# RESIDUALS BIOSOLIDS SLUDGE

A Curriculum Infusion for Secondary Teachers

# Residuals – Biosolids – Sludge
## Curriculum Infusion Unit

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# Table of Contents

# Table of Contents

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# Foreword

When I was approached by the Florida Water Environment Association (FWEA) Public Communications and Outreach Committee Chair, Shea Dunifon, to update and adapt my 2005 "Residuals- Biosolids- Sludge" infusion unit for today's use, I was delighted! Shea was perfectly in tune to the original intent of my biosolids work. Positive change and adaptability are a stalwart foundation of education. Understanding those basics of education, she enlisted teachers, engineers, graphic artists and municipalities who have helped us make a somewhat dated educational reference into a freshly invigorated edition that is current and extremely relevant. This work is for you teachers, the facilitators of learning. We hope and trust that this work will serve you well.

When one considers how to facilitate people's learning about any concept, there are numerous ways to do so. For the topic of biosolids, infusion is an excellent way to do so. What is infusion? Infusion involves a multidisciplinary approach to learning. For use in a formal educational setting, it is an adaptable approach where biosolids would not simply be taught in a single traditional class subject area such as science. Learning about biosolids could and should be experienced in any class subject area. Biosolids knowledge and understanding would be infused or incorporated into all aspects of the curriculum. This approach is one that introduces knowledge, attitudes, and psychomotor skills into the student's holistic learning environment and experiences. Approaching biosolids from a multidisciplinary infusion approach creates an environment where the students can develop a holistic reference base that serves as a starting point for future guidance all their lives. Any future encounters with biosolids issues will be as biosolids literate citizens.

This updated and current teacher's biosolids infusion unit edition is intended to be an inspiration, guidance, reference, and a point of departure. Due to the ever changing nature of biosolids, this infusion unit is assuredly not the absolute authoritative reference for biosolids. It is, however, an effort to

# Foreword

provide the best and most accurate possible current teacher resource on the subject of biosolids that could be developed. This updated current edition continues the initial edition's intent to serve as an ongoing resource into the future.

The issues and elements involved with biosolids continue to be varied and wide ranging ones that cannot be completely addressed in any single curriculum resource such as this unit and that is not its intent. This updated edition is an educational resource that is to be used in any manner deemed relevant. Teachers understand their students and the needs of those students. It is hoped that this educational resource will provide a springboard from which you, the teacher, may confidently address the complex changing and challenging world of biosolids. All of us are participants in the world of biosolids. An overwhelming urgency continues to exist facilitating people's understanding of biosolids, because biosolids are definitely part of our lives. Facilitating the creation of a biosolids literate citizens is the primary goal of this curriculum infusion unit.

Energetically remaining true to the intent of adaptability, I hope that you will use this book to help you address the changing and challenging world of a subject that evokes varied responses. This biosolids guide provides you with knowledge and understanding venues to address the many aspects of biosolids education. Lastly, from experience, it is advised that you remain patient with a sense of humor, as that approach will enable you to successfully facilitate biosolids literacy education.

Philip N. Kane, Ed. D.

Phil Kane, Ed.D
2005
3/31/2021 edited

# Notes

# Teacher Background

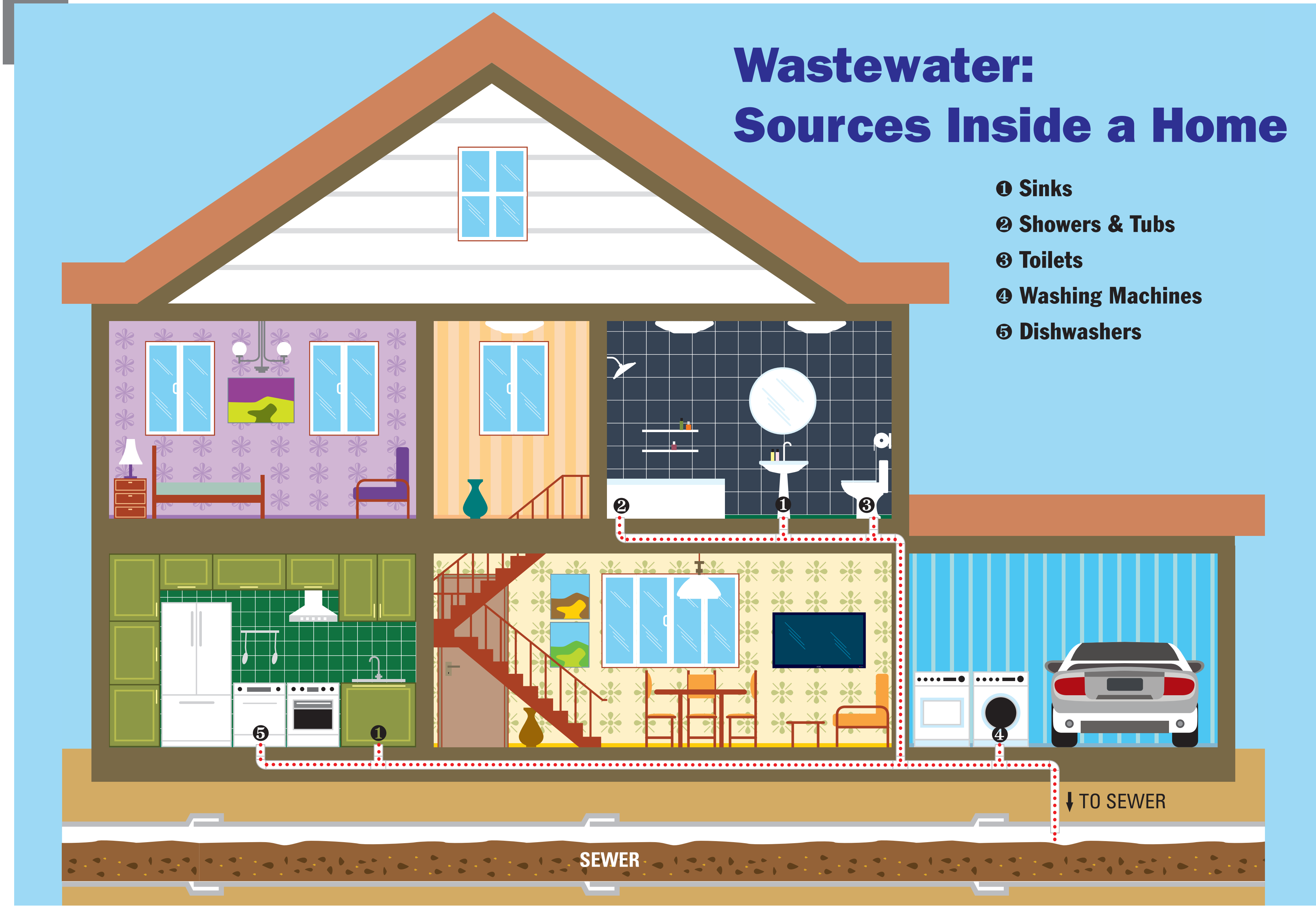
## *You eat. You poop. You flush. Butt where did it all go?*

The average American household contributes between 80 and 100 gallons of **wastewater** each day. Wastewater is defined as the "used" water that goes down drains like sinks, tubs, and showers as well as water flushed down a toilet (see next page). In Florida, this does not include **stormwater** (i.e. water that is collected from drains on the sides of the roads after a rainfall event). According to the Water Research Foundation, almost 24% of Americans' water usage comes from flushing toilets and another 20% is from baths (showers and tubs). In other words, almost half of our daily water usage comes from using the restroom (add 19% for the faucet and it's above 50%). With Americans generating so much wastewater each day, where does all that used water go after it leaves a building?

