

*R.O. for Point-of-Entry,  
A Case Study in Commercial/Light Industrial Applications*

**Summary:** Reverse Osmosis is the preferred technology for many commercial and light industrial applications where purification of feed waters and consistency of the final product water is essential. The growth of microbreweries in the U.S. has created an opportunity for the application of light industrial reverse osmosis systems. This case study offers an additional area of interest in that the feed water to the microbrewery is product from a local municipal reverse osmosis plant.



Beer, by definition, is an aqueous solution, 91-97% of which is water. The importance of water quality in beer production cannot be understated and was the driving force behind consideration of a reverse osmosis water purification system for brewing. The Outer Banks Brewing Station, in Kill Devil Hills, North Carolina is a microbrewery with a projected need of up to 3,000 gallons per day of purified water to support production of 500 gallons per batch of their brewed products. A microbrewery is a brewery that produces less than 15,000 barrels (17,600 hectoliters) of beer per year. Raw water is supplied to the microbrewery from the local municipal reverse osmosis plant lacks the quality and consistency needed for optimal brewing.

### ***Importance of water source***

Long before the water chemistry behind the brewing process was scientifically understood, great breweries sprang up in the proximity of excellent water sources. If the local water source was inadequate for proper brewing, the beer produced would be of poor quality, and either the brewery moved to a better source of water, they adapted their brewing techniques, or they perished.

Water profiles from the classic brewing regions are surprisingly different from each other, accounting for the evolution of unique beer styles from those areas. It was the early trial and error compensating methods in addition to the presence of certain mineral ions that determined the style of beer that evolved from an area. When certain Munich brewers moved to Prague, they were amazed at how light and delicate their beers turned out from essentially the same recipes and ingredients they were using in Munich.

What is most important to the brewer is the effect the brewing water has on mash pH. Malt enzymes are very particular about temperature and pH, and mashing is essentially an enzymatic process. Proper mash pH, usually preferred at around 5.2 - 5.4, can be achieved by several means. In the early days of brewing, the methods were mostly limited to malt composition and biological acidification. Modern breweries may add food grade acids such as lactic acid, or phosphoric acid to adjust the mash pH.

London water is high in carbonate ions which tends to drive the mash pH up, but dark roasted malts acidifies the mash and the balanced pH results in an excellent Porters. North of London in an area called Burton Upon Trent the water has extremely high levels of dissolved minerals, especially gypsum, which lowers mash pH, thus enabling a balanced mash with minimal dark malts resulting in exceptional Pale Ales.

It is interesting to note here that both Prague and Burton Upon Trent produce world class light beers while Prague has very low (around 31 ppm) total dissolved solids (TDS), and the Burton has exceptionally high TDS (around 1,226 ppm). The reason they both work for brewing is the overall balance of ions and especially the residual alkalinity (RA).

$$\text{RA} = \text{Total Alkalinity} \times 0.056 - \text{Ca} \times 0.04 - \text{Mg} \times 0.033$$

(All concentrations represented as ppm as CaCO<sub>3</sub>)

RA values less than 1 are considered good brewing water. By this formula, Burton Upon Trent water is actually superior to Pilsner (Prague) water. In fact, the practice of adding gypsum to brewing water to achieve a lower mash pH is still sometimes referred to as "Burtonization".

There are many subtleties to managing the ion balance. While it is essential to keep the mash in the right pH range by whatever means, the presence of certain minerals does have an effect on flavor and character of the beer. Many of them have a positive effect on brewing up to a point after which they are detrimental, causing excessive saltiness, sourness, or bitterness. Yeast requires a proper balance of Calcium with

Magnesium for optimal fermentation along with several other nutritional requirements. Thus, absolutely pure water would not make very good brewing water. But by using reverse osmosis as pre-treatment of brewing water, the brewer can add back minerals so suit any style of beer he or she is trying to create or duplicate.

***The Outer Banks Brewing Station***

The Outer Banks Brewing Station is a new operation with its grand opening in May 2001. The beers produced by the microbrewery will be sold initially through its 215-seat restaurant, with limited distribution of its products in kegs and bottles in 2002. Brewmaster Scott Meyer is planning to use RO water, possibly custom salted, in the kitchen in addition to the beer production. "I expect that if we pay as much attention to the water that is used in our sauces, stocks, and breads as we do to the water used for brewing, we can improve on our foods."

To produce the highest quality product for his patrons, Brewmaster Scott Meyer determined that a point-of-entry water purification system would be essential to meet the following objectives:

- Reduce the TDS and chloride concentrations from the raw water to acceptable levels. Chloride concentrations must be below 25 mg/L for optimal brewing.
- Reduce the pH to enable precise pH control of the treated water prior to brewing.
- Provide low TDS permeate as make-up water for cleaning solutions. Acid and alkali cleaners are made much more effective if they are made up with low TDS water. "Beerstone" and other mineral deposits can be very difficult to remove.

Raw water to the Outer Banks Brewing Station is supplied by the Kill Devil Hills municipal water plant. As shown in Table 1, the Kill Devil Hills plant utilizes reverse osmosis to reduce the TDS from local surface water supplies from 4,380 mg/L TDS to a final blended product of about 400 mg/L TDS. Water from the municipal plant has been treated after the reverse osmosis process with chlorine and caustic chemicals for residual disinfection and corrosion protection, respectively.

