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A survey of dissolved oxygen in groundwater during drought conditions, Barton Springs segment of the Edwards Aquifer, central Texas

Barton Springs/Edwards Aquifer Conservation District

A Survey of Dissolved Oxygen in Groundwater During Drought Conditions, Barton Springs Segment of the Edwards Aquifer, Central Texas

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BACKGROUND & MOTIVATION

Dissolved oxygen (DO) is critical for the survival of aquatic species. The distribution, values, and processes influencing the supply of DO are well-known for surface water bodies. The endangered Barton Springs salamander (*Eurycea sosorum*, fig.1) relies on spring flow and adequate DO for its survival at Barton Springs (fig. 2), the primary discharge point for the aquifer. However, the nature and distribution of DO in groundwater within the aquifer supplying Barton Springs is unknown. Previous studies have focused on the relationship between Barton Springs flow and DO with regard to the salamanders. Those studies have reported population declines at levels below 5mg/L and warn that DO should be no less than 3mg/L to safeguard the salamanders. Previous studies have also shown a decline of about 1.5mg/L DO at Barton Springs from drought to non-drought. A better understanding of DO in the aquifer during drought conditions will help scientists understand, and possibly predict, DO at Barton Springs and the potential impact on the endangered species.

Fig. 1 Barton Springs Salamander

Fig. 2 Barton Springs

PURPOSE

- To characterize the nature and distribution of DO in the Barton Springs segment of the Edwards Aquifer.
- A secondary purpose was to evaluate various methods of measuring DO in groundwater.

STUDY AREA

This study presents the results of groundwater DO measurements during moderate drought conditions (May-July, 2011) from 43 wells and 8 springs in the Barton Springs segment of the Edwards Aquifer (fig. 3 & 4).