The term "wastewater" is a misnomer: clean water is an important resource that is becoming increasingly scarce; hence, local governments, **municipalities** and private ownerships have shifted from just treating wastewater and are increasingly working towards recovering wastewater as a **renewable resource**. Once wastewater leaves a building it travels through a **sewer system** to a treatment facility where it undergoes a series of processes so that it can be made safe. These facilities are often referred to as Water Resource Recovery Facilities, Water Reclamation Facilities or Wastewater Treatment Facilities. While these facilities are sewage treatment facilities, the industry has shifted away from the using the terminology "sewage" because it invokes a negative response from the general public. It also misses the end goal of newer technologies: to recover resources (wastes) and make them into safe and often profitable products like **reclaimed water** or **fertilizers**.

# Wastewater: Sources Inside a Home

1. Sinks
2. Showers & Tubs
3. Toilets
4. Washing Machines
5. Dishwashers

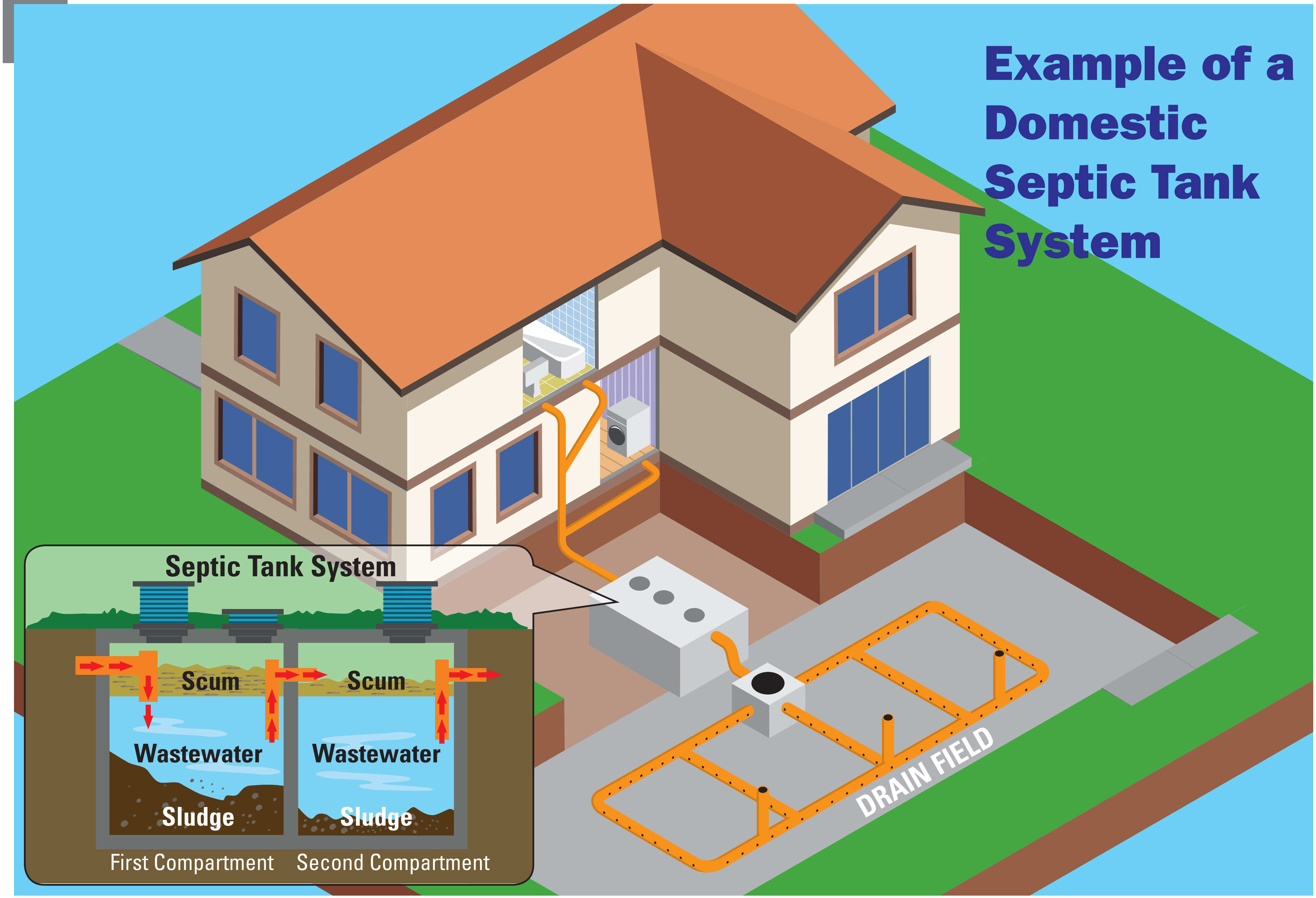


# Teacher Background

## *You eat. You poop. You flush. Butt where did it all go?* *(continued)*

It is worth mentioning that not every building in Florida is connected to a sewer system. Many older homes and buildings in rural areas, send their wastewater to a septic tank. While septic tanks are not the focal point of this guide, they are a means of managing wastewater on-site whereas treatment facilities require sewer systems with pipes and pumps to direct wastewater to a facility. Both septic tanks and wastewater treatment facilities have the same end goal: to treat wastewater so that it can be safely returned to the environment (see next page). Water Resource Recovery and Water Reclamation Facilities take that goal one step further by treating wastewater so that the water can be reused.

**Reuse water** is highly treated wastewater made for safe reuse for such applications as irrigation (reclaimed water), aquifer storage, cooling power plants, generating steam for manufacturing gasoline, cooling computer servers and in some parts of the state, for human consumption. Different types of reuse water are made for different uses and thus, their treatment varies from facility to facility. To find out more about how wastewater is treated and how it is used in your area, contact your local municipality. Some facilities even offer tours to the public by request.


Example of a Domestic Septic Tank System
Septic Tank System
Scum
Wastewater
Sludge
Scum
Wastewater
Sludge
First Compartment
Second Compartment
DRAIN FIELD

# Teacher Background

## *Enter treated domestic wastewater solids*

Wastewater is about 99% water by weight and the other 1% of the wastewater stream is made up of **solids**. The names **residuals**, **biosolids**, or **sludge** all are ones that refer to a treated product generated at a domestic wastewater treatment facility that originates from human wastes or more specifically, poo. When treated, these wastes can be made into a safe and profitable product. Many municipalities across the state turn these solid "wastes" into an **organic** fertilizer or compost that can be safely applied to palms, turf grass and citrus farms. Think of it as "poo makes food for plants!" And while the subject of human excrement may seem a bit gross or unconventional, it is important to remember that all animals do it, it's a natural process. As populations grow, so does the amount of excrement generated—it's an issue that simply can't be ignored.

