Large volumes of co-produced water are brought to the surface everyday during the production operations for oil and gas. Produced water, sometimes referred to as “brine” or “saltwater”, can contain formation water from the reservoir, water previously injected into the formation, and chemicals used during the production process. These waters are generally high in dissolved solids and contain some of the chemical characteristics of the formations they were in contact with. Produced water is the largest volume by-product and waste stream associated with oil and gas production. In a report on national produced water volumes and management practices (Clark and Veil, 2009), it was estimated that 98% of produced waters from onshore wells is injected back into the subsurface.

In 2014, more than 442 million barrels of subsurface brine were produced in North Dakota. Available information indicates that approximately 88% was injected back in the subsurface for disposal. Of the other 12%, most was injected into the subsurface for enhanced oil recovery purposes while lesser amounts were managed for beneficial reuse such as the production of heavy drilling mud.

Subsurface brines are a natural feedstock for a variety of industrial minerals and chemicals. Within a broadly similar setting to the Williston Basin, the Michigan Basin has been home to operators such as Dow Chemical Company. To our north, formation water in Saskatchewan has been utilized for the production of calcium and magnesium chloride brines for use in dust suppression on gravel roads and as ballast in tractor tires (Rostron et al., 2002).

Knowing the chemical nature of the produced water from various formations and localities is the first step toward developing beneficial reuse of this waste stream. Water chemistry information collected by the North Dakota Department of Mineral Resources (DMR) was examined for this article.

**Methods**

The Oil & Gas Division of the DMR maintains a database of water chemistry analyses received from producers operating within the state. As of April 28, 2015 this database contained 7,570 water sample entries, often including multiple samples from a well collected at differing intervals, sample ports, or times. A majority of the samples have been processed for “standard” analyses which include major ions (Ca, Mg, Na, Cl, Fe, K, SO4, HCO3, and CO3) as well as additional measurements such as pH and specific gravity. A simplified culling process derived from Hitchon and Brulotte (1994) was utilized to reject bad data due to poor sampling, laboratory error, or drilling fluid contamination. Sample analyses were eliminated from the dataset if any of the following eight criteria were met:

1. Either Ca, Mg, Cl, SO4, or HCO3 ≤ 0
2. Mg>Ca
3. pH<5 or pH>10
4. OH>0
5. CO3>0
6. Specific gravity >0 and <1
7. Fe>200 mg/L
8. Cr>4 mg/L

Additional culling was performed by looking for suspect data in the remaining analyses. In all, 1,754 sample analyses (23%) were eliminated from the dataset. Those remaining were sorted by pools, fields, and counties and presented as mean and median concentrations for Ca, Mg, Na, and Cl.

**Discussion**

Variability in concentrations of the above elements is observed in both a basin-wide pool to pool comparison (fig. 1 and table 1) and within pools further subdivided by fields (table 2) or county (table 3). It is important to note that produced water properties can vary throughout the lifetime of a reservoir. While these data provide a starting point for examining standard brine chemistries throughout the Williston Basin, more extensive data culling should be undertaken prior to any production of isocontour maps for water chemistry across the basin. In particular, attention to the method of production or sampling, for which information was not immediately available for this article, should be considered.
Table 1. Presented are concentrations of Ca, Mg, Na, and Cl for various pools throughout the North Dakota portion of the Williston Basin. All data are in mg/L.

Table 2. Presented are concentrations of Ca, Mg, Na, and Cl for selected oil fields in the North Dakota portion of the Williston Basin. Field data is subdivided by the individual pools sampled within each field. All data are in mg/L.

Table 3. Presented are concentrations of Ca, Mg, Na, and Cl for the Duperow pool. The Duperow pool data is subdivided geographically by county. All data are in mg/L.

References