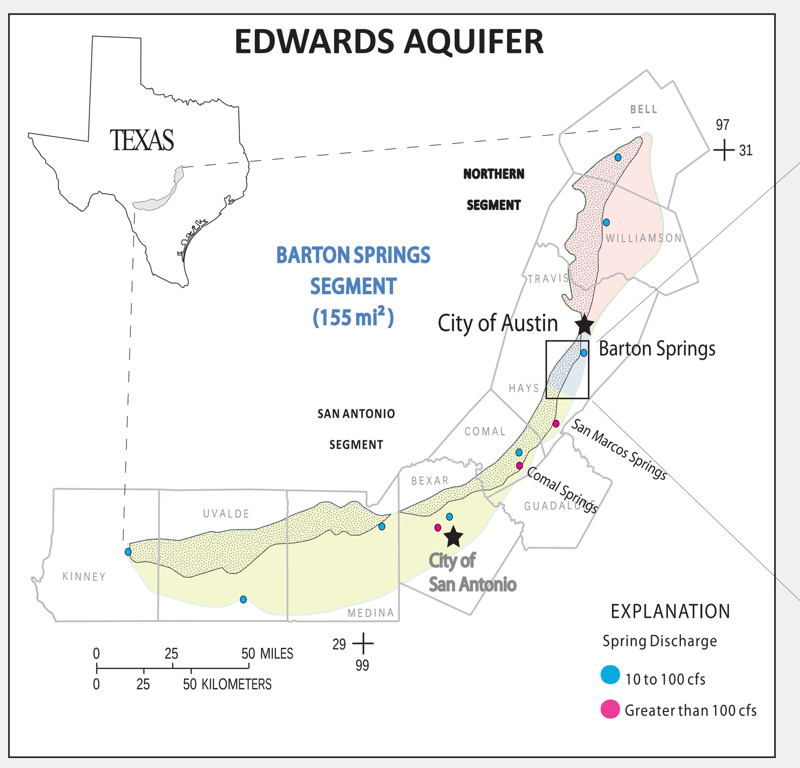


Fig.3 Edwards Aquifer location in Central Texas

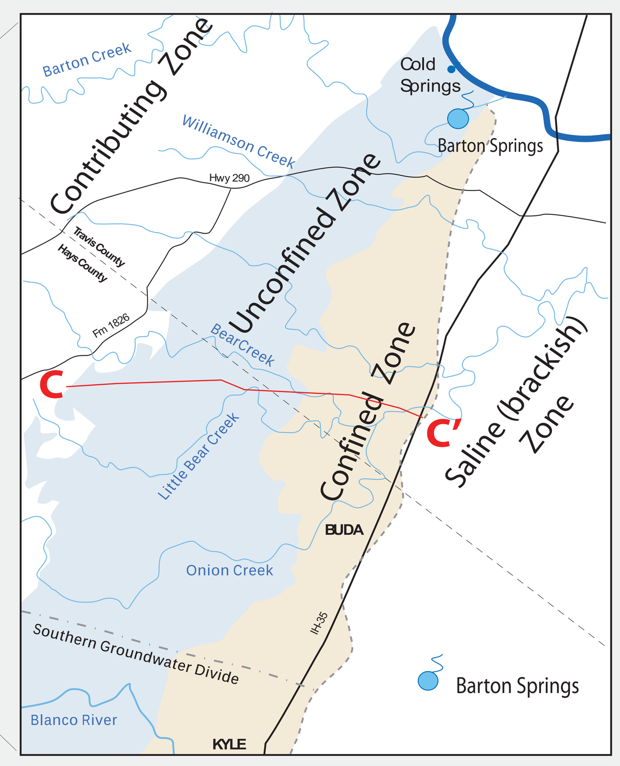


Fig. 4 Overview of the Barton Springs segment of the Edwards Aquifer.

Cross sectional view of the Edwards and Trinity Aquifers from C to C' as seen in Fig. 4.

