Brewers Association

Wastewater Management Guidance Manual

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acknowledgements

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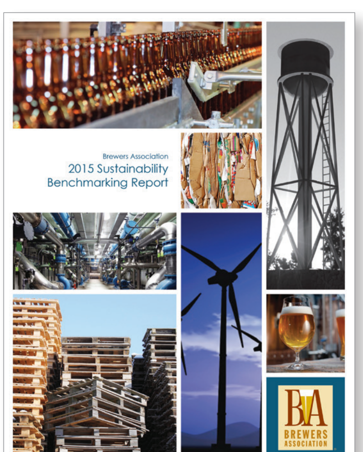
introduction

In 2013, the Brewers Association (BA) published a series of three sustainability guidance manuals related to the key environmental aspects and impacts of craft brewing. One of the manuals, *Water and Wastewater: Treatment/Volume Reduction Manual,* addresses water and wastewater management. The wastewater section of that manual provides a basic primer on brewery wastewater effluent and case studies of on-site wastewater pretreatment options.

Since the publishing of the first water and wastewater guidance manual there has been significant regulatory and brewery activity. The continued rapid growth of craft brewing in the United States has stimulated concern from local municipal sewer districts as they begin to accept and treat increasing levels of brewery wastewater.

The BA has also collected brewery specific wastewater data and costs as part of the *2015 Sustainability Benchmarking Report*. Please reference this report for specific data and trends on wastewater and other brewery sustainability-related key performance indicators. The wastewater data collected has also been included and analyzed in this guidance manual.



For many municipalities, accepting the additional loadings from craft brewing can be safely done within their operating design specifications. However, this can eventually lead to an unbalanced allocation of fees for treatment versus residential users. Municipalities, therefore, are beginning to characterize craft breweries as significant industrial users that should be permitted, monitored and assessed high strength surcharges to treat the organic and solid materials inherent in brewery wastewater.

In some situations, the municipality simply cannot accept additional wastewater from craft breweries without potentially putting their own discharge permits at risk. In such instances, the craft brewery will have to formulate a solution that will be technically and economically feasible. In many cases, this will involve obtaining approvals for a permit to discharge. The permit may include a requirement to conduct some form of pretreatment prior to discharging to the municipal sewer system.

Some craft breweries are building in geographic areas where no municipal sewer system is available. In such cases, the brewery should look for other means to dispose of their wastewater properly. Many breweries have looked at using septic fields or land application as an alternative disposal method with varying degrees of success.

Finally, some craft brewers are situated within large municipal systems where their loadings are insignificant compared to the total effluent treated by the municipal plant. In cases such as these, the brewery is not currently required to obtain a permit or charged high strength surcharges.

This manual is written as a more advanced look at craft brewery wastewater management and strategies. For a more basic understanding of wastewater characteristics and issues, please refer to the Brewers Association *Water and Wastewater: Treatment/Volume Reduction Manual.*

section one

General Wastewater Discussion

1.1 Background

Beer is an alcoholic beverage made by fermenting wort. The main byproducts from this process are spent grains, spent yeast and trub. Trub consists of high weight protein precipitates.

These byproducts are mostly liquid, and are high in organic materials and suspended solids. Brewery wastewater is often primarily regulated on a defined set of analytical parameters, such as Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), and pH.

The organic content of wastewater is expressed and measured as BOD. BOD is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample. The oxygen content is measured when the test starts, and again at the end of five days. The difference in the oxygen content on the first day and on the last day is used to calculate the BOD of the wastewater. To properly understand and analyze wastewater characteristics such as BOD, reference the handbook *Standard Methods for the Examination of Water and Wastewater*.

BOD is an important wastewater pollutant and causes a decline in DO (Dissolved Oxygen). Because of that, it can severely impact aquatic ecosystems. When wastewater with a high BOD is released into surface waters, it can quickly cause a hypoxic (low in DO) or anoxic (lacking DO) condition. This can lead to high rates of mortality among fish and benthic organisms. Anoxic water can also lead to the production of sulfide and methane, which causes various other risks.

The amount of dissolved oxygen in water is an important indicator of the life-supporting ability of a river or stream. Ecosystems are dependent upon adequate dissolved oxygen to remain healthy and productive. The testing of dissolved oxygen is often performed by a government agency.

The concentration of DO in a water sample is significantly influenced by:

- ***Temperature:*** *As warmer water holds less oxygen; with increased temperatures, DO decreases.*
- ***Salinity:*** *As water gets saltier, it holds less oxygen; with water salinity increases, DO decreases.*
- ***Atmospheric Pressure:*** *As pressure increases, DO also increases.*

Another parameter that is often used for wastewater characterization is COD, or Chemical Oxygen Demand. COD is the most popular alternative test to BOD for quickly estimating the concentration of organic matter in wastewater samples.

The COD test only takes a few hours to complete, giving it a major time advantage over the 5-day BOD test. Wastewater treatment system personnel can use COD as an almost real-time operational adjustment parameter. The COD test should be considered an independent measure of the organic matter in a wastewater sample rather than a substitute for the official BOD test.

Can I use my COD results to predict my BOD?

COD can be used to estimate BOD concentrations. For brewery wastewater, COD values are usually higher in concentration than actual BOD. It is generally accepted that COD and BOD share an empirical relationship. A good estimate of a BOD/COD ratio for brewery wastewater is 0.5 to 0.7.

Since water that is high in BOD and TSS can have a negative impact on ecosystems when released into surface waters, they are regulated and permitted under the Clean Water Act (CWA). A higher rate of BOD and TSS, therefore, ultimately means more work for city wastewater systems to meet these regulatory requirements.

Spent yeast and trub are not only high in BOD, but also have a high level of TSS. They are direct liquid byproducts from the brewing process and contain a high concentration of both suspended and dissolved organic materials. TSS is an environmental concern because it can cause turbidity in aquatic ecosystems, which blocks UV penetration and can clog filter-feeding organisms.

TSS is essentially a measure of how "dirty" the water is in terms of solid material suspended in the water. The more solid particles suspended in the water, the higher the TSS value. The TSS of a wastewater sample is measured using an extremely fine filter to trap and weigh suspended solids.

Do not confuse TSS with settleable solids. Settleable solids are larger particles, like grains, caps, glass, and so on. Many times, brewers install screens on sewer drains to prevent these large materials to enter the sewer system.

A more detailed discussion of BOD and TSS sources in brewery effluent is available in the Brewers Association *Water and Wastewater: Treatment/Volume Reduction Manual*.

1.2 Benchmarking Results

In 2015, the Brewers Association performed a sustainability benchmarking study with 80 breweries of varying sizes. Some Important metrics collected and analyzed from the study include:

Water Use Ratio

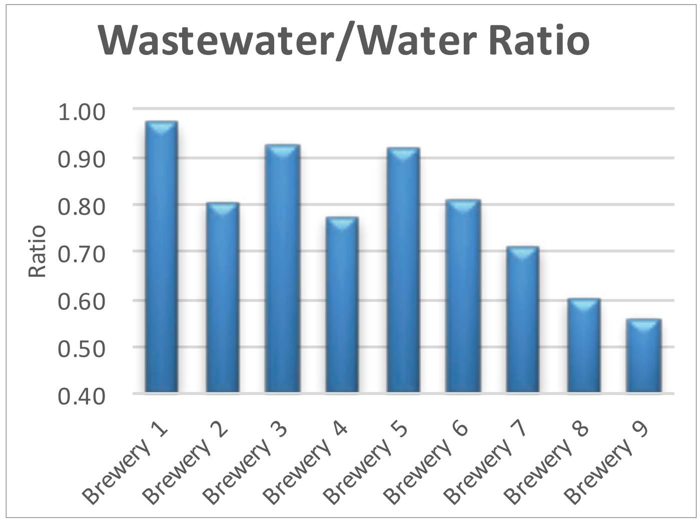
Sometimes also called the Water to Beer ratio, this ratio is one of the most commonly used metrics in the beverage industry to determine water usage efficiency. It is simply determined by dividing total water intake by total production volume. The higher the ratio, the more water used and the more wastewater discharged. The *2015 Sustainability Benchmarking Report* provides some insights into how your peers are performing, helping you to understand and bring perspective on your performance.

Wastewater to Water Ratio

The wastewater to water ratio helps to estimate wastewater volume based upon measured water usage. Often wastewater volume flow is not measured, so an estimate or approximation will have to be used.

The BA benchmarking survey reveals a range of ratios from breweries that have measured water and wastewater flow.

The median ratio for brewery wastewater discharge is approximately 80% of their incoming water as effluent (wastewater to water ratio of 0.8). Effluent is defined as generated wastewater that flows to the sewer system.



Wastewater to Beer Ratio

The third important ratio is the Wastewater to Beer ratio. This ratio provides insights in the overall wastewater discharges with respect to the amount of beer produced. It gives additional insights on top of the two previous ratios, as it shows specifically what happens with wastewater volume as beer production varies.

BOD and TSS Concentration

Representative BOD and TSS concentration data was compiled and analyzed from nine breweries ranging in production volume from 1,600 bbls/yr to 130,000 bbls/yr. The data are representative of many breweries that are beginning to face challenges with respect to wastewater management and have not yet begun any level of pretreatment. The data also includes brewpubs with restaurants that are typically less water efficient. Given the range in production size, differences in equipment/operations, and sampling techniques there is considerable variation within each parameter.