The consequences for not treating human wastes would be devastating on human health and the environment:

- ***Increased spread of disease.*** Many **pathogens** (see Table 1 on next page) may cause diseases like cholera and Hepatitis A, if spread via the "fecal-oral route" by persons who don't properly wash their hands before handling food.
- ***Eutrophication.*** Lakes and other water bodies will become "poo-lluted" when the excess nutrients, primarily nitrogen and phosphorus, cause algae and plants to grow, bloom, and die in large abundance. This consumes the dissolved oxygen needed by aquatic life to survive.
- ***Fish die-offs.*** With eutrophication, as the dissolved oxygen levels decrease, more fish and other marine life will begin to die in mass quantities as waters become **hypoxic**.
- ***Unsightly environments.*** No one wants to see (or smell) raw human wastes in waterbodies that may appear brown or cloudy in color.

# Teacher Background

## Table 1

*Select Pathogens found in Domestic wastewater*

| Pathogen | Disease or Ailment | Type of Pathogen |
|---|---|---|
| ***Vibrio cholerae*** | Cholera | Bacterium |
| ***Shigella sp.*** | Dysentery | Bacterium |
| ***Salmonella typhii*** | Typhoid fever | Bacterium |
| ***Campylobacter jejuni*** | Gastroenteritis | Bacterium |
| ***Escherichia coli*** | Gastroenteritis | Bacterium |
| ***Yersinia sp.*** | Dysentery | Bacterium |
| **Hepatitis** | Hepatitis | Virus |
| **Norwalk viruses** | Gastroenteritis | Virus |
| **Rotaviruses** | Gastroenteritis | Virus |
| ***Cryptosporidium sp.*** | Gastroenteritis | Protozoa |
| ***Giardia lamblia*** | Giardiasis | Protozoa |
| ***Toxoplasma gondii*** | Toxoplasmosis | Helminth worm |
| ***Ascaris lumbricoles*** | Digestive issues | Helminth worm |
| ***Necator americanus*** | Hookworm | Helminth worm |

# Teacher Background

## *Enter treated domestic wastewater solids* *(continued)*

- ***Decreased quality of life.*** Beaches, lakes and even pools where we live, work, and play would be shut down due to fecal contamination.
- ***Decrease in agricultural food and floral production.*** While wastes contain nutrients for plants, too many nutrients can cause crops to allocate their energy into vegetative growth, not crop production. For instance, flowering plants have been observed not to produce blooms when nitrogen levels far exceed the amount of potassium present. No blooms means no flowers and subsequently, no fruit.

On the contrary, there are a number of benefits associated with treating wastes:

- It prevents algal blooms and fish kills.
- It keeps our recreational waters clean and safe for usage.
- It helps prevent the spread of disease.
- It creates jobs in residual management, resource recovery, sustainability, environmental regulation, facility operations, research, and engineering, to name a few.
- It may generate revenue, especially from the sale of fertilizers.
- It ensures all wastes are treated properly by trained and certified wastewater treatment operators and that all facilities are regulated by the Florida Department of Environmental Protection (FDEP).
- It allows locals to control nutrient loads by selling and/or hauling them to other areas of the state that might be deficient or need those nutrients for crops. In other words, not all Florida soils are created equally!
- It can even produce other benefits like energy in the form of natural gas during the treatment process, which is a cost savings to the treatment facility!

# Teacher Background

## *Feces are a natural source of fertilizer*

In natural systems, feces contain nutrients like nitrogen and phosphorus which are essential to plant life. However, not all raw feces contain nutrients that are **"plant available"**; meaning they contain nutrients in an **organic** form that plants can't readily use. In order for those organic nutrients to become plant available, they need the assistance of other living organisms including **decomposers** and **microorganisms** to consume the carbon-rich compounds and break them into plant-available (or **inorganic**) forms. The complex organic compounds in feces provide carbon as an energy source to the hungry microorganisms in the soil. As these microorganisms have a "fecal feast" in the soil, breaking organic compounds down, they release nutrients into the soil that plants can either access directly through their roots or through water transporting nutrients through the **soil profile**.

The environment is harmed when too many nutrients, like the nitrogen and phosphorus commonly found in retail fertilizers, are released into soils and waterbodies. For instance, on land many agricultural crops that produce fruits need to first produce flowers that are pollinated and those pollinated flowers will then develop into fruits that are harvested for consumption. When such a crop takes up too much nitrogen, it may result in a flush of growth known as "luxury consumption." In other words, when flowering and fruiting crops take up too much nitrogen, they don't bloom or produce fruit, instead they focus their energies on growing bigger and greener. This is an issue for farmers because time lost is money lost. On the other hand, golf courses use nitrogen weekly to keep their courses looking green and lush—it also explains why they mow so frequently! In Florida's sandy soils, some forms of nitrogen like **nitrates**, can move quickly through the soil profile via water and **leach** into water table. While nitrates are safe for plants as a nutrient or fertilizer, nitrates are harmful to humans, especially babies, in large quantities.

# Teacher Background

## *Feces are a natural source of fertilizer* *(continued)*

As populations continue to grow, more pressure is being put upon the natural environment to recycle wastes faster. This also means managing the nutrients found in these treated or recycled wastes. Capturing solids during the wastewater treatment process is important for recovering nutrients. These nutrients are a valuable resource recovered from "wastes" and a natural source of fertilizer! This is why wastewater treatment is essential to life in a modern world. There are currently too many people in the world and in our cities to not treat wastes.

# Teacher Background

## *... And a good soil amendment*

People and plants need many of the same nutrients. The nutrients that people discard from their physiological activities through feces are abundant in the domestic wastewater stream and are present as the solid (or sludge) component of the wastewater stream. The nutrients contained in human feces are separated from the water portion of the wastewater stream and are recycled via biosolids (i.e. fertilizers). The use of biosolids benefits crops such as citrus, trees, palms, and grasses.

In addition to nutrients, the cohesive nature of biosolids creates what are called **aggregates**. These aggregates help to improve the structure of Florida's sandy soils by acting like a sponge and allowing them to hold moisture. This is important because many nutrients like nitrogen, are mobilized by water. As water loaded with nutrients passes through the root zone, plants are able to uptake those nutrients. However, if soils are sandy, the water will pass too quickly through the root zone and leach beyond the roots. As compared to chemical fertilizers like those found in retail stores; biosolids improve soil structure, whereas chemical fertilizers don't. This makes biosolids a more desirable and beneficial product to farmers, ranchers or anyone growing crops.

# Teacher Background

## *Wastewater treatment is designed to mimic natural processes*

When the wastewater containing solids (feces; not garbage or solid objects like toilet paper) first arrives at a treatment facility from the sewer system, the solids are in a raw form derived directly from human excrement. As the solids move through the treatment processes, they change forms much like they would in a natural system where soil microorganisms would feast upon them and release nutrients into the surrounding soils for plants to uptake.