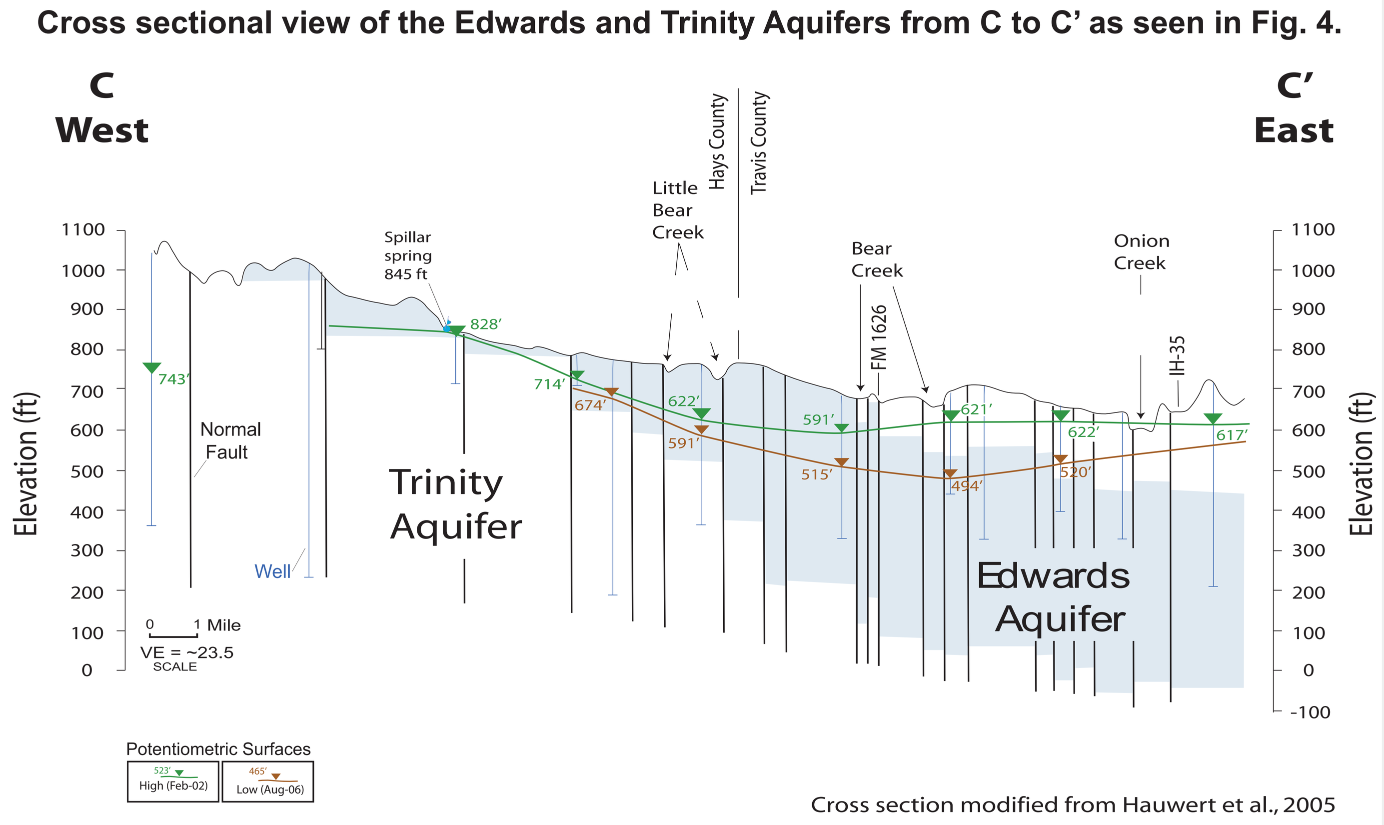
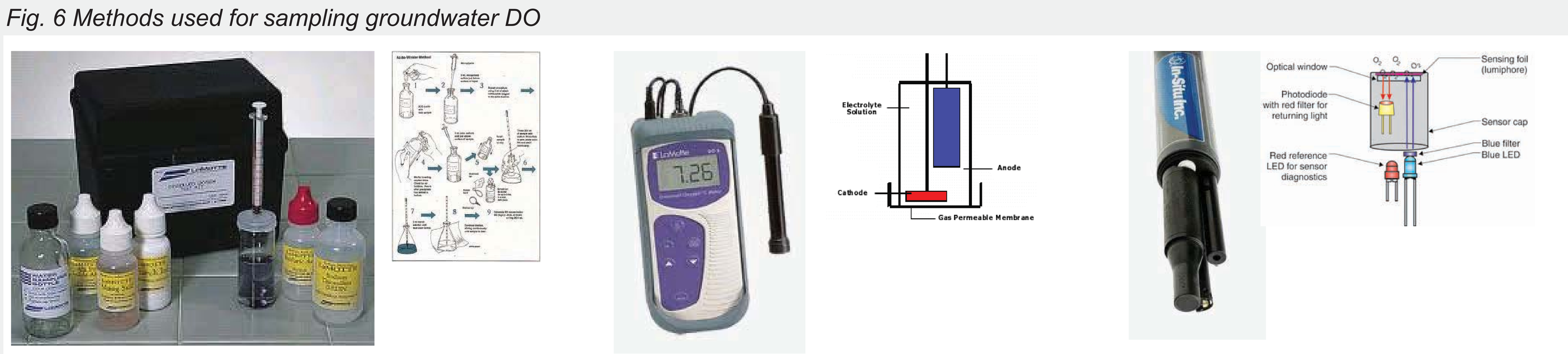


Fig. 5 Shows potentiometric surfaces that reflect low (drought) and high (non-drought) measurements.

METHODS

Well samples were collected from well head spigot, through hose, into bucket to minimize turbulence that would introduce air. Wells were purged until field parameters stabilized prior to taking DO readings. Sample collection time ranged from 20 min to >1hr. Pump type did not seem to influence DO values. Springs were sampled near the orifice at spring upwellings to minimize contact with surface water in pools. Three different instruments were used for quality assurance and control (fig.6).

Fig. 6 Methods used for sampling groundwater DO



1. Modified Winkler Titration
- Measures by tritration based on permanganate reaction.
- **Pro:** Portability, reliablity-- QA, and is very reasonably priced.
- **Con:** Requires refill reagents, low resolution (0.2mg/L), sample time ~10min. Must calculate %sat.
- Sample Required: ~50ml

2. Galvanic Probe
- Measures by combustion of oxygen
- **Pro:** Portable, easy calibration, moderate price, small probe diameter, resolution 0.01mg/L.
- **Con:** Stabilization can take a long time, and it easily fluctuates.
- Sample Requirement: Flow.

3. Optical Probe
- Measures by dynamic luminescence quenching principle.
- **Pro:** Excellent resolution, internal memory, sample time instantaneous, capable of logging samples continuously, low maintenance
- **Con:** Expensive instrument, must be shipped back to lab for repairs, bit cumbersome.
- Sample Requirement: ~40mL of sample, or ~6in.depth.