These ranges should be considered in absence of any on-site data collection. The concentration of wastewater discharged to the municipality will be an important factor in determining potential fees and surcharges.

Parameter	Average	Max
Water Use Ratio (bbl/bbl)	6.94	12.60
Wastewater to Water Ratio (bbl/bbl)	0.78	0.93
Wastewater to Beer Ratio (bbl/bbl)	5.39	10.20
BOD Concentration (mg/L)	10,563	16,000
TSS Concentration (mg/L)	2,330	5,960

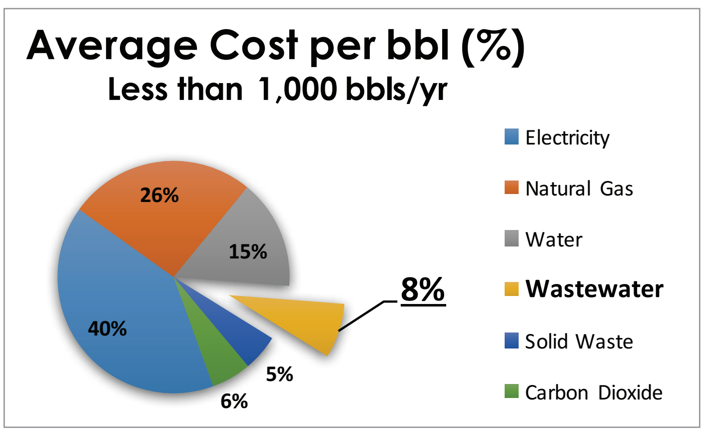
Wastewater Fees and Surcharges

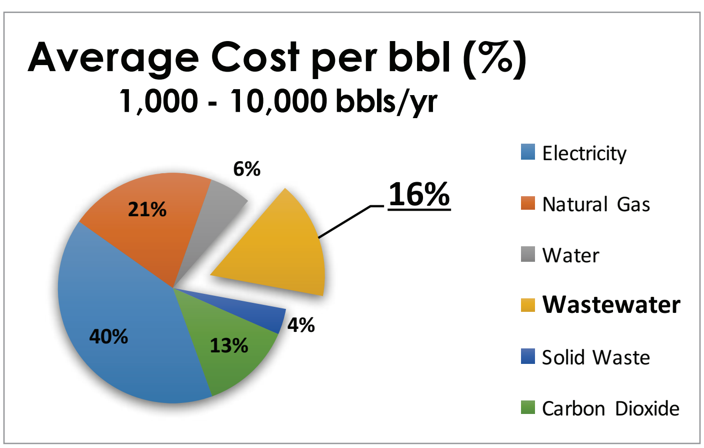
The following table summarizes wastewater cost per barrel of production. There is a wide variation in these numbers partly due to the variation in production volume among the breweries studied. Large breweries are usually at the lower end of the cost per bbl spectrum, and small brewpubs are usually at the upper end. While cost per barrel is an important indicator when assessing your own wastewater profile, there are other important factors to consider.

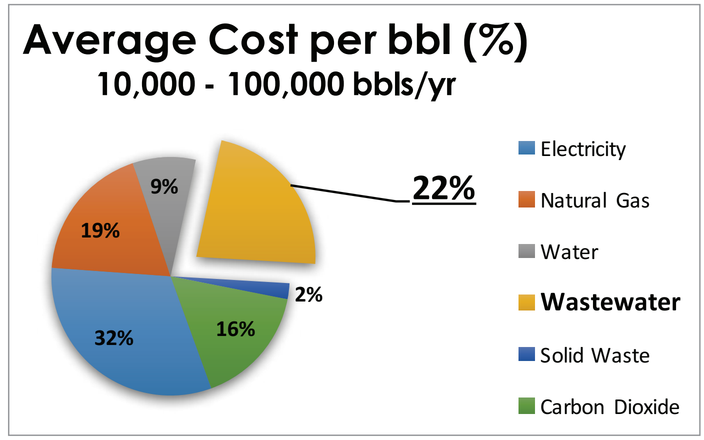
The following table shows an overview of the different cost analyses performed on the benchmarking data.

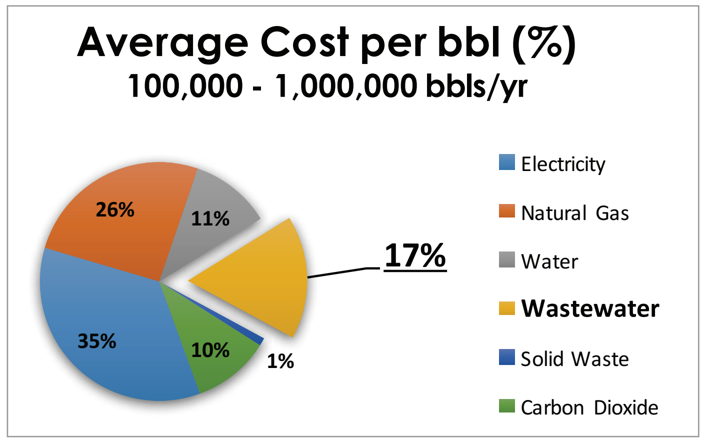
Parameter	Min	Average	Max	Typical Range
Base charge ($/bbl)	$0.08	$1.46	$4.71	0.40–3.00
BOD surcharge ($/bbl)	$0.24	$1.46	$6.79	0.75–3.00
TSS surcharge ($/bbl)	$0.06	$0.39	$1.42	0.25–1.00
Total WW cost ($/bbl)	$1.22	$4.16	$12.35	1.50–4.00

The data also shows the potential cost contribution of wastewater surcharges to overall utility operating costs.



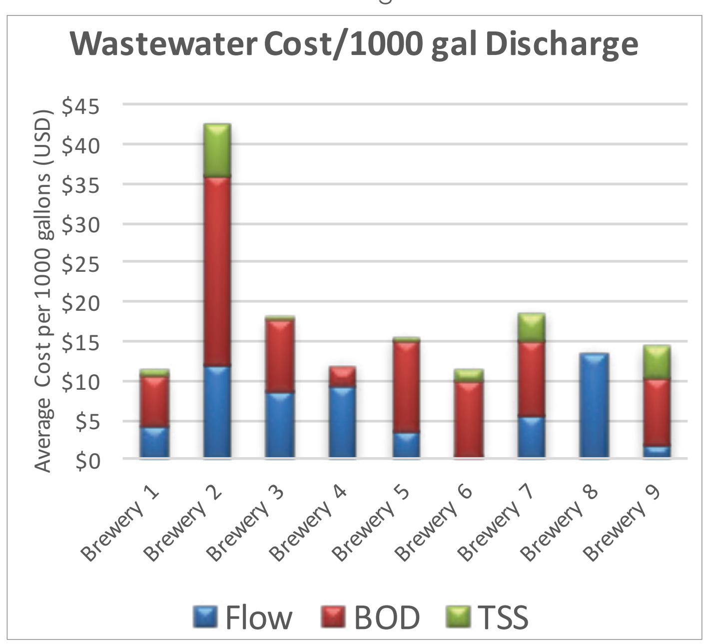






The other factor that will significantly affect cost/bbl is the municipal rate structure. See section three of this document for more information.

An additional way to view the cost data collected from the benchmarking study is on a cost per 1000 gallons discharged basis as illustrated in the following chart:



1.3 Example Calculations

Concentration (most often reported in wastewater samples as mg/L or ppm) tells how much of a substance (that is, mg of BOD) is present in a known volume of wastewater (for example, 1 Liter). However, concentration isn't the whole story since it does not tell how much (that is, mass or weight) of a substance is going down the drain over time – commonly referred to as pollutant loading. Pollutant loadings are commonly calculated on a daily basis.

While wastewater pollutant concentrations are typically reported as mg/L or ppm, wastewater pollutant loadings are typically calculated and reported as pounds per day (lbs/day).

Load is a combination of flow and concentration. Flow is usually measured in gallons or liters per day.

Think of pollutant loading this way: Imagine you have a keg of waste beer and dump it all down the drain over a ten minute period. Now imagine you take that keg of waste beer and dump it slowly down the drain over the course of the day. The pollutant loadings are the same, but the wastewater concentrations are very different.

Loading is a term that wastewater operators use when talking about the capacity of a treatment plant. BOD and TSS loadings are calculated the same way, and are expressed in pounds:

Loading in Pounds of (BOD or TSS) per day =

$$\frac{8.34 * (\text{BOD/TSS in mg/L}) * \text{Flow in gallons/day}}{1{,}000{,}000}$$

Example:

15,000 gallons/day of 6,000 mg/L BOD wastewater equals

$$\frac{8.34 * 6{,}000 * 15{,}000}{1{,}000{,}000}$$

= 751 pounds of BOD/day

The importance of understanding both concentration and loading can be highlighted by comparing two fictitious breweries. Brewery A discharges effluent with a BOD level of 2,500 mg/L, while Brewery B's discharge is 10,000 mg/L. Simply looking at the difference in concentration between the two breweries would lead us to believe that Brewery B contributes a much higher amount of organics (four times as much) into the sewer. However, we need to take into account that Brewery A discharges 1,000,000 gallons of wastewater per day (1.0 MGD), while Brewery B is a much smaller facility only discharging 50,000 gallons each day (0.05 MGD). Plugging these values into the pollutant loading formula gives the following results:

Brewery A: (1.0 MGD) (2,500 mg/L) (8.34) = 20,850 Lbs/day

Brewery B: (0.05 MGD) (10,000 mg/L) (8.34) = 4,170 Lbs/day

As this example shows, Brewery B's BOD concentration is four times higher than Brewery A. But, the loadings formula shows that Brewery A produces five times more BOD by weight than Brewery B.

