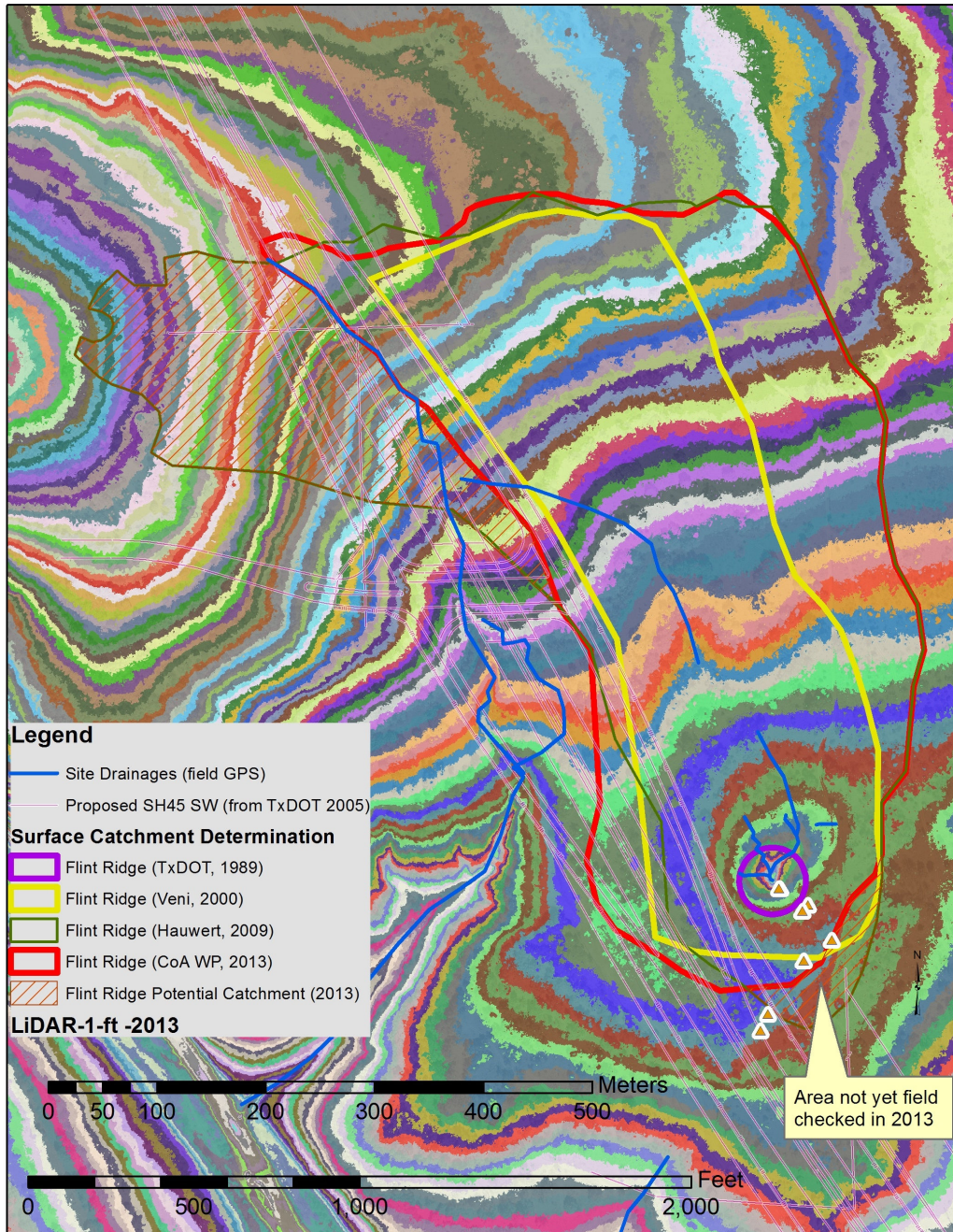
On October 12, 2013, heavy precipitation fell over the Flint Ridge Cave area. Stormwater runoff ponded about 9 feet in depth in the Flint Ridge sinkhole, partially due to the previous heavy rain on September 20, 2013, saturating the ground, but also because washed in debris largely blocked the cave gate inside the cave. On Tuesday October 15, 2013, three WPD geologists (David Johns, Scott Hiers, and Nico Hauwert), inspected the Flint Ridge sinkhole and the western side of the Flint Ridge surface catchment area to field verify the catchment area discrepancy identified by the LIDAR coverage. Because of the recent flooding, flow debris was frequently observed on the surface and used to interpret runoff directions. The geologists field-delineated the surface divide just west of Flint Ridge Cave using a Trimble XT GPS unit, then followed along a drainage to Bear Creek north, cutting through the Flint Ridge Cave surface catchment area interpreted by Hauwert (2009). While the drainage swale to Bear Creek was defined in both the 2013 LIDAR maps and field inspection, it was not defined in the 2005 topographic survey, probably due to the lower density of data points.