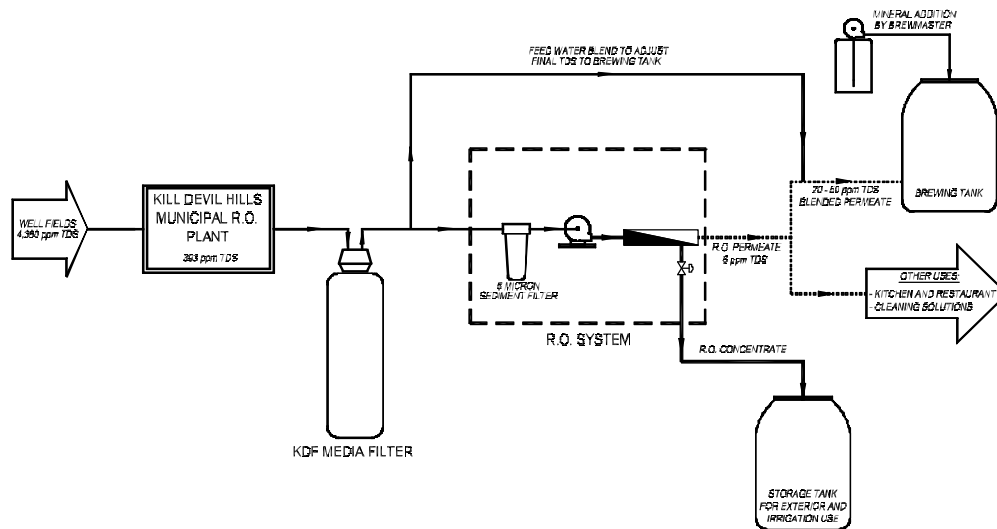
**TABLE 1  
FEED WATER CHARACTERISTICS**

	<b>RAW WELL WATER</b>	<b>TREATED MUNICIPAL WATER</b>	<b>DISTRIBUTED MUNICIPAL WATER</b>	<b>OUTER BANKS BREWING STATION R.O. PERMEATE</b>
pH	7.8	7.6	7.6	5.8
Total Alkalinity, CaCO <sub>3</sub> , mg/L	210.0	40.0	36.0	0.8
Total Hardness, CaCO <sub>3</sub> , mg/L	600.0	36.0	32.0	0.4
Sodium, Na, mg/L	777.0	112.0	125.0	1.8
Potassium, K, mg/L	76.8	4.9	4.7	0.1
Chloride, Cl, mg/L	2300.0	210.0	210.0	2.8
Sulfate, SO <sub>4</sub> , mg/L	132.0	11.1	14.5	0.1
Silica, SiO <sub>2</sub> , mg/L	10.2	4.1	3.2	0.1
TDS, mg/L	4380.0	410.0	393.0	5.6

## The Reverse Osmosis Solution

Brewmaster Scott Meyer decided to use RO in his water treatment system to give him control of the brewing water parameters. The purified water would give him a "blank canvas" on which he could add mineral salts back in measured quantities tailored to the different beer styles he produces. Additionally, reverse osmosis removes about 97% of sodium nitrate from the water. Nitrates reduce to nitrites in solution, which are toxic to yeast.

Brewmaster Meyer turned to local dealer Le Bleu Water Treatment for a complete water purification solution. A process designed to accommodate all the purified water needs of the brewery was formulated by Le Bleu and the Outer Banks Brewing Station. As illustrated in Figure 1 below, the raw water is pre-treated with KDF media for chlorine and organics removal prior to treatment by the reverse osmosis unit. The reverse osmosis unit is sized to produce 3,200 GPD of product water. The reverse osmosis permeate water is output to brewing process tanks for adjustment with brewing salts. The concentrate water from the R.O. unit is stored in separate tanks for outside use, such as irrigation. Concentrate recycling was deliberately excluded from the R.O. equipment as it was determined that better control of the brewing process parameters could be maintained while increasing overall system recovery by blending pre-treated water with R.O. permeate.



**FIGURE 1  
PROCESS DESCRIPTION**

The R.O. system includes dual high-flow (low-pressure) 4" x 40" membranes to maintain the required production in the event the feed water temperature drops below the optimal 77 degrees F. Stainless steel pressure vessels, control panel, and high-pressure pump were installed on the R.O. skid for corrosion resistance and to provide an appearance consistent with the restaurant and brewing equipment of the facility.

### ***Conclusion***

Brewing beer is a complicated process, combining craft and science. Brewmaster Scott Meyer and his local water treatment dealer have conceived a water treatment system tailored to the needs of a modern microbrewery. Reverse Osmosis is a critical element of this system since it provides the brewmaster with the highest quality raw material upon which he can perform his craft.

### ***About the Authors:***

Edward Closuit is President of Haliant Technologies, a Reverse Osmosis equipment manufacturer based in Sarasota, Florida. Mr. Closuit received a Bachelor of Science in Engineering from the University of Florida in Gainesville and a MBA from Rollins College in Winter Park, Florida. He has many years of experience in manufacturing water treatment equipment and was previously President of Environmental Products USA, Inc.

Joel Walker is a Water Specialist with Le Bleu Water Treatment, a division of Le Bleu of The Outer Banks, a water treatment equipment and bottled water supplier in Harbinger, NC. Mr. Walker has over 16 years experience as an independent water treatment contractor prior to joining Le Bleu.

Scott Meyer is one of the owners of the Outer Banks Brewing Station. He is a certified Brewmaster through the Siebel Institute of Brewing Technology in Chicago, Illinois.

### ***Sources:***

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3. Water analysis courtesy of Dare County, North Carolina, sample taken 3/3/01.