Since surcharges are not only based on flow but also on loading, diluting your wastewater with clean water is not an effective way of reducing pollutant loadings or reducing costs. In fact, many municipal ordinances prohibit the introduction of clean water into the sewer as a method of dilution for compliance or disposal purposes.

section two

Municipal Discharge Requirements

2.1 Background

The vast majority of craft brewers are currently discharging wastewater to a municipal wastewater system for proper treatment and discharge to a river, stream or lake. Most municipalities have ordinances with general and specific prohibitions on what can be discharged to their piping and treatment infrastructure. This section will describe the basic requirements of a municipal sewer district and how these requirements are evolving, specifically for craft brewers.

It is important for craft brewers to understand the specific requirements of their local municipal system to avoid discharging wastewater that could cause a municipality to violate their environmental permits or to adversely affect municipal employee health and safety or the environment.

2.2 General Municipal Ordinance Limitations

The discharge from a municipal wastewater treatment plant is governed through a National Pollutant Discharge Elimination System (NPDES) permit issued by the United States Environmental Protection Agency (USEPA) or a State environmental agency. This permit affects how a municipality handles its wastewater and storm water runoff. Properly managed municipal facilities, such as publicly owned treatment works (POTWs), play an important role in protecting local water quality. These municipalities operate in a manner to ensure they can meet the requirements contained in their NPDES permits.

POTWs collect wastewater from homes, commercial buildings, and industrial facilities and transport it through gravity or pressurized piping to the treatment plant. Typical treatment consists of solids removal, pH neutralization, aeration of organic material, and disinfection of bacteria. Generally, POTWs are designed to treat domestic sewage only from nearby homes. However, POTWs also receive wastewater from industrial users. General Pretreatment Regulations are in-place to control discharge of pollutants from industrial users that might pass through or interfere with POTW treatment processes, or that might contaminate sewage sludge.

An industrial user, such as a brewery, may not introduce into a POTW any pollutant(s) that might cause interference with the treatment systems installed in order to ensure compliance with the POTW NPDES permit. A list of specific prohibitions covered under Federal regulation (40 CFR 403.5) include:

1. *Pollutants that create a fire or explosion hazard in the POTW, including, but not limited to, waste streams with a closed cup flashpoint of less than 140 degrees Fahrenheit;*

2. *Pollutants that will cause corrosive structural damage to the POTW, but in no case discharges with pH lower than 5.0;*

3. *Solid or viscous pollutants in amounts that will cause obstruction to the flow in the POTW resulting in interference;*

4. *Any pollutant, including oxygen-demanding pollutants (BOD, and so on), released in a discharge at a flow rate and/or pollutant concentration that will cause interference with the POTW;*

5. *Heat in amounts that will inhibit biological activity in the POTW resulting in interference, but in no case heat in such quantities that the temperature at the POTW Treatment Plant exceeds 40 °C (104 °F);*

6. *Petroleum oil, non-biodegradable cutting oil, or products of mineral oil origin in amounts that will cause interference or pass through;*

7. *Pollutants that result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity that might cause acute worker health and safety problems; and*

8. *Any trucked or hauled pollutants, except at discharge points designated by the POTW.*

The USEPA Office of Water, Office of Wastewater Management provides guidance to assist municipalities that own or operate POTWs in developing and implementing local pretreatment programs. Each municipality has the discretion to create additional prohibitions to ensure compliance with NPDES permits and to protect the structural integrity of their piping and treatment systems.

Local municipal codes can include other prohibitions, for example:

1. *Any rainwater, storm water, groundwater, street drainage, subsurface drainage, roof drainage, yard drainage, water from yard fountains, ponds or lawn sprays, or any other uncontaminated water;*

2. *Any matter having a temperature higher than 150 degrees Fahrenheit or at a temperature which causes the influent to the waste treatment plant to exceed 104 degrees Fahrenheit;*

3. *Fats, oils, and greases of animal or vegetable origin in a concentration that exceeds 500 mg/L;*

4. *Any strongly odorous matter or matter tending to create odors;*

5. *Any matter containing over 1.0 mg/L of dissolved sulfides;*

6. *Any matter with a pH equal to or greater than 12.5 standard units;*

7. *Any matter requiring an excessive quantity of chlorine or other chemical compound used for disinfection purposes;*

8. *Any excessive amounts of deionized water, steam condensate, distilled water, or single pass cooling water.*

Some of these prohibitions are in place to ensure proper operation of the POTW; others are there to protect the infrastructure of piping and tankage associated with conveying and treating wastewater. Most importantly, limitations on temperature and pH protect workers that may have to enter sewer systems to perform maintenance or conduct sampling.

These prohibitions can affect a brewery in many different ways. For example, many breweries are being built within commercial spaces that discharge into large POTWs. In these cases, the scrutiny of the municipality is much less than a brewery that is located in a small town where the POTW is designed to handle residential wastewater only.

2.3 Industrial User

Municipal systems primarily designed to handle residential wastewater are designed and operated in a manner consistent with receiving normal household sewage. There are various published design specifications that estimate the volume and strength of typical residential wastewater. Most of these are calculated on a per-person basis. Municipalities can then determine pollutant loadings based on an estimated number of households and an average number of persons per household.

Household wastewater characteristics (USEPA Onsite Wastewater Treatment Systems Manual; Section 3:)

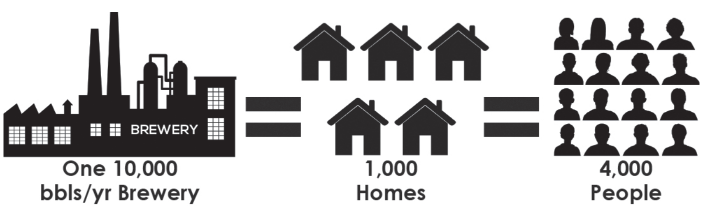
Flow = 50 – 70 gal/person/day
BOD = 155 – 286 mg/L
TSS = 155 – 330 mg/L
TN = 26 -75 mg/L

For example, the City of Fort Collins, Colorado Municipal Code Chapter 26 defines normal domestic-strength wastewater as containing no more than 200 mg/L of BOD and 250 mg/L of TSS. This is a key insight for a brewer to understand. Using these flow and concentration ranges, a brewery can estimate the pollutant loading and the equivalent number of residential discharges compared to one brewery discharge.

Brewery
Annual Production = 10,000 bbls/yr
Daily Production (250 days/yr) = 40 bbls/day
Water Usage = 8 bbl/bbl
Wastewater/Water Ratio = 0.6
Wastewater Flow = 6,000 gal/day
BOD Loading (8,000 mg/L) = 400 lb/day
TSS Loading (2,000 mg/L) = 100 lb/day
N Loading (125 mg/L) = 6 lb/day

Residential
Wastewater Flow (4 person household) = 240 gal/day
BOD Loading (200 mg/L) = 0.4 lb/day
TSS Loading (250 mg/L) = 0.5 lb/day
N Loading (50 mg/L) = 0.1 lb/day

Equivalent number of residences to one 10,000 bbls/yr brewery based on BOD loadings = 1,000 homes



This understanding of how brewery wastewater loadings can impact a municipal system designed for residential loadings is a key element in section three of this manual, Municipal Rates and Surcharges. Since homes represent a significant source of revenue to the municipality, the loss of residential growth treatment capacity is often recovered with the imposition of surcharges.

Larger municipal systems may also receive wastewater from a variety of commercial and industrial operations. To ensure proper recognition and treatment of incoming wastes, many municipal ordinances require an industrial user discharge application to be filed and often a permit or approval to be issued. New or expanding craft brewers may encounter the need to complete an industrial user discharge application and estimate the amount of flow and concentrations of pollutants sent to the POTW. Most existing craft brewers are paying for wastewater discharge services similar to a residential or commercial operation without any specific requirements beyond the general and specific prohibitions listed in the ordinance.

2.4 Significant Industrial User

Federal regulations define a "Significant Industrial User" under 40 CFR 403.3: "Any other Industrial User that discharges an average of 25,000 gallons per day or more of process wastewater to the POTW (excluding sanitary, noncontact cooling and boiler blowdown wastewater); contributes a process waste stream which makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW Treatment plant; or is designated as such by the Control Authority on the basis that the Industrial User has a reasonable potential for adversely affecting the POTW's operation or for violating any Pretreatment Standard or requirement."

This definition is important to brewers since many larger operations could be classified as Significant Industrial Users depending on production volume. For example, at a water usage ratio of 7 bbl/bbl, and a wastewater/water ratio of 0.6, a brewery operating on a five day per week schedule producing about 50,000 bbls annually would be considered a Significant Industrial User.

The implications of this categorization by the municipal treatment plant are typically:

1. The requirement to complete an application and get some form of industrial discharge permit;
2. Additional scrutiny and evaluation for pretreatment requirements at the brewery prior to discharging to the municipal system;
3. Notification of a significant user by the municipality to the State Environmental Agency; and
4. Sampling and testing requirements.