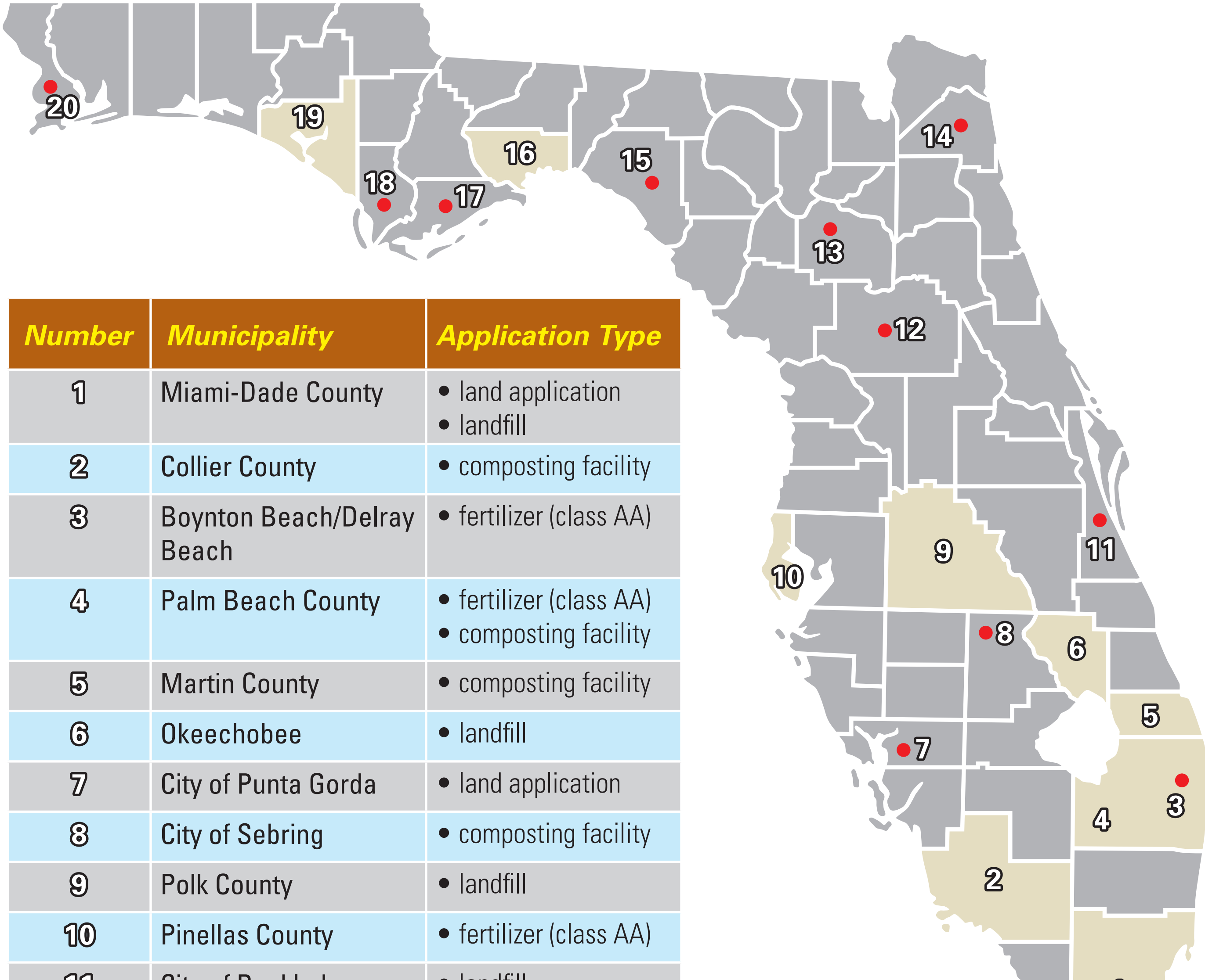
Many of the microorganisms found in wastewater treatment facilities are ubiquitous; they are also found in soils and waterbodies. Some of these organisms like protozoans, are filter feeders helping to clean the wastewater. As the organisms consume the solids in the wastewater (they need carbon), they grow, reproduce and die. They too become food for other microorganisms, creating a **food web**.

At the end of the wastewater treatment processes, the remains of these organisms will be made into biosolids. In other words, the poo that you flushed will be consumed by microorganisms during the treatment processes who will then die and be made into a safe, poo-free product.

The fate of these biosolids varies across Florida. A few examples of how biosolids are used (or disposed of) are included on the next page. To find out how your local municipality handles its biosolids, consider looking online. All facilities handling biosolids are regulated by the FDEP and must maintain records.

While the treatment processes may vary from facility to facility, they can also be very technical in nature. Engineers designed these processes with an end goal in mind and these designs are inspired by nature. Take for instance how

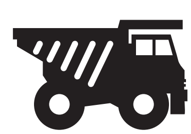
# Teacher Background




| Number | Municipality | Application Type |
|---|---|---|
| 1 | Miami-Dade County | • land application<br>• landfill |
| 2 | Collier County | • composting facility |
| 3 | Boynton Beach/Delray Beach | • fertilizer (class AA) |
| 4 | Palm Beach County | • fertilizer (class AA)<br>• composting facility |
| 5 | Martin County | • composting facility |
| 6 | Okeechobee | • landfill |
| 7 | City of Punta Gorda | • land application |
| 8 | City of Sebring | • composting facility |
| 9 | Polk County | • landfill |
| 10 | Pinellas County | • fertilizer (class AA) |
| 11 | City of Rockledge | • landfill |
| 12 | Ocala | • landfill |
| 13 | Gainesville (GRU) | • fertilizer (class AA) |
| 14 | Jacksonville (JEA) | • fertilizer (class AA)<br>• composting facility<br>• landfill |
| 15 | City of Perry | • land application |
| 16 | Wakulla County | • land application |
| 17 | Town of Eastpoint | • fertilizer (class AA) |
| 18 | City of Port St Joe | • biological dredge |
| 19 | Bay County | • land application |
| 20 | Pensacola (ECUA) | • fertilizer (class AA)<br>• composting facility<br>• landfill |


fertilizer (class AA)

composting facility



landfill

land application

biological dredge

# Teacher Background

## *Wastewater treatment is designed to mimic natural processes* *(continued)*

the South Cross Bayou Advanced Water Reclamation Facility in St. Petersburg, uses **anaerobic digesters** to break down organic materials (image below). The anaerobic digesters are designed to facilitate the growth and reproduction of bacteria that would otherwise die in oxygen-rich (or **aerobic)** environments. Add organic materials such as human wastes, fats, oils, and grease to these large tanks and these specialized bacteria will begin eating the organics, reproducing, dying and then be consumed by other hungry microorganisms.

This process mimics nature; whereby decomposers break down organic materials into smaller ones, turning wastes into nutrients that can be used by plants and other organisms. Nutrients which are present in feces, cycle through the environment, changing forms along the way. This can be illustrated for example, by the viewing the nitrogen cycle.