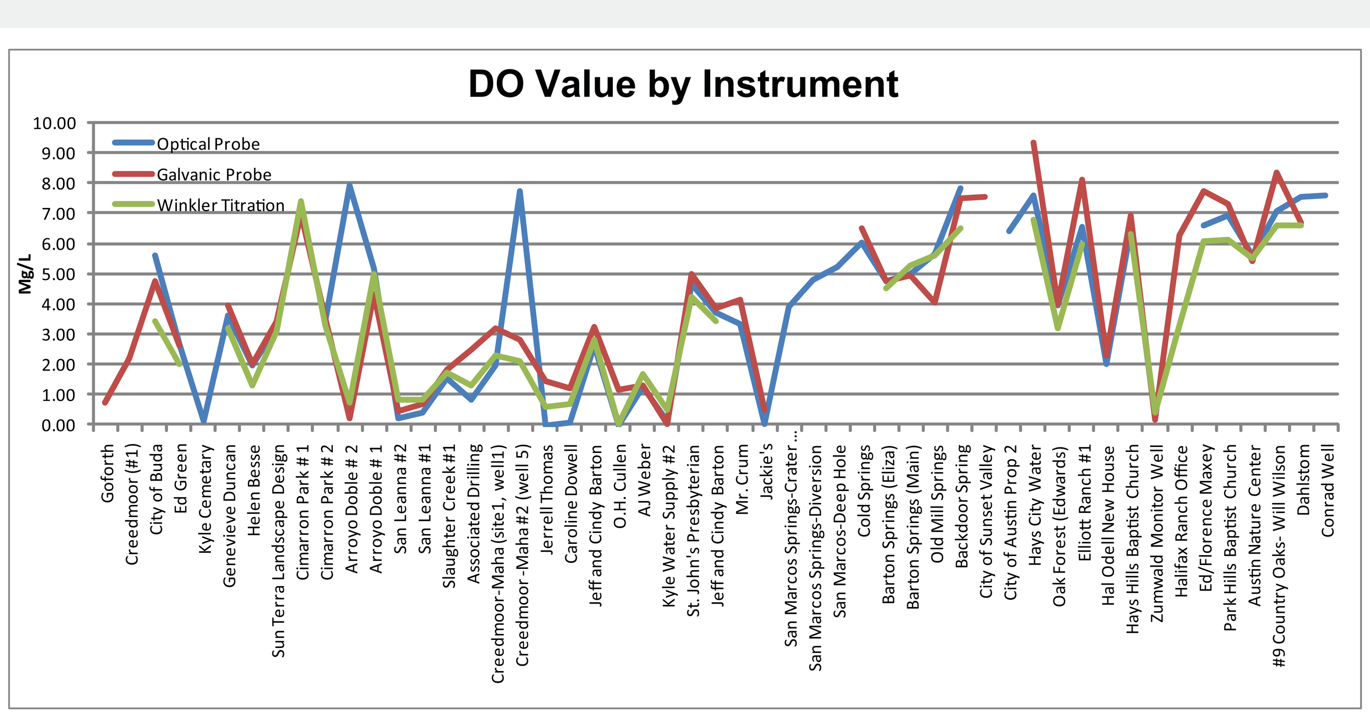


Fig. 7 Compares measurement value of each instrument by site

4. Discussion of Methods

The three instruments were a QA/QC measure as well as a comparative evaluation of the performance of each instrument in testing groundwater. Most measurements were within 1.0 mg/L of the three methods. We found that the optical probe tended to measure a median value, the galvanic probe a high value, and the Winkler titration the lower value (fig.7).

DATA & RESULTS

This map shows all sample sites symbolically categorized into springs, confined and unconfined zone wells. They are also color coded into three categories of 1) absent to low (0.0-0.99), 2) low to medium range (1.0-4.0), and 3) mid to high levels (4.01-7.65) of DO in mg/L (Fig. 8).

There is an obvious majority of low DO sites that lie within the boundaries of the confined zone (Figs. 8 & 9).