The King County Industrial Waste Program serves the general Seattle, Washington area – a home to many craft breweries. The following questions are provided as guidance for potential users of their municipal treatment system:

- *Is my business/facility considered a discharger of industrial wastewater?*

If your company or facility sends wastewater to the King County sewer system during manufacturing, remediation, cleaning, or rinsing processes, it is most likely industrial wastewater and is subject to local, state and federal regulations, and you will be required to get discharge approval from the King County Industrial Waste Program.*

**This waste differs from residential household wastewater which includes domestic sewage from toilets, showers, washing machines, and other activities.*

- *How can my business or facility obtain approval to discharge?*

Prior to discharging industrial waste to the King County sewer system, all dischargers that generate and dispose of industrial wastewater should contact the Industrial Waste Program. Staff will discuss your operation with you. Potential dischargers will be sent a permit application package if a written discharge approval is necessary. But you should strongly consider discussing your operation and what information may need to be submitted with KCIW staff prior to developing an application.

The King County Wastewater Treatment Division also has a supplemental questionnaire specific to breweries that should be completed as part of the application process.

2.5 Total Maximum Daily Loads

The goal of the Clean Water Act (CWA) is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Under section 303(d) of the CWA, states, territories, and authorized tribes, collectively referred to in the act as "states," are required to develop lists of impaired waters. These are waters for which technology-based regulations and other required controls are not stringent enough to meet the water quality standards set by states. The law requires that states should establish priority rankings for waters on the lists and develop Total Maximum Daily Load (TMDL) for each of these waters. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards.

The CWA includes two basic approaches for protecting and restoring the nation's waters. One is a technology-based, end-of-pipe approach, whereby USEPA promulgates effluent guidelines that rely on technologies available to remove pollutants from waste streams. These guidelines are used to derive individual, technology-based NPDES permit limits. The other approach is water-quality based and is designed to achieve the desired uses of a particular water. This approach may ultimately result in more stringent NPDES permit limits.

Municipal wastewater treatment plants discharge treated effluent to a water body through a NPDES permit. If the receiving water body is subject to additional restrictions under the TMDL program, the municipality may need to inventory and sample industrial users to require pretreatment of these pollutants prior to discharge by the user.

USEPA is working diligently with its partners to combat the nitrogen and phosphorus pollution problems in the United States. Nutrient pollution is one of America's most widespread, costly, and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water.

Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. Large growths of algae are called algal blooms and can severely reduce or eliminate oxygen in the water, leading to illnesses in fish and the death of large numbers of fish.

Why should brewers care about TMDL?

Brewery wastewater effluent contains levels of nitrogen from the proteins in grains. If a brewery discharges to a municipal treatment plant that is subject to TMDL requirements, there may be increased scrutiny from the municipality to ensure compliance with the POTW's NPDES permit. At a minimum, this will include additional sampling and monitoring for nitrogen and phosphorous and ultimately could lead to some form of pretreatment at the brewery site prior to discharging to the municipal system.

In the case of nitrogen, there is a cycle in which nitrates are formed which must be removed (denitrification) by the treatment plant before discharge to a river, lake or stream. Denitrification is a biological process by which nitrate is converted to nitrogen and other gaseous end products. The requirements for the denitrification process are: a) nitrogen present in the form of nitrates; b) an organic carbon source, and c) an anoxic environment.

Nitrate is commonly removed from wastewater in both industrial and municipal applications with biological treatment using nitrate-reducing (denitrifying) bacteria. Added methanol or a comparable carbon source typically serves as an electron donor for the bacteria. Because the nitrate ion is stable and highly soluble it is not amenable to removal by conventional water treatment processes such as coagulation and precipitation or adsorption and filtration.

Breweries discharge wastewater that contains nitrogen that will be converted to nitrates and must be treated and removed by the municipal plant. Breweries also produce weak wort which could be used as a "natural" organic carbon source to feed the denitrifying bacteria. So in a way, breweries can add to the nutrient problem and potentially help solve the problem! Many wastewater treatment plants are looking at chemical additions of methanol to feed the bacteria, but a few are also looking at brewery weak wort.

The City of Boulder, Colorado and Avery Brewing Co. are working together to use weak wort to help the City actually remove nitrogen at the POTW. Based on laboratory-scale experiments, the city determined this byproduct (the weak wort) includes the high levels of biodegradable carbon needed to help feed the microorganisms that break down and reduce nitrogen compounds in wastewater. This would be an interesting solution since a safe byproduct from the brewery could be used to avoid purchasing and handling chemical products.

However, do not misinterpret that this could solve all of the issues with high BOD brewery discharges. If this approach is successful, a municipality is not going to take all of a brewery's high BOD wastewater streams for this potential source of carbon. They are only looking at limited amounts of weak wort.

section three

Municipal Rates and Surcharges

3.1 Background

In section two, the concept of residential strength wastewater was introduced. Most municipalities establish rates and fees in relationship to these residential values. If a brewery discharges wastewater with characteristics higher than residential strength, they may be subject to higher rates and fees often referred to as high strength surcharges.

In many small communities, breweries may be the largest consumer of water and the largest source of organic effluent treated by the municipal treatment plant.

If breweries discharge into the sewage system for treatment at the municipal treatment plant they are often subject to discharge fees based on the actual costs of treating this high strength wastewater. Aeration basins are typically used by the municipality to reduce BOD levels. Supplying air to these aeration basins requires large blowers that consume a considerable amount of energy.

Simply put, breweries discharge large amounts of organic material which must be treated properly. This organic material is essentially food to microorganisms at the treatment plant. Aeration blowers ensure that the microorganisms have sufficient oxygen available to consume the food discharged by the brewery. A higher BOD wastewater requires more aeration and more horsepower, and ultimately the municipal plant has a higher electricity bill. Eventually the microorganisms die off and have to be disposed of as sludge. More BOD results in more sludge, which equals higher sludge disposal costs to the municipality.
These higher costs compared to treating residential wastewater are often charged directly to the brewery. In those cases there is an economic incentive for brewers to evaluate methods of reducing the amount of BOD and TSS prior to discharge.

For breweries, municipal rates usually consist of a cost per volume of effluent (flow charge) and a cost per pound of pollutant (high strength surcharge). The pounds of pollutant treated are based on estimated or sampled concentrations in the effluent.

*Flow charge = flow * ($/1000 gal) rate = $*

*High Strength Surcharge = (Actual concentration – residential strength concentration) *8.34 * flow in MGD * ($/lb rate) = $*

Each municipality has the flexibility to set unique rate structures and calculations. The methodology is written into municipal ordinances and the rate structure is usually updated and published once a year. Many municipalities have an independent board or committee that reviews and approves proposed increases in rates. Once again, these rates are for concentrations above residential strength wastewater for each affected pollutant. Given this flexibility in setting charges, breweries in planning should consider this variable in the site selection process.

As part of the *BA 2015 Sustainability Benchmarking Report* brewers were asked to report their wastewater charges. The following table summarizes the data received.

Parameter	Min	Average	Max	Typical Range
Flow ($/1000 gal)	$0.25	$6.50	$13.27	3.00–10.00
BOD surcharge ($/lb)	$0.11	$0.34	$0.69	0.20–0.60
TSS surcharge ($/lb)	$0.11	$0.16	$0.77	0.11–0.60

The wide range of rates in the study reflects the differences inherent in the location, cost structure, capacity, growth strategy and other political drivers within a municipality. It is important to remember that municipalities have a great deal of freedom to define and assess surcharges as they see fit. The values presented here may not accurately reflect the wastewater rates for your brewery.

3.2 Sampling and Analysis

The calculated amount billed by the municipality to a brewery depends significantly on the flow and concentration values assumed. Most times, these are established through physical sampling of brewery wastewater at a manhole, or other access points as it leaves the brewery property and enters the municipal system.

The sampling of brewery wastewater by a municipality can be on a grab or flow weighted composite basis. A grab sample can be very misleading, depending upon the status of operations within the brewery. Flow-weighted composite sampling will be more accurate and consists of several samples taken during normal brewery operating hours, often over multiple days.

Some breweries may be sampled as often as twice per week, and others may be sampled every six months. Most municipalities have surcharges for BOD and TSS; however, nitrogen and phosphorous surcharges are starting to be assessed based on the cost for the municipality to meet their nitrogen discharge limits under the TMDL program.

There have also been instances where breweries have been singled out for additional fees outside of the normal rate structure simply because of the nature of brewery effluent and the available capacity at the treatment plant.

A new brewery locating in a community may also face additional one-time fees and charges to reserve treatment capacity at the municipal plant.

3.3 Negotiation Strategies

A thorough understanding of the material and calculations presented in section two is essential for effectively negotiating permit limitations and rates with a municipal sewer district. Most districts have rate structures which reflect the actual cost of treatment operations. It is in the brewer's best interest to be knowledgeable and transparent with the municipality about the volume (hydraulic) and concentration (strength) of the wastewater discharged.

It is also very important to understand the driving forces and constraints of the municipality in order to negotiate a fair and equitable wastewater agreement. Hopefully, the municipality will be just as transparent during the negotiation process.

If a municipality is currently operating at or above design capacity, the chances of a brewery getting a new permit without extensive pretreatment are limited. An existing brewery discharging to this overloaded system could face new limitations that can be very difficult or impossible to meet.

If a municipality has excess capacity, it becomes a matter of negotiating an agreement that is economically acceptable to both parties.