# Teacher Background

## *The sciences of wastewater treatment*

The processes of a wastewater treatment facility are classified as **primary**, **secondary** or **tertiary** (i.e. advanced). Primary treatment processes may utilize screens, grit chambers, and sedimentation tanks to physically or mechanically remove floatable and settleable solids from the wastewater stream. Secondary treatment processes utilize microorganisms, such as nitrogen-fixing bacteria, to consume the organic material contained in the wastewater and convert dissolved unsettled solids into sinking **sludge** that can then be recovered. The remaining water is disinfected before it is reused or released into the environment. A number of wastewater treatment facilities employ tertiary treatments that may include physical, chemical or biological processes to remove additional nutrients such as nitrogen and phosphorus. For example, in Pinellas County, the South Cross Bayou Advanced Water Reclamation Facility uses what are called **denitrification filters** to remove nitrogen compounds after the solids have been removed.
This helps the facility reduce its impact on the environment by releasing **effluent** (or treated water) with minimal nitrogen (less than 3 ppm).

# Teacher Background

The Federal government uses the term biosolids to describe the treated solids recovered from domestic wastewater. Historically, in Florida they were called residuals. Often at a wastewater treatment facility, sludge is the common term.

- S The **Aeration Tanks** use aerobic microorganisms to break down solids in the wastewater and remove ammonical nitrogen compounds.
- S The **Anoxic Tanks** use microorganisms to remove nitrate nitrogen compounds from the wastewater.
- P The **Headworks** uses physical processes like screens to capture and remove trash from the wastewater.
- D Ultraviolet light (UV) and **Chlorine** are commonly used to kill microorganisms, rendering it safe for reuse or release into the environment.
- S The **Secondary Clarifiers** allow sludge to settle to the bottom of the tanks so it can be separated from the wastewater and made into fertilizer.
- T The **Denitrification Filters** removes additional nutrients, like nitrates, from the wastewater, making it safer for release into the environment.


**Example of a Wastewater Treatment Facility**

P PRIMARY TREATMENT S SECONDARY TREATMENT
T TERTIARY OR ADVANCED TREATMENT D DISINFECTION

# Teacher Background

## *All wastewater treated solids are not created equal!*

Wastewater treatment facilities are permitted by the FDEP. The permit, a detailed document describing the facility's operations, will state which use or disposal method the facility is allowed to use: transfer (to another facility), landfill, incineration, distribution as a fertilizer, or land application (soil amendment or fertilizer). If the biosolids are to be recycled and used as a soil amendment, they must be created from US Environmental Protection Agency (EPA) approved processes. Solids or biosolids that are not to be recycled are typically disposed of in a landfill or incinerated. Nearly two thirds of the state's biosolids are used beneficially as fertilizers or land applied whereas the other third is disposed of.

The EPA defines soil amendment products somewhat differently than the state of Florida but the results are basically the same. In Florida, there are three classes of biosolids that are regulated for beneficial use (fertilizer or soil amendment for land application): **Class B**, **Class A**, and **Class AA**. To generate Class B biosolids, an EPA 'Process to Significantly Reduce Pathogens' must be used by the wastewater treatment facility (Table 2). Class B biosolids are the minimum quality of treated biosolids that may be land applied in Florida. Class A is intermediate quality and Class AA is rated the highest quality (it has a greater reduction in available heavy metals than Class A). See Table 2.

The Class B biosolids generated by an EPA approved method, such as lime stabilization, anaerobic digestion, or aerobic digestion process are suitable for land application. As can be determined from the term "significantly reduce" the sludge still retains a slight possibility that some pathogens or disease causing organisms may still be present.

# Teacher Background

## *All wastewater treated solids are not created equal!* *(continued)*

Class B biosolids may be land applied, but due to the possibility of lingering pathogens the land application activities have to follow some restrictive requirements such as setbacks from water, wells, and publicly occupied buildings, etc. The land application restrictions may be thought of as a protective "belt and suspenders" approach to recycling biosolids. If the biosolids generated follow a "Process To Further Reduce Pathogens" (Class A or AA) where the process typically involves increased temperature and longer treatment times, there are fewer numbers of restrictions (see table 3). Class AA biosolids are deemed to be free from pathogens. The laboratory methods used to detect pathogens are approved by the EPA and may change with time as newer and better technologies emerge.

Whether a Process to Significantly Reduce Pathogens or a Process to Further Reduce Pathogens is used, another EPA process must be used to reduce the product's attractiveness to **vectors** that may disperse any pathogenic elements of the residuals out of their intended area of use as a soil amendment. These EPA approved processes are called vector attraction reduction requirements (see Tables 4).

# Teacher Background

## Table 2

*EPA Approved Processes to Significantly Reduce Pathogens (PSRPs)*

| | |
|---|---|
| **Aerobic Digestion** | Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time (i.e. solids retention time) at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 20°C (68°F) and 60 days at 15°C (59°F). |
| **Air Drying** | Sewage sludge is dried on sand beds or on paved or unpaved basins. The sewage sludge dries for a minimum of 3 months. During 2 of the 3 months, the ambient average daily temperature is above 0°C (32°F). |
| **Anaerobic Digestion** | Sewage sludge is treated in the absence of air for a specific mean cell residence time (i.e. solids retention time) at a specific temperature. Values for the mean cell residence time and temperature shall be between 15 days at 35°C to 55°C (131°F) and 60 days at 20°C (68°F). |
| **Composting** | Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 40°C (104°F) or higher and remains at 40°C (104°F) or higher for 5 days. For 4 hours during the 5-day period, the temperature in the compost pile exceeds 55°C (131°F). |
| **Lime Stabilization** | Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after 2 hours of contact. |

# Teacher Background

## Table 3

*EPA Approved Processes to Further Reduce Pathogens (PFRPs)*

| | |
|---|---|
| **Composting** | Using either the within-vessel composting method or the static aerated pile composting method, the temperature of sewage sludge is maintained at 55°C (131°F) or higher for 3 consecutive days. Using the windrow composting method, the temperature of the sewage sludge is maintained at 55°C (131°F) or higher for 15 consecutive days or longer. During the period when the compost is maintained at 55°C (131°F) or higher, there shall be a minimum of five turnings of the windrow. |
| **Heat Drying** | Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content to 10% or lower. Either the temperature of the sewage sludge particles exceeds 80°C (176°F) or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80°C (176°F). |
| **Heat Treatment** | Liquid sewage sludge is heated to a temperature of 180°C (356°F) or higher for 30 minutes. |
| **Thermophilic Aerobic Digestion** | Liquid sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time of the sewage sludge is 10 days at 55°C (131°F) to 60°C (140°F). |
| **Beta Ray Irradiation** | Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20°C [68°F]). |
| **Gamma Ray Irradiation** | Sewage sludge is irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at dosages of at least 1.0 megarad at room temperature (ca. 20°C [68°F]). |
| **Pasteurization** | The temperature of the sewage sludge is maintained at 70°C (158°F) or higher for 30 minutes or longer. |