All springs were in the upper range of DO with a low of 3.9 mg/L at Crater Bottom Spring in San Marcos, and a high of 7.65 mg/L at Back Door Springs in Austin. The median value of the 8 sampled springs was 4.99 mg/L. The concentration of DO at the sampled springs lies between the concentration range of the confined (2.0mg/L) and unconfined (6.4mg/L) zone medians (fig.10).

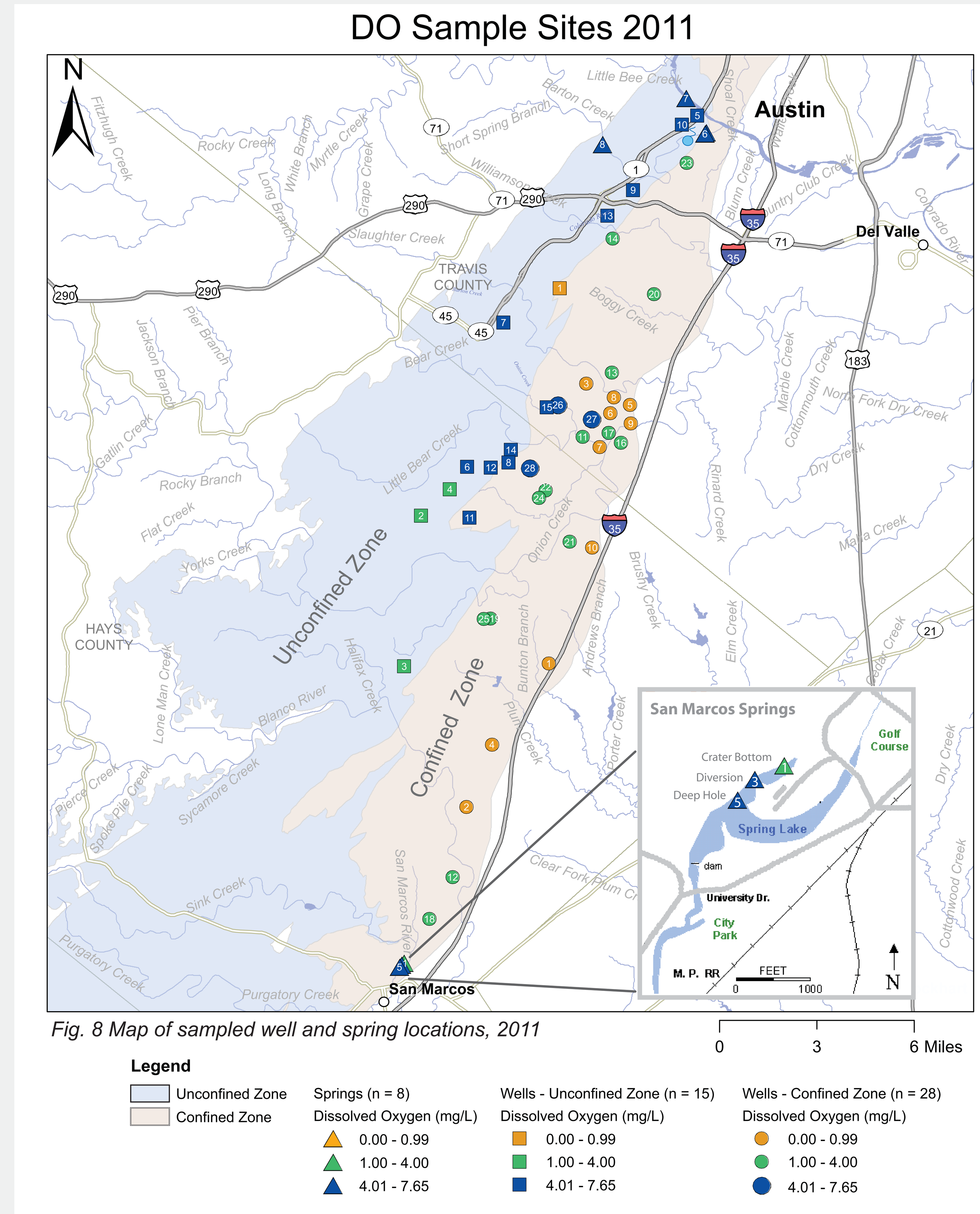


Fig. 8 Map of sampled well and spring locations, 2011

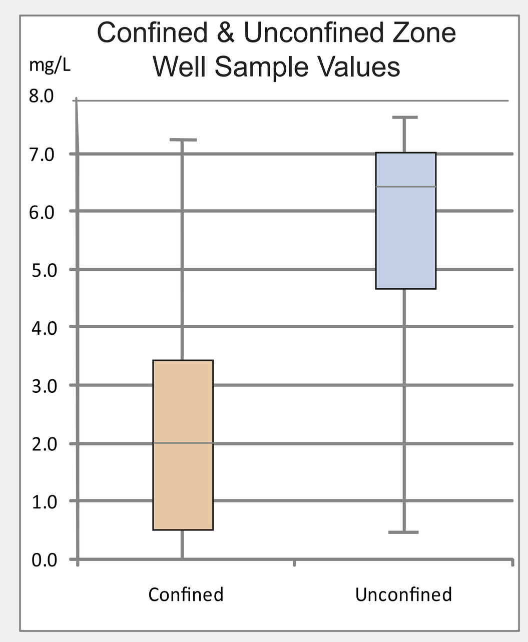


Fig. 9 Box plot showing quartile and median DO values of sampled wells in confined and unconfined zones.