In either case, a brewery should fully understand the characteristics of their wastewater and the options available to reduce flow or loadings. As explained in later sections, the key is to start simple with estimates and build out detail with sampling and testing as needed. This manual presents the basic assumptions, calculations and data necessary to provide an adequate foundation for reducing flow and loadings. These loadings form the basis for discussion with the municipality, whether applying for a new discharge permit or for determining the impact of an existing brewery discharge.

An early meeting with the municipal wastewater treatment team and tour of the treatment plant is highly recommended for a number of reasons:

- *To open the lines of communication and to start building a relationship of trust;*
- *To provide the brewer with an understanding of the treatment plant operational constraints and NPDES compliance issues; and*
- *To provide the treatment plant operator a better understanding of brewery discharge characteristics, especially when large concentrations are discharged in a short period of time (often called slug loadings.)*

Many municipalities have heard past stories about breweries releasing large vessels of wort or beer to the sewer system. This can result in slugs of extremely high BOD loadings that upset biological treatment systems and cause the municipality to violate their permit with USEPA. Even worse, without biological treatment systems operating properly, the discharge from the municipality can severely affect the ecosystem of a river or lake. A brewer can be implicated in these situations and be at high risk for financial penalties and a damaged public image.

Ultimately, it becomes an economic analysis to determine the optimum wastewater management strategy. If excess treatment capacity is available, it may be strategic to pay a fee to lock in or reserve that capacity for future brewery expansion. Although each case can be unique, this document outlines some practical strategies for different sized breweries.

section four

Data Management

4.1 Background

The *BA Water and Wastewater: Treatment/Volume Reduction Manual* primarily focused on primarily focused on the basics of water management and water use reduction. Section four of this manual describes additional steps you can take to further understand and reduce your wastewater discharge.

In order to effectively optimize your wastewater streams and wastewater loads, it is very important to develop a proper water and wastewater mass balance. This does not need to be a very sophisticated exercise. It will, however, provide a deeper and better understanding of your brewery's discharges.

The main purpose of developing a water/wastewater balance is to understand where your wastewater is coming from, where in the process it is discharged to the sewer, what the content of that specific wastewater stream is, the volume flow, and an understanding of the frequency, so you can determine the total loading discharged over time.

A mass balance is an accounting of a material for a specific system boundary. In other words, you are keeping track of all sources of the material that enter the system, all sinks of the material that leave the system, and all storage of the material within the system.

The mass balance can help provide you with the following insights:

- The sources that contribute the most to wastewater loadings;
- The effect if you successfully minimized a given source; and
- The discharges you should focus on and how you can prioritize your wastewater minimization efforts.

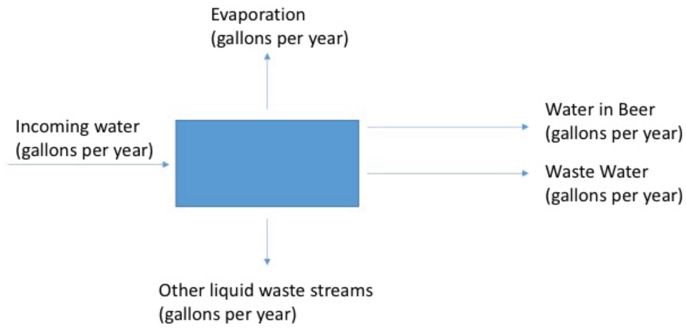
A balance shows the relation between incoming and outgoing water.

4.2 Incoming water and outgoing wastewater

First, determine the annual amount of incoming water and make a simple overview of outgoing wastewater discharges.

A portion of outgoing water is in the product, in spent grains/ solid residuals, and lost to evaporation. The remainder will be discharged as wastewater.

Build a simple water balance.



As shown in this water balance exercise, both the water use ratio (water used versus beer production) and the wastewater/water ratio discussed earlier are important brewery parameters. The higher the wastewater/water ratio, the more water sent to the drain.

4.3 Inventory of Drains

To further understand the outgoing water, start by making an inventory of all drains in the brewery. Be sure to include the tap room, restaurant and other areas of the building(s). This should include both sanitary (washrooms, etc.) and process drains. Pay particular attention to automated drain sequences from the brewhouse.

The purpose of the inventory is to determine where wastewater is generated and all the ways that wastewater can enter the sewer system.
Look around the brewery and find:

- Where pipes are indirectly connected to a sewer or drain system.
- Where pipes are directly connected to a sewer or drain system.
- Where water is being drained from the floor.
- Where water is leaking.
- Where water is being used that is not specifically for beer production.

This information can be gathered during an intensive walk through the brewery. It may require following some pipes or even looking under certain tanks and equipment.

When specific drains have been identified, the next step is to estimate the volume discharged. The most accurate method for doing this is to use a (mobile) flow meter, but a simple "bucket and stopwatch" measurement can be used. (These measurements do not need to be 100% accurate.) The purpose of this water balance exercise is to help determine where the main sources of wastewater come from, and to help focus efforts for wastewater reduction.

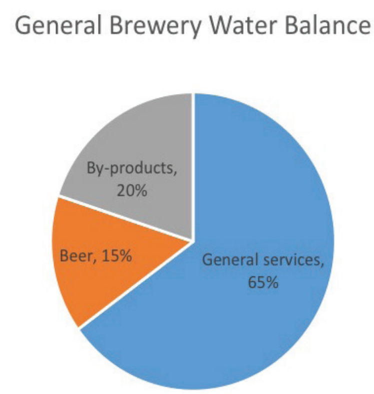
Also determine how often this specific drainage occurs. Is it a continuous stream of water or wastewater, or does it only happen during a certain period of the day or during a certain step of the brewing process? Determine the frequency and duration of each identified drain.

Once all the information is gathered, enter it in a simple table.

Location	Description	Flow (gpm)	Frequency & Duration	Annual Flow (gallons)
Mash tun	CIP water	10	30 min/day, 100 days per year	30,000
Brew kettle	Condensate	2	6 hrs/day, 200 days per year	144,000
Fermentation	Spent yeast	3	4 hrs/day, 200 days per year	144,000

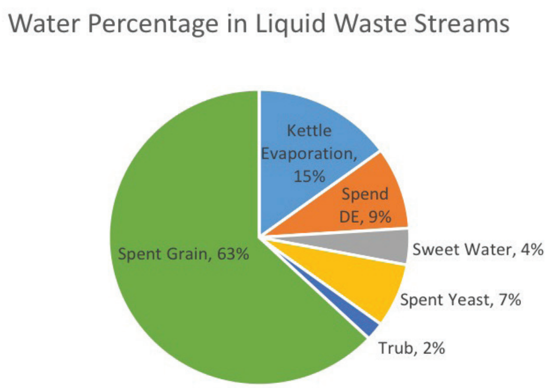
A water balance represents all water going into the brewery and all wastewater going out of the brewery. To complete the balance, identify the other sources that contribute to water leaving the brewery. The following parameters can be helpful in conducting a water balance:

Water in Beer
To determine how much water is leaving the brewery in the form of beer, estimate the average alcohol percentage of total beer production. If a barrel of beer contains an average of 5% alcohol, the remaining 95% can be considered water.



Water Lost to Evaporation
Evaporation losses depend very much on the brewing process, utilities and climate. For example, breweries with cooling towers will evaporate more water than those without. If you don't have any data specific for your brewery around evaporation losses, for the purpose of this exercise use 15% evaporation losses during the brewing process (particularly from the brew kettle). If you are recovering that vapor, you can reduce evaporation losses accordingly.

Water in Residual Waste Streams
Take a sample of residual waste streams and determine the water content. A simple method is to weigh a small sample and then have it dry completely. Then weigh the remains. This will yield a good approximate of how much water has been evaporated and thus how much water was in the original sample. The next diagram shows some average water percentages in liquid waste streams.



Finally, also measure the total wastewater flow sent to the POTW plant. If there is more than one sewer line, you should sample all of them.

4.4 Sampling and Analysis

You are now ready to start collecting data to determine the wastewater content or pollutant concentration of each stream. This will enable you to develop the mass balance more completely. You do not need to sample all drains; you only need to sample drains that contribute the most to your wastewater profile.

Again, you should sample your final, combined, wastewater flow to the POTW plant. If you have properly separated sanitary from process sewer lines, there is no need to sample the sanitary sewer discharge, only the process line.

Location	Description	Flow (gpm)	Frequency & Duration	Concentration (mg/l)	Loading (lbs/day)
Mash tun	CIP water	10	30 min/day, 100 days/year	500	1.25
Brewkettle	Condensate	2	6 hrs/day, 200 days/year	250	1.50

To accurately measure the final wastewater sent to the municipality, you could use an automated wastewater sampler. See web links at the end of this document for examples of sampling equipment.

Most wastewater test results will be reported in either milligrams per liter (mg/L) or parts per million (ppm). These two units are interchangeable. However, make sure you always note the units reported. Some wastewater parameters (for example, heavy metals) are often reported in smaller units such as micrograms per liter (µg/L) or parts per billion (ppb).

Once you have an understanding of the wastewater quality and its parameters, it is also important to consider what influences have an effect on those parameters. For example, certain brews can have a significant effect on your wastewater profile. You might have a particular baseline profile that can be completely skewed by one CIP of your mash tun. This knowledge will help you determine what techniques could be applied to lower your overall wastewater load.