# Teacher Background

## Table 4

*EPA Approved Vector Attraction Reduction Requirements*

| Requirement: | What Is Required? | Most Appropriate For: |
|---|---|---|
| **Option 1** 503.33(b)(1) | At least 38% reduction in volatile solids during sewage sludge treatment. | Sewage sludge processed by: Anaerobic biological treatment Aerobic biological treatment. |
| **Option 2** 503.33(b)(2) | Less than 17% additional volatile solids loss during bench-scale anaerobic batch digestion of the sewage sludge for 40 additional days at 30°C to 37°C (86°F to 99°F). | Only for anaerobically digested sewage sludge that cannot meet the requirements of Option 1. |
| **Option 3** 503.33(b)(3) | Less than 15% additional volatile solids reduction during bench-scale aerobic batch digestion for 30 additional days at 20°C (68°F). | Only for aerobically digested liquid sewage sludge with 2% or less solids that cannot meet the requirements of Option 1 - e.g., sewage sludges treated in extended aeration plants. Sludges with 2% solids must be diluted. |
| **Option 4** 503.33(b)(4) | Specific Oxygen Uptake Rate (SOUR) at 20°C (68°F) is ≤ 1.5 mg oxygen/hr/g total sewage sludge solids. | Liquid sewage sludges from aerobic processes run at temperatures between 10 to 30°C (should not be used for composted sewage sludges). |
| **Option 5** 503.33(b)(5) | Aerobic treatment of the sewage sludge for at least 14 days at over 40°C (104°F) with an average temperature of over 45°C (113°F). | Composted sewage sludge (Options 3 and 4 are likely to be easier to meet for sewage sludges from other aerobic processes). |
| **Option 6** 503.33(b)(6) | Addition of sufficient alkali to raise the pH to at least 12 at 25°C (77°F) and maintain a pH ≥ 12 for 2 hours and a pH ≥ 11.5 for 22 more hours. | Alkali-treated sewage sludge (alkaline materials include lime, fly ash, kiln dust, and wood ash). |
| **Option 7** 503.33(b)(7) | Percent solids ≥ 75% prior to mixing with other materials. | Sewage sludge's treated by an aerobic or anaerobic process (i.e. sewage sludges that do not contain unstabilized solids generated in primary wastewater treatment). |

# Teacher Background

## Table 4 (continued)

### *EPA Approved Vector Attraction Reduction Requirements*

| Requirement: | What Is Required? | Most Appropriate For: |
|---|---|---|
| **Option 8** 503.33(b)(8) | Percent solids ≥ 90% prior to mixing with other materials. | Sewage sludges that contain unstabilized solids generated in primary wastewater treatment (e.g., heat-dried sewage sludges. |
| **Option 9** 503.33(b)(9) | Sewage sludge is injected into soil so that no significant amount of sewage sludge is present on the land surface 1 hour after injection, except Class A sewage sludge which must be injected within 8 hours after the pathogen reduction process. | Sewage sludge applied to the land or placed on a surface disposal site. Domestic septage applied to agricultural land, a forest, or a reclamation site, or placed on a surface disposal site. |
| **Option 10** 503.33(b)(10) | Sewage sludge is incorporated into the soil within 6 hours after application to land or placement on a surface disposal site, except Class A sewage sludge which must be applied to or placed on the land surface within 8 hours after the pathogen reduction process. | Sewage sludge applied to the land or placed on a surface disposal site. Domestic septage applied to agricultural land, forest, or a reclamation site, or placed on a surface disposal site. |
| **Option 11** 503.33(b)(11) | Sewage sludge placed on a surface disposal site must be covered with soil or other material at the end of each operating day. | Sewage sludge or domestic septage placed on a surface disposal site. |
| **Option 12** 503.33(b)(12) | pH of domestic septage must be raised to ≥12 at 25°C (77°F) by alkali addition and maintained at ≥12 for 30 minutes without adding more alkali. | Domestic septage applied to agricultural land, a forest, or a reclamation site or placed on a surface disposal site. |

# Teacher Background

## *All wastewater treated solids are not created equal!* *(continued)*

Vectors can be organisms like flies, rodents and birds that might otherwise carry the biosolids (and their contents) to areas where people may potentially come into contact with them. This is not a concern when proper pathogen reduction and vector attraction reduction methods are combined. The correct combination provides a safe and beneficial soil amendment product.

In summary, biosolids that are generated from domestic wastewater may be unsuitable for land application or treated to different levels of suitability for land application. In Florida, Class AA biosolids have fewer biosolids use restrictions while Class B has more restrictions on use since it is generated from a process that may allow some pathogens to exist in the product for a period of time. It should be noted that even with Class B biosolids, the EPA and FDEP have determined that when the appropriate restrictions are followed, the biosolids used for land application will be as safe as possible. The EPA uses different names for the biosolids products generated by the different levels of treatment, while in Florida the products are different classes generated from EPA approved processes.

# Teacher Background

## *All wastewater treated solids are not created equal!* *(continued)*

In addition to the level of treatment, biosolids can be primarily described as one of two types: liquid or cake. **Cake biosolids** are those that have been dewatered to the point of retaining at least twelve percent solids and less than eighty eight percent liquid. Cake biosolids more closely resemble soil in some form and may be transported in a vehicle like a dump truck. **Liquid biosolids** are often extremely watery and must be transported in a vehicle that will contain the liquid. Depending on the amount of dewatering the biosolids will range from a swampy watery texture to a dry crusty soil consistency. Another type of biosolids is pellets.

Whatever the class or type, the biosolids product must be generated with approved EPA processes that create a soil amendment product appropriate for land application.
The treatment of biosolids may add significant costs! These costs may be passed on to the generator of the wastes (the utility customer) or the end user of the biosolids products. The utility has the responsibility of striking an appropriate balance when expending monies, ensuring that treatment decisions are both fiscally prudent and protective of public health.

# Teacher Background

## *A historical perspective on domestic wastewater solids*

Depending on the part of the world you live in and on the period you lived, people have dealt with the disposal and use of solids differently. For example, in many Asian countries for thousands of years it was common for raw untreated domestic wastes (solids) to be used as fertilizer for rice paddies. The name for those untreated domestic solids was “night soil.” It was called that because some people went around the neighborhood at night collecting the material from people’s chamber pots. India with its caste system called individuals involved with night soil work “untouchables.” In ancient Rome, the domestic wastewater including the solids was flushed into the nearest river, the Tiber River, eventually making their way downstream to the Mediterranean Sea.

Another historical approach to domestic wastewater solid disposal use that is closer to home (and our present time) was the use of the **outhouse**. Outhouses can be crude or elaborate structures that contain four walls, a roof, and a seat over a hole in the ground. If the structure was moved, the hole was simply filled in. That is, if the hole was not first shoveled out and the material taken for whatever purpose the person doing the digging desired. As a common practice the outhouse was around for many years and they still exist

# Teacher Background

## *A historical perspective on domestic wastewater solids* *(continued)*

today as a rustic historically reminiscent option. As a child I can remember my grandfather's home where there was a "two seater" outhouse located in his home's large attached woodshed in Ellsworth, Maine. In any event, the disposal of the solids component of domestic wastewater has been a concern of people as long as people have existed.

In the recent past Florida has seen many changes in biosolids treatment and use. The advent of and widespread use of wastewater treatment facilities has helped ensure consistency in the approach to treating domestic wastewater. About thirty years ago it was possible for anyone to go to a sewage treatment plant and remove a quantity of dubiously stabilized (treated) sludge from the facility and take it to their home for whatever fertilizer application purposes they desired. Biosolids, food service sludge and septage could be stabilized by adding lime in a truck enroute to the land application fields. Historically, land application of biosolids as a soil amendment was a primary way of disposing biosolids in a productive manner. Land application of biosolids as a soil amendment was widespread for all treated wastewater treatment facility solids. Stabilization or treatment of the domestic wastewater solids and site restrictions were less restrictive in general. The Florida rule governing biosolids

# Teacher Background

## *A historical perspective on domestic wastewater solids* *(continued)*

was rudimentary and called F.A.C. 17-7. It was at least a start towards adequate regulation.