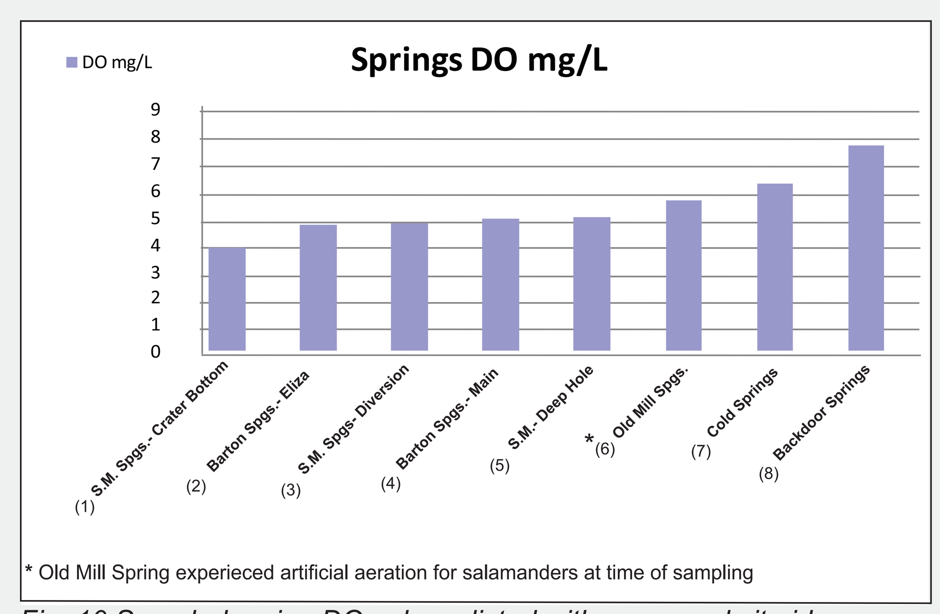


Fig. 10 Sampled spring DO values, listed with name and site id

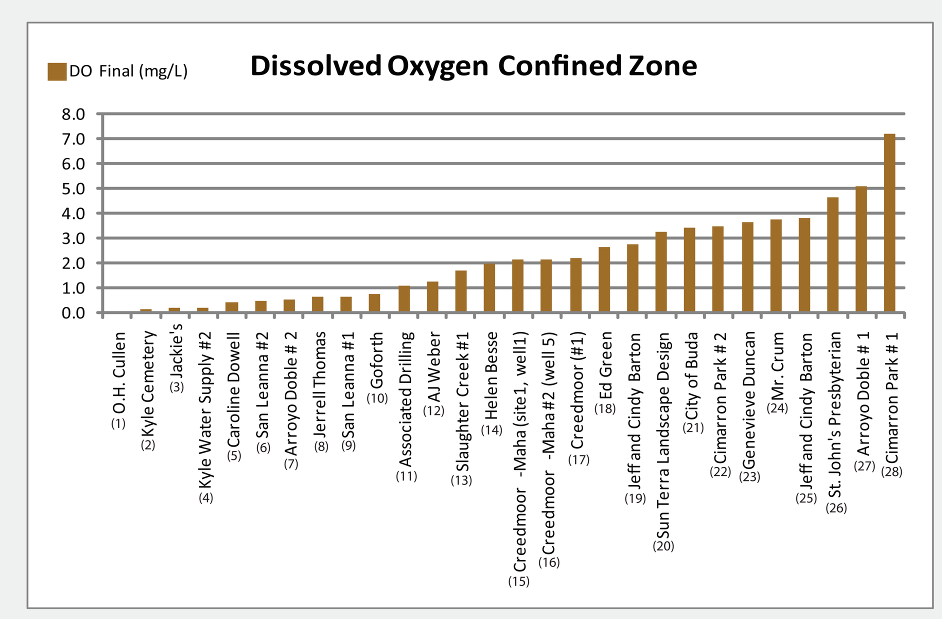


Fig. 11 Confined zone DO values listed with name and site id

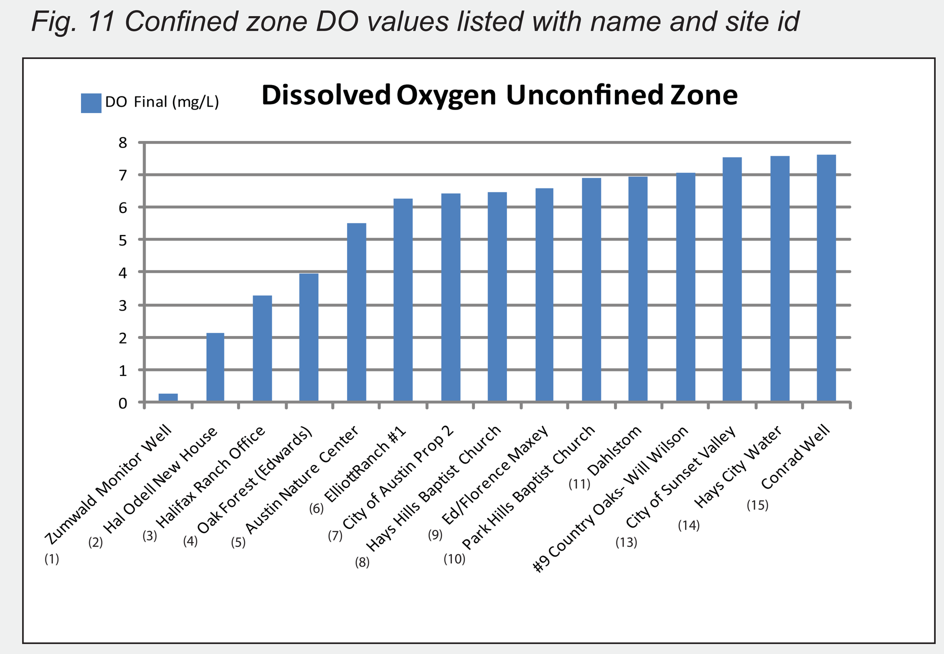


Fig. 12 Unconfined zone well DO values listed with name and site id

Statistical Analysis:

I ran a two-sample unequal variance student T-test on my data. I found that: Confined versus unconfined data: $P<<0.01$; $P=9.99107E-06$. The results allow rejecting the null hypothesis. However, the semi-confined versus unconfined data: $P= 0.2457$ -small difference in population. While semi-confined data versus confined showed a statistical population difference sufficient to reject null hypothesis. For this reason, two categories were retained: confined and unconfined. The semi-confined data were classified into the two groups according to their geographical location.

CONCLUSIONS

- Dissolved oxygen for the unconfined zone had a median value of 6.4 mg/L while the confined zone had a median value of 2.0 mg/L.
- There is sufficient statistical difference between water samples in the confined versus unconfined zones to have two distinct populations.
- There is an insignificant statistical difference between unconfined and semi-confined zones to distinguish the populations.
- Measure of confinedness has a high correlation with dissolved oxygen levels in this aquifer.
- There are significant levels of dissolved oxygen within the unconfined portion of the Barton Springs segment of the Edwards Aquifer under moderate drought conditions.
- Samples from Barton Springs (Eliza and Main) during this study appear to be a mixture of confined and unconfined zone groundwaters.

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