With the information retrieved from the samples, it is now also possible to develop a wastewater mass balance. To do this we add two extra columns to our initial table and calculate the total mass for a certain time frame per discharge point.

section five

Best Practices

5.1 Background

The Brewers Association *Water and Wastewater: Treatment/ Volume Reduction Manual* focuses mainly on possible water use reduction best practices. It provides general methods that craft brewers can apply in order to reduce their water consumption and lower their wastewater flows.

The focus of this section is wastewater and load reduction best practices in order to lower POTW surcharges.

The following table shows some methods to treat wastewater and specific parameters (BOD, TSS, and pH.) Examples and descriptions of these measures will be discussed later in this section.

Containment of concern	Side Streaming	Screening	Settling/ equalization	Chemical Addition	Biological treatment
BOD	X		X		X
TSS	X	X	X	X	X
pH			X	X	X

Physical treatment of your wastewater is a key step to reducing your wastewater streams at the brewery. Traditional physical treatment methods such as screening, settling, sedimentation, flotation and filtration can be applied in order to remove some solids, consequently reducing BOD and TSS. Screening and settling are the two most commonly used methods. All of these applications require some regular level of attention and maintenance.

Side streaming wastewater from spent grains, spent yeast, trub, wort and beer may be the most cost-effective step to lower BOD and TSS surcharges.

5.2 Best Practices

The following best practices are for reducing water consumption and lowering your wastewater surcharges. Some of these practices have already been mentioned in the BA *Water and Wastewater: Treatment/Volume Reduction Manual*. We mention them again in this manual to emphasize their significance.

It is important to always challenge the status quo ("the way it has always been done") when looking for water and wastewater reductions. The following questions can be useful when starting a water reduction initiative or when performing regular reviews of a mature program:

- Is the process or activity necessary?
- Is it necessary to use water?
- Why does the process use so much water?
- Can the amount of water be reduced?
- Can lower quality water be used?
- Can water be recovered elsewhere?
- Is the process authorized and legal?
- Is it necessary to produce wastewater or effluent?
- Is clean water going down the drain?
- Is the discharge authorized and legal?
- Would it be cost effective to treat wastewater or effluent on site for re-use?

Several simple best practices were identified during discussions with small brewers in the preparation of this guidance document. A few are listed below by process:

Mashing and Brewing

- Do not overfill vessels. Train staff to add the correct amount of liquor and consider installing a meter to measure the volume of liquor being added.
- If new batches are frequently brewed, store surplus wort and add it to the next brew.

Fermentation

Fermenters can be the source of almost half of the BOD content and almost 70% of the suspended solids content of a typical brewery. Therefore, it is important to understand possible water use reduction practices that will help reduce your wastewater flow and load in this process.

- Do not fill your fermenter vessels too full. This can cause massive blow-offs of beer and cause BOD and TSS to be discharged to the sewer.
- Use short bursts of water to rinse soil from vessel wall. Screen particulate out of rinse water before sending to drain.
- Collect trub and excess yeast from the bottom of the vessel. Dispose of solids instead of sending to drain.
- Monitor the pH of acidic cleaning and sanitizing solutions. Neutralize acidic solutions before sending to drain to protect sewage infrastructure

CIP systems

Using a clean-in-place system (CIP) is generally more efficient than manual cleaning. The advantages include:

- Increased vessel cleanliness due to chemicals and high temperatures employed.
- High levels of automation.
- Reduced water and chemical consumption.

Due to high levels of automation, it is possible to better control flows, pH, and temperature compared to manual operations. These are parameters that are important when managing your wastewater flows and loads.

Simple systems use the vessel to be cleaned as a detergent reservoir. The most complex systems are multi-channel, with tanks for detergent, pre- and post-rinses, and sometimes disinfectant.

With complex systems also come ease of operation, repeatability, and reduced running costs, but at the expense of higher installation charges and reduced flexibility in terms of the ability to adapt to plant or product changes.

It may be possible to reuse water and detergents from some washing operations to clean the mash tun. For example, detergents used to clean the fermenter could be stored and subsequently transferred to the mash tun. After cleaning the mash tun, the same detergent could be reused to clean the copper.

You can install a water tank so that the final rinse water can be recycled to the pre-rinse stage. To prevent overflows from the recovered water tank, make sure that the volume of the water used in the final rinse and the pre-rinse roughly balances.

5.3 Sanitary vs. process wastewater

Brewery wastewater generally falls into one of several categories:

- Floor drains in the brewery, which collect spilled or overflow areas
- Hard piping of brewing process effluent directly to the sewer

Also, there are often two other categories to take into account:

- Kitchen drains, which may contain grease
- Restrooms, which typically go directly to the POTW

Since these last two categories are so different from general brewery wastewater, they should be handled as separate cases.

Sanitary drains should flow directly to the sewer, and your kitchen will probably need a grease trap before going to the sewer. This sounds obvious, but when managing wastewater it is very important to verify that your brewery has separated brewery wastewater from sanitary water. By not combining the two wastewaters under your slab, you avert the possibility of having to separate them in the future, as well as the possibility of having to treat your kitchen and restroom wastewater because you cannot dig up the slab.

5.4 Solids removal

There are a few simple ways to keep settleable solids, like glass and caps, out of the wastewater, including keeping screens in the drains. Using the correct gauge of screen aids in ease of access, but make sure workers do not dump these solids down the drain, like they would at a kitchen sink. Workers may also remove screen plugs for cleaning and then forget to put them back in. Also, if you have a wastewater collection tank downstream, use a basket at the end of the line to catch big things like wrenches, pallet chunks, bottles, caps, and shrink wrap. If the basket gets plugged, make sure it can easily overflow into the tank.

You also want to keep the grains out of your sewer discharge. One reason is the high BOD content we discussed earlier, but they can also cause blockages in your sewer system.

Coagulation/Flocculation Chemicals

Some brewers have taken advantage of old unused vessels to settle out TSS through coagulation or flocculation. The addition of wastewater chemicals such as aluminum sulfate (often referred to as "alum") and polymers are often used to help either precipitate or float solids. Alum helps float fatty acids by allowing them to attach to the alum so they can be skimmed off. Polymers have varying molecular chain lengths attached to solids and either float or sink to the bottom so they can be skimmed, drained, filtered, or centrifuged. This type of chemistry is typically used for the high water volume of users that have some residence time to allow for the settling or flotation. For this type of chemistry, special equipment also has to be installed to either skim off or remove the solids, depending on the type of contaminant to be removed from the wastewater.

5.5 Side streaming options

Side streaming consists of separating high strength, concentrated wastes at the source and setting them aside for disposal.

Sources of this high strength wastewater include fermenter bottoms, spent yeast, returned beer in kegs, fermenter blow off, and beer in hoses or pipes at the beginning or end of a packaging run, but the primary source is the brewhouse.

Side streaming is an extremely effective method of reducing BOD because effluent from fermentation and filtration typically account for only 3% of wastewater volume, but as much of 97% of the BOD load. The TSS reduction can also be substantial from the removal of spent yeast and trub.

Photo credit: Bell's Brewery, Inc.

Often a challenging part of side streaming is finding a responsible way to dispose of the high-strength side-streamed waste. With its high protein content (40%) spent yeast, for example, can be a suitable animal feed supplement. But the high water content (80-90%) can make it too difficult or too expensive to transport and serve to animals. The various possible uses for the side streamed waste streams are summarized in the table below.

Co-product	Source	Attributes	Possible uses
Spent Grain	Lauter Tun	High Carbohydrate, protein	Cattle Feed
Sweet Water	Lauter Tun	High Carbohydrate	Animal Feed
Spent Hops	Brew Kettle	High Carbohydrate	Animal Feed, Soil amendment
Trub	Whirlpool Tank	High Carbohydrate	Cattle Feed
Spent Yeast	Tank Bottoms	High Protein	Animal Feed, Distillation
Spent DE	Filtration	Porous Silica	Soil amendment
Ullage	Racker	Ethanol	Distillation

Spent grain and trub can be mixed together and sold (or given for free) to farmers as cattle feed. These materials should not be directly applied to crops intended for human consumption without careful evaluation and regulatory approval. Side-streamed products can also be applied as fertilizer addition, or added to compost.

Side streaming considerations:

- *More work*
- *More space is needed*
- *Odor control can be a problem*
- *Not needed if there is no enforcement*
- *Not needed if no surcharges*
- *Not recommended if cost of hauling is higher than savings of reduced surcharges*

Since spent yeast may contain traces or even large portions of active yeast, precautions have to be taken while sending it out as ruminant animal feed.

It can be used as a low-cost feedstock for ethanol production, which is probably the highest end-value application of the spent yeast waste product. Ethanol made with fermentation waste is reportedly better for the planet than relying on standard production methods, such as growing vast fields of corn.

With proper care of use, live yeast can be a healthy part of a typical cattle diet and does not require any heat (or acid) treatment at the brewery.

TIP: Write up an agreement with your spent yeast end user to let them know that you are shipping live yeast and agreeing that the use of this material as cattle feed is their responsibility.

Occasionally you will end up with beer that is out of specification. In addition, old kegs are often returned with some beer left in them. These sources can also be side streamed out of the process sewer system.

When you have collected all the side stream material, place it in a tank. Outdoors is preferable in order to dissipate any unpleasant odors. You could use one big tank or several used chemical totes.

Photo credit: John Mercer, Brewery Wastewater Design

Due to the higher water content of side streams, breweries in colder climates need to take steps to prevent waste streams from freezing when stored outside.