Results

Based on observations of flood debris, the investigating geologists determined that the drainage to Bear Creek appeared to direct most of its runoff from the western lobe as delineated by Hauwert (2009) and labeled “potential catchment” in Figure 1 to Bear Creek. However, in some cases, flood debris on the east edge of this drainage appeared to be directed southeast towards the entrance of Flint Ridge Cave. Therefore, it appeared the upper reaches of the drainage to Bear Creek served as a surface water divide under certain conditions due to low topographic relief. The geologist concurred that under most conditions all of the surface runoff reaching the drainage is directed to Bear Creek or infiltrates within the drainage channel but some contribution of surface runoff toward Flint Ridge Cave is possible under less frequent, large rainfall events.

The field observations also documented that the surface catchment area closest to the cave opening (due west of the sinkhole and cave opening) is larger than previously identified by approximately 250 ft. The new catchment area extends almost to the western edge of the proposed roadway ROW and significantly increases the area potentially impacted by the roadway closest to the cave opening and over the cave footprint.

Figure 3
2013 Investigation of Flint Ridge Cave Surface Catchment Area



Conclusions

Based on LIDAR aerial surveys and field delineation of drainage patterns along the western side of the Flint Ridge Cave surface catchment area, a primary surface catchment area is interpreted to be 57.8 acres (Figure 1). It is possible under some conditions that runoff generated within the potential surface catchment area of 13.2 acres also contributes runoff to the entrance of Flint Ridge Cave. Based on observations of flood flow debris, runoff contribution from this additional area to Flint Ridge Cave is expected to occur less frequently. The field delineation also increased the surface catchment area immediately west of the cave opening and over the cave footprint by approximately 250 feet.

Recommendations

Further investigations using dye tracing could identify under what rainfall conditions the potential surface catchment may provide additional surface water runoff to Flint Ridge Cave. This dye tracing involves placing dye receptors in both the drainage to Bear Creek and at the entrance of Flint Ridge Cave as well as in other drainages known to discharge to the cave. During a storm event, dye is placed in the upstream portion of the drainage to Bear Creek, possibly also on the surface in other areas within the potential surface catchment area. The distribution of flow can also be measured by measuring the dye concentrations and flow rate at both locations (entrance of Flint Ridge Cave and mouth of drainage to Bear Creek) using an autosampler. This method is resource intensive.

More importantly, the delineation of the subsurface catchment area of the cave has not been conducted. The subsurface catchment directs infiltrating water to cave drips. These cave drips are important in maintaining the health of the cave ecosystem, including karst species of concern. This effort is also resource intensive and dependent on rain events to generate runoff, carry dye to the cave and activate cave drips. Additional background water quality data in both the surface runoff and in the cave drips is also needed. This data will be valuable in evaluating potential impacts to the cave ecosystem resulting from road construction and operation and in formulating stormwater treatment methods to minimize those impacts.

References

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