Florida greatly improved on that rule on March 1, 1991, when Chapter 62-640 (Domestic Wastewater Biosolids) became effective. On February 19,1993, the EPA published Title 40 of the Code of Federal Regulations [CFR], Part 503. It was titled, "The Standards for the Use or Disposal of Sewage Sludge." The State of Florida revised its 62-640 rule and on March 30,1998, the revised F.A.C. Chapter 62-640 became effective.

In 2010, F.A.C. Chapter 62-640 was revised to include some notable changes. For one, under the new revisions, Class AA biosolids must only be distributed and marketed as a fertilizer to someone with a fertilizer license. The alternative is, they can only be land applied. Another notable change in 2010 had to do with land applications now requiring a **nutrient management plan** in addition to a site permit. Nutrient management plans are commonly used by the agricultural operations like farms, to ensure farm production as well as environmental stewardship. Nutrient management plans evaluate environmental risks such as soil slope, surface waters (potential to be contaminated by nutrients and cause eutrophication), soil erosion and runoff control (i.e. buffer

# Teacher Background

## *A historical perspective on domestic wastewater solids* *(continued)*

zones), among many other factors. In Florida, nutrient management plans must determine the application rate based on crop need (no excess application), phosphorus levels, and soil testing (for nutrients). Nutrient management plans must be site specific.

Consistent with the ever changing nature of biosolids, in 2021 the biosolids rule was revisited. The biosolids rules were updated to better manage phosphorus and land application sites, taking into account the solubility of phosphorus in biosolids and the ability of the soil to hold phosphorus.

# Teacher Background

## *What rules?*

At the federal level, the rules created for governing the proper treatment and use of biosolids are called Title 40 Code of Federal Regulations (CFR) Part 503. They are commonly referred to as 503. The State of Florida has adopted rules pertaining to residuals or biosolids. They are called the Chapter 62-640, Florida Administrative Code (F.A.C. 62-640 or commonly 640). In this set of rules biosolids are clearly defined. The 2010 Florida definition of biosolids is that "residuals" or "domestic wastewater residuals" refers to the solid, semisolid, or liquid residues generated during the treatment of wastewater in a treatment facility. This does not include the solids (like trash flushed down a toilet) removed from the sewer systems and primary treatment (like screens) of a domestic wastewater treatment facility, other solids as defined in Rule 62-640.200(24) F.A.C., or ash generated during the incineration of biosolids.

# Teacher Background

## *What rules?* *(continued)*

Occasionally in Florida there is an additional level of regulation at the county level. These local rules are called **ordinances**. When descending from the federal level down to the potential county level, each lower level of regulation must be at least as stringent as the level above it. In this manner the rules are tailored to the specific needs of each lower regulatory level down to the desired local level. It is possible that even a city may enact biosolids rules. Biosolids generation and use as a beneficial soil amendment is therefore conducted under the auspices of distinct rules intended to ensure public health and environmental protection. Science, industry, technology, agriculture, political entities, the public, and others have combined to ensure that public health and the environment are protected while this product is being generated and used. The combined interested parties or **stakeholders** created the regulations that ensure the wise reuse of treated domestic wastewater solids. This rule making process adapts to the times as we go into the future.

# Teacher Background

## *Issues? We got issues!*

For many people, the mere thought of anything related to the topic of treated domestic wastewater solids (or products derived from human feces for that matter) instills fear, anger, panic, bewilderment and/or disgust. This is because most people do not understand biosolids and unfortunately, many fear what they do not understand. For many people working in the wastewater treatment and/or biosolids industries, with time and knowledge, they have learned to appreciate the science, the engineering, and the importance of such facilities to protecting the environment as well as human health. And while you might be thinking, "why do I care?" or "how does this effect me?" just think of the alternative: living in a world surrounded by raw human feces; lakes that are green from algal blooms; and shores covered in dead, rotting fish. If that's not an uncomfortable image, consider the unbearable smell.

Often emotional responses are the normal reactions to the idea of beneficial use of biosolids for land application or any other use one could think of for such a product. This is unfortunate because people all too frequently discover biosolids recycling by accident rather than education and training. Land application in their area or trucks traveling the roads with biosolids may be their first encounter. Truck traffic or an odor that catches their attention may initiate an inquiry on their part. The first encounter may concern the person enough to expand their interest or questions to the related areas of health and drinking water. Lacking an understanding of biosolids from a cradle-to-grave perspective may therefore cause people to become alarmed at this new bizarre unknown product. Education could have mediated this reaction.

# Teacher Background

## *Issues? We got issues!* *(continued)*

People often respond positively when they are educated about biosolids. However, issues will arise from the individual all the way to the municipal or government level in some cases. At the individual level, people are concerned about their well being and their family's well being, including finances. At the government level, there is concern for treatment, disposal, costs, regulations (including compliance), community health and environmental impacts.

Trucking companies that transport biosolids for further treatment or to the land application site or even to the landfill struggle to conduct their business successfully with respect to regulation and profit for their companies. The media is readily available to investigate and present thought provoking issues about biosolids. At any level and from innumerable perspectives, biosolids present a plethora of issues. Odors, truck traffic, health, ground water, land owner rights, worker safety, crop health, cattle grazing, and others are all issues that may be associated with the generation and use of biosolids. Education through this infusion unit will allow students to begin to not only learn about biosolids, but also how biosolids issues impact their own lives.

# Teacher Background

## *The Future*

One thing is certain—nothing is forever in the biosolids industry! Change is the only constant. Over the years, the biosolids industry has progressed from producing a scarcely treated product to an industry capable of producing a product that anyone could safely use in their home.

The source of all biosolids, the human population, continues to increase in size. From the perspective of the biosolids industry population growth means that more people will generate more biosolids. Subsequently, the beneficial reuse of biosolids and recycling methods land application practices will need to adapt quickly to keep pace with population growth. More people need more space to live and that means less available land for biosolids land application activities. Currently, biosolids at the lowest level suitable for land application in Florida (Class B) have restrictions for land application use (including restricted public access) are finding available land more difficult to locate. The Florida industry will, out of necessity, continue to change to one producing and utilizing biosolids suitable for unrestricted public access (Class A or Class AA). The unrestricted public access biosolids may be used on playgrounds, hospital grounds and other areas where there is frequent public contact with the land applied biosolids. Some of these biosolids are combined to create custom blended fertilizer products. As the amount of land available for restricted biosolids land application diminishes, biosolids products will need to be those that are treated to a level that poses minimal risks to the public and the environment. Please note that life is not risk free! The biosolids industry will continue to develop new treatment

# Teacher Background

## *The Future* *(continued)*

methods and biosolids products that will progressively pose as little risk as possible to the public health and environment. Science and technology ceaselessly work to develop new and improved biosolids knowledge, treatment methods, and reuse and recycling products. The industry constantly changes. It is a dynamic one always in progressive motion into the future. Government regulation parallels the biosolids industry's changes and improvements. Government will continue to work closely with the biosolids industry to ensure protection of public health and the environment.