There are a few options for collection, transport and disposal:

Gravity
The easiest method for collecting side-stream material is to use an equipment drain. An equipment drain is very similar to a floor drain, but there is no actual drain. Instead a pipe extends up through the floor about 6 inches. This prevents other material from entering the pipe. Specific high-strength materials, like trub and spent yeast are piped or hosed into the equipment drain. Everything else enters the normal floor-drain system.

An equipment drain requires a separate set of drain lines under your slab: one set for floor drains and another set for side-stream drains. When building a new brewery or tearing up the slab in an existing building, this is definitely the preferred way to proceed.

Only a few of these side-stream equipment drains are needed:

- One in the brewhouse area
- One to two in the cellar area
- One to two in the packaging areas

Photo credit: John Mercer, Brewery Wastewater Design

Pump
Pumps are needed to transport the streams collected. If tearing up a floor slab isn't feasible, and of course it often isn't, a pumped collection system works fine. Materials would be collected in small, simple vessels (trash can, stainless crab pot) and pumped in to an overhead collection pipe, and delivered to storage vessel (tank or tote). Double diaphragm and pneumatic diaphragm pumps work fine. Be sure your pumps can handle solids, and pumps used in the brewhouse should be able to handle high temperatures.

Photo credit: John Mercer, Brewery Wastewater Design

A "portable floor drain" made of stainless steel that can be wheeled around is needed to pump your waste stream out from the bottom of the tank. A pump with short casters on it is preferred, as it can pass under a whirlpool or lauter tun.

Disposal
In some circumstances and with the proper regulatory approval, material can be deposited on fields as is. Application to hay crops or pasture land is possible with proper regulatory approval. Generally the price of the fertilizer content of the material is lower than the cost of hauling, so you may have to pay out-of-pocket for removal.

If you are using the material as animal feed, make sure you are indemnified for any misuse of this product by the hauler/farmer; it can cause bloating and other undesirable side effects in livestock when not correctly monitored.

Other potential disposal options are:

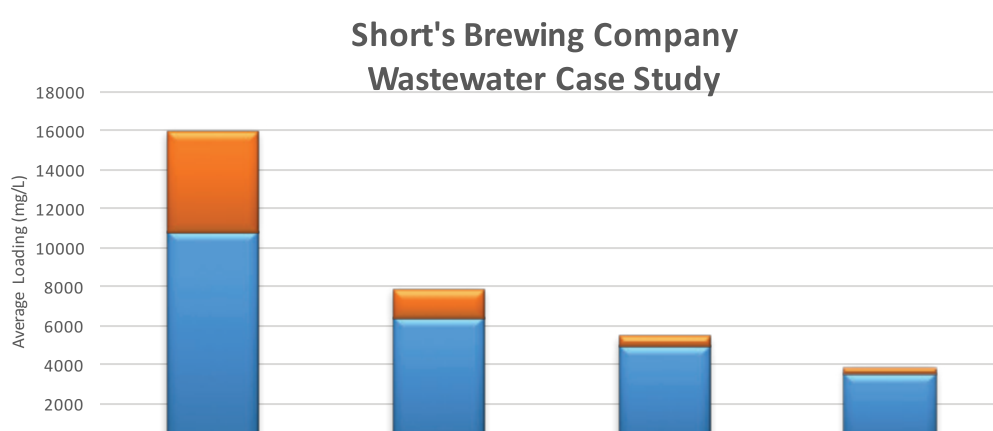
- Delivering direct to the local wastewater plant to assist with denitrification or to their anaerobic digesters for methane potential.
- Delivering to a commercial compost facility as a carbon and water source.
- Delivering to a fertilizer plant.

Some Examples:

Shorts Brewing Company *has measured the effect on BOD/TSS caused by their side streaming projects. The chart clearly shows the big effect side streaming has had on their BOD and TSS numbers. From a base scenario of a BOD concentration of ~ 10,000 ppm and TSS of ~ 5,000 ppm, they were able to lower their loads to 3,550 and 580 ppm respectively.*

Odell Brewing Company *in Fort Collins, Colorado used to give their spent yeast, trub and waste beer to the same farmer that purchases their spent grain for cattle. The farmer applied it to his grass fields as fertilizer. More recently, Odell is working on an agreement with the City of Fort Collins to beneficially use the spent yeast as an aide in wastewater nitrate removal.*

Iron Horse Brewery *in Ellensburg, Washington has found a symbiotic business relationship with Natural Selection Farms. Natural Selection Farms uses the spent yeast, trub and waste beer from Iron Horse as compost material. Iron Horse uses IBC totes to collect yeast. Eventually it is pumped into a 6,000 gallon outdoor tank where a tanker truck picks up about 5,500 gallons of brewing byproduct once a week for a cost to Iron Horse of about $250 per load.*



Effluent Notes	BASELINE	NO YEAST	NO YEAST , TRUB, or WEAK WORT	NO YEAST, SUGARS, OR CELLAR
TSS (mg/L)	5130	1430	540	280
BOD (mg/L)	10830	6420	4900	3550

section six

Zero Liquid Discharge

Zero Liquid Discharge means that your brewery is reclaiming and reusing all of its wastewater. The only water leaving the brewery is in product or from evaporation and water in the product/residuals. This has traditionally been a future aspiration or vision, but with the frequency and prolonged duration of droughts and other water shortages, this vision may be getting closer to reality.

In order to pursue a "Zero Liquid Discharge" status for your brewery, the following steps should be taken. The process follows the same approach as many other environmental strategies (like solid waste and carbon) – Reduce, Reuse, Recycle.

6.1 Reduce

These are your water and wastewater reduction projects, and it includes lowering the water use of your brewery in order to save money and send less water to the drain. All efforts in this first step are focused on minimizing your water intake and thus minimizing your wastewater discharge.

This guide and the *Water and Wastewater: Treatment/ Volume Reduction Manual* illustrate several best practices and examples of what you can do to minimize and reduce your water consumption.

6.2 Reuse

The next step is trying to reuse wastewater flow that would otherwise discharge and use it for another purpose within your brewery.

Examples and best practices for reuse are provided in the *BA Water and Wastewater: Treatment/Volume Reduction Manual*. Also, the drain inventory performed in your brewery, as described in the Data Management section of this manual as part of your water mass balance, is of real help here.

When you have identified a wastewater stream and performed analysis on those flows to understand the impact on your total wastewater characteristics, you should also be able to identify possible wastewater sources that may be reused for other purposes.

Residual water in the brewing process, for example:

- *Residual water in mash tun*
- *Residual water in whirlpool*
- *Residual water in lauter tun*
- *Packaging water;*
  for example keg washer discharge
- *Other sources including:*
  - *Vacuum pump discharges*
  - *Seal pump discharges*
  - *CIP final flush*

This reclaimed water could be reused in hose stations in the spent grain area, as landscaping water, as water for CIP pre-rinsing, for floor washing, or as make-up water for your boiler or cooling tower.

6.3 Recycle

Once you have optimized your water use in the brewery as much as possible, the last step of a 'Zero Liquid Discharge' strategy is recycling or treating your actual, final wastewater. This means that you take the final effluent flow and treat it onsite to make "new" water for appropriate application.

The prospect of treating process wastewater and redirecting it back into faucets is considered by many the future of California. Such recycling, which involves treating water that washes down the drain until it is pure, would save hundreds of billions of gallons that is now dumped into the Pacific Ocean annually.

section seven:

A Practical Perspective on Brewery Wastewater

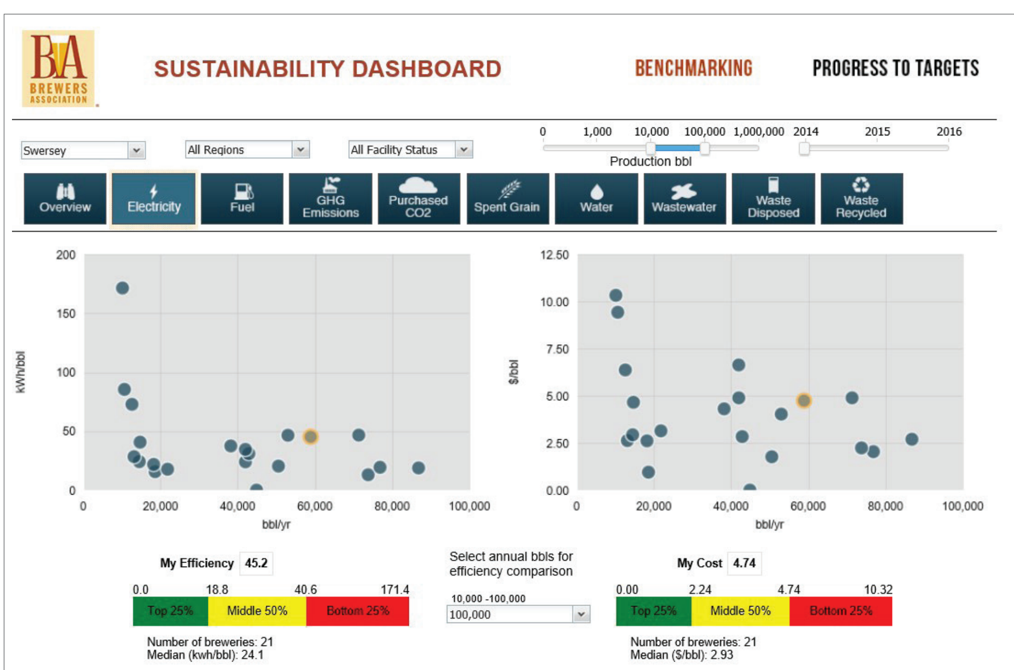
7.1 Introduction

It is easy to get overwhelmed by the technical information presented in this and other related sources of wastewater management. This section attempts to keep it as simple as possible, presenting practical steps for wastewater management at different sized breweries. Of course, each approach is dependent upon unique site-specific variables; however, the approaches discussed in this section will provide a starting point for evaluating the best alternatives for your facility.

7.2 Less than or equal to 1,000 bbls per year

1. Read and track your utility bills.
2. Develop a simple water balance. Focus on volume.
3. Understand your ordinance restrictions.
4. Benchmark your performance against others. Enter and track your data using the Brewers Association Sustainability Benchmarking Tools.
5. Look for continuous improvement opportunities. Reference the BA Sustainability Manuals for ideas.

Tracking utility billings, setting targets, and benchmarking performance against peers has become much easier with the release of the BA Sustainability Benchmarking Tools.



7.3 1,000 – 10,000 bbls per year

1. Read and track your utility bills.
2. Develop a water balance. Focus on volume and loading.
3. Understand your ordinance restrictions
4. Benchmark your performance against others. Enter and track your data using the Brewers Association Sustainability Benchmarking Tools.
5. Look for continuous improvement opportunities. Reference the BA Sustainability Manuals for ideas.
6. Evaluate the feasibility and economics of side streaming options.

As an example, let us consider a brewery with an annual production volume of 5,000 barrels that is currently paying $15,000 per year in BOD and TSS surcharges. It is reasonable to estimate that spent yeast side streaming could reduce BOD and TSS loading by at least 25%. It is also assumed that the yeast would be given away free of charge, and that the brewery can tolerate up to a 3-year payback. In this case, up to $11,250 could be invested to implement a solution for collection, storage and removal. The annual savings would then be $3,750 per year or more.

7.4 10,000 – 100,000 bbls per year

1. Read and track your utility bills.
2. Develop a water balance. Focus on volume and loading.
3. Understand your ordinance restrictions.
4. Benchmark your performance against others. Enter and track your data using the Brewers Association Sustainability Benchmarking Tools.
5. Look for continuous improvement opportunities. Reference the BA Sustainability Manuals for ideas.
6. Implement side streaming options.
7. Evaluate feasibility and economics of simple pretreatment systems.

Consider a brewery with an annual production volume of 50,000 barrels that is currently paying $75,000 per year in BOD and TSS surcharges. The brewery has already implemented side streaming of yeast and spent grain. The next step would be to consider additional solids removal through wastewater screening. A wastewater screening vendor promises a 15% reduction in BOD and TSS for $30,000. If this claim is valid, you would pay for the system in 2.7 years with an annual savings of $11,250.

7.5 Greater than or equal to 100,000 bbls per year

1. Read and track your utility bills.
2. Develop a water balance. Focus on volume and loading.
3. Understand your ordinance restrictions.
4. Benchmark your performance against others. Enter and track your data using the Brewers Association Sustainability Benchmarking Tools.
5. Look for continuous improvement opportunities. Reference the BA Sustainability Manuals for ideas.
6. Implement side streaming options.
7. Evaluate feasibility and economics of full scale pretreatment systems. See next section of case studies.

section eight:

Wastewater Pretreatment Case Studies

As a general rule of thumb, the justification of on-site biological wastewater pretreatment has historically not been economically or technologically justified for breweries under approximately 250,000 bbls packaged per year. Of course there are always unique situations and exceptions to this rule of thumb.

Many smaller breweries, especially those under 100,000 bbls packaged per year are facing wastewater disposal decisions that warrant a closer look at on-site pretreatment. Wastewater treatment companies are beginning to enter this smaller market with new and innovative technologies. They are advertising a small footprint, simple plug and play installation that can be economically justified. As of the date of this publication, it is too early to judge the validity of these claims. However, as brewers gather operating experience with these units this vision could become a reality.

This section will begin to identify some breweries faced with unique situations where an on-site pretreatment system made financial sense or reflected the only option available to remain in operation. Several other breweries were contacted for case study information for inclusion in this section. Most reported they were in the construction or start-up phase and reluctant to share their experiences at this time. The Brewers Association Sustainability Subcommittee is evaluating more timely communication options to better alert member companies of new developments in this area.

The following case studies reflect brewers that installed on-site wastewater pretreatment systems in response to some unique challenges. Examples of larger brewery pretreatment systems are available in the Brewers Association Water and Wastewater: Treatment/Volume Reduction Manual.

Real Ale Brewing Company operates in Blanco, Texas and discharges production and process greywater to the municipal sewers. As production increased from 5,000 barrels in 2006 to 60,000 barrels in 2014, gray water averaging 6,000 mg/L BOD and 750 mg/L TSS threatened to overwhelm the aging municipal wastewater treatment plant.

"Our city officials have always been strong partners," says Tim Schwartz, director of brewing for Real Ale, a craft brewery in Blanco, Texas. "They allowed us to continue operations while we built a pretreatment facility. Meanwhile, we side streamed some high BOD items into a haul-off tank, which reduced BOD loading to 4,500 mg/L and TSS to 300 mg/L."

The newly installed pretreatment system has lift stations, screening and dewatering equipment, pH balancing, and an aerated lagoon. The system, which went online in June 2013, has reduced BOD strength significantly. It requires weekly maintenance such as cleaning the screens, emptying and rotating the hoppers, and topping off caustic and microbe levels. Twice daily, staff members pump the cone-bottom tank for five minutes, sending a total of 80 gallons of dense sludge to a diversion tank.

"The lab measures TSS, dissolved oxygen and chemical oxygen demand and checks pH," says Schwartz. "Fortunately, the pretreatment system is fairly hands-off, because we're brewers, not wastewater operators. That was the most challenging aspect of running the system."

New Glarus Brewing Company operates in New Glarus, Wisconsin. The village of New Glarus, WI, has a population of about 2,100 people. The New Glarus brewery would have overwhelmed the public waste-water plant and the surcharge penalties would have been severe. Therefore they opted to build their own treatment facility. The project objectives were to construct a system that was easy to operate, simple to maintain and be expandable to handle future brewery production increases. It needed to be aesthetically pleasing, economical to operate, and provide consistent high-quality effluent while eliminating land application of the brewery's high strength wastewater.

The system features primary and secondary treatment. Primary treatment consists of flow equalization, screening, and dissolved air flotation clarification for removal of particulates. Secondary treatment is accomplished with activated sludge with membrane clarification (ASMC). The entire system is controlled and monitored with a programmable logic controller and data-logging industrial computer.

The submerged membranes replace the passive settling clarifier in a conventional activated sludge process. This filtration process is not adversely affected by filamentous bacteria and consistently produces high quality effluent by providing a positive barrier to suspended solids.

Since the ASMC system allows more microorganisms per unit volume, a much smaller footprint is required than a conventional activated sludge system allowing the entire ASMC system to fit in a 52ft × 52ft (250 m2) area.

The wastewater treatment system consistently achieves BOD and TSS reductions of well over 95% or more. The effluent averages 6.2 mg/L BOD and 10.3 mg/L TSS. The whole plant was then hidden behind a Wisconsin red barn.

Upland Brewing Company operates a beer production facility and a wood aged sour facility in Bloomington, Indiana. Both facilities use similar equipment to collect and reduce the amount of BOD and TSS sent to the municipal sewer system.

The configuration consists of two 2,000 gallon tanks to pretreat wastewater. The first tank is primarily used to allow settling of solids. The next tank is used to neutralize pH and reduce phosphorus with alum treatment before releasing to the municipal sewer system. The sludge is then pumped from the bottom of the tanks every other week.

Lagunitas Brewing Company operates in Petaluma, California. Historically, Lagunitas transported its 50,000 gallons per day of high-strength wastewater to East Bay Municipal Utility District, requiring over 3,000 trucks a year. This is a reality for many breweries, as breweries produce wastewater streams rich in nutrients (food source) that disrupt biologically based municipal wastewater systems. The wastewater should then be treated to comply with environmental regulatory standards and comes with both monetarily and environmentally high costs.

A newly developed pretreatment solution uses electrogenic organisms to generate clean energy from wastewater. These recently discovered organisms convert wastewater pollutants into electricity, which is subsequently funneled to a circuit and back into an electrode where a different set of microorganisms convert electricity and carbon dioxide into methane fuel—forming a complete treatment process. The methane can be used on-site for clean power and heat production.

The treatment system is a robust, end-to-end, anaerobic wastewater treatment solution that can be rapidly installed and scaled across a range of BOD loadings. Its bioelectric capability allows for continuous remote monitoring and control. The system is prefabricated and provides for turnkey installation and can easily accommodate facility expansion, as well as new system installations. These attributes minimize installation and operation complications.

Bear Republic Brewing Company is located in Cloverdale, California and has achieved a 3.5 to 1 water use ratio in a drought stressed region. After an extensive onsite pilot test, they are installing the world's first bio-electrically enhanced wastewater pretreatment. This scalable system will create high quality methane and provide 25 percent of hot water heating and close to 30 percent of electrical needs.

Photo from Bear Republic

They also installed a Membrane Bio Reactor to further reduce BOD loading down to below 3 mg/liter. Much of this water can be reused within the brewery in applications such as cooling towers, boiler feed water and non-product contact wash down.

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