An important change needed for the future biosolids industry is education. People must become better informed about biosolids. Much like death and taxes, biosolids are unavoidable and do not magically disappear when you wish upon a star.

Teachers are an important key component for the future. Educators provide a knowledge base and attitude that helps students make informed decisions based on the roles they wish to play in the dynamics of the biosolids issues. Student biosolids education provides one of the best chances we as citizens have for the appropriate reuse and recycling of renewable biosolids resources. The sky really is the limit on how we choose to best cope with biosolids. Let's work together to educate our student population about biosolids!

# A Note To Teachers

Our hope is that as an educator, you will first present your students with a background of biosolids and their associated issues. The Teacher Background Section should provide enough basic information that can in whole or in part be presented to your students. It is intended that you utilize the student activities by adapting them to your curriculum subject area and student needs. The activities are an inspirational starting point and not the definitive end. They will help infuse biosolids education into all aspects of your curricula.

***Please adapt and conduct these activities using your best professional judgment.***

# Notes

# Notes

# Student Activity

## Activity 1:
## *Biosolids Around the World*

**Subject Areas:**
English Language Arts; Social Studies; Food, Agriculture and Natural Resources; Computer Science; and Environmental Science.

**Behavioral Objectives:**

1. The students will evaluate the historical and current ways that domestic wastewater is "treated" in another country. Biosolids will be the focus.

2. The students will describe at least one domestic wastewater treatment process or biosolids product used by a foreign country.

3. The students will evaluate a foreign country's domestic wastewater treatment and compare it with treatment in Florida.

**Activity:**
The United States is one of many countries around the world and Florida is just one of its 50 states. Begin by telling the students that they are going to research how other countries handle their biosolids. Since not all other countries have the same resources or technology as the United States, inform the students that they might not be able to simply use the term "biosolids" as a point of study but should expand their research to include how domestic (i.e. household) wastes are treated. Some countries may not even have basic treatment. The internet will be the prime source of the research activities but encourage students to ask family, friends, or even neighbors, especially those born or whom have resided in other countries about their experiences abroad. The students should choose a country that interests them (or is assigned) and then proceed to find out as much as they can about that country's domestic wastewater treatment, rules or laws governing human wastes, and the usage of those wastes

# Student Activity

## Activity 1:
## *Biosolids Around the World* *(continued)*

(i.e. fertilizer or disposal). The students should compare and contrast the foreign country with a municipality in Florida. Encourage students to seek information from their city or county. As some municipalities have more information on the internet than others, as an alternative, encourage students to research an area of the state that they like or wish to live in. Whether in a written report, an oral report, a poster, or a pictorial collage, the students should communicate their research findings to the rest of the class. Inform the students that key words like domestic, wastewater, sludge, biosolids, sewage, effluent, sewer, human excrement, feces, and/or combinations of those words may be necessary to discover information. Information gathered from interviewing family, friends, or individuals who resided in other countries abroad are also acceptable and may uncover interesting stories or information.

**Evaluation Options:**

1. Quantitative measurement of the reports that the students generate for the number of comparisons and contrasts that the students show between a foreign country and Florida.

2. Qualitative evaluation of the reports by peer evaluation or possibly teacher evaluation of the students' research efforts

3. Mastery evaluation of the reports is accomplished when the student has completed the report with the foreign country's efforts compared and contrasted with the efforts of a municipality in Florida.

**Florida Standards:**
LAFS.8.RL.1, LAFS.8.RL.2, LAFS.8.RL.4, LAFS.8.RI.1, LAFS.8.RI.2, LAFS.8.RI.3, LAFS.8.RI.4, LAFS.8.SL.2, LAFS.8.L.2, LAFS.8.L.3, LAFS.910.RL.1, LAFS.910.RL.2,

# Student Activity

## Activity 1:
## *Biosolids Around the World* *(continued)*

LAFS.910.RL.4, LAFS.910.RI.1, LAFS.910.RI.2, LAFS.910.RI.4, LAFS.910.SL.1, LAFS.910.SL.2, LAFS.910.L.3, LAFS.910.RH.1, LAFS.910.RH.3, LAFS.910.RH.4, LAFS.910.RST.1, LAFS.910.RST.2, LAFS.910.RST.3, LAFS.910.RST.4, LAFS.910.WHST.3, LAFS.1112.RL.1, LAFS.1112.RL.2, LAFS.1112.RL.4, LAFS.1112.RI.1, LAFS.1112.RI.2, LAFS.1112.RI.4, LAFS.1112.SL.1, LAFS.1112.SL.2, LAFS.1112.L.2, LAFS.1112.L.3, LAFS.1112.RH.1, LAFS.1112.RH.2, LAFS.1112.RH.3, LAFS.1112.RH.4, LAFS.1112.RST.1, LAFS.1112.RST.2, LAFS.1112.RST.3, LAFS.1112.RST.4, ELA.8.R.3, ELA.8.C.4, ELA.8.V.1, ELA.9.R.3, ELA.9.C.4, ELA.9.V.1, ELA.10.R.3, ELA.10.C.4, ELA.10.V.1, ELA.11.R.3, ELA.11.C.4, ELA.11.V.1, ELA.12.R.3, ELA.12.C.4, ELA.12.V.1, SS.8.G.1, SS.8.G.2, SS.8.G.5, SS.8.G.6, SS.912.G.1, SS.912.G.2, SS.912.G.3, SS.8.A.1, SS.8.A.4, SS.912.A.1, SS.912.A.7, SS.912.W.1, SS.8.C.2, SC.912.CS-PC.2, SC.912.CS-PC.3, SC.8.N.4, SC.912.L.17, SC.912.N.4, SS.912.G.6, SS.912.H.3

# Notes

# Student Activity

## Activity 2: *Rule Making*

**Subject Areas:**
English Language Arts; Environmental Science; Social Studies; History; Computer Science; and Government and Public Administration.

**Behavioral Objectives:**

1. The students will practice the politics involved in rule making.

2. The students will identify the factors involved in rule making decisions.

3. The students will generate biosolids rules and compare them with the current biosolids rules.

**Activity:**
Begin the class by telling the students what biosolids are and how they are produced. Then ask them if there should be any rules for the land application and use of the biosolids products as agricultural soil amendments (fertilizers). When the students respond that of course there should be some rules, have them decide who should make the rules. Guide them into realizing that there are often many interested parties involved in rule making and different agencies at the federal, state, and local level might be involved. Inform them that they will be approaching a fictitious governing body with an agency that will regulate rules concerning biosolids. Separate the class into groups representing the different interests involved in the biosolids issue. This would include homeowners, domestic wastewater facilities, land owners such as cattle ranchers, biosolids land application companies, scientists, engineers, developers, and so on (examples included after directions). Decide on how many different groups, but ensure that at least several groups have opposing positions on the issue of land application. Next,

# Student Activity

## Activity 2:
## *Rule Making* *(continued)*

have the students discuss, decide, and record what they would like to see made into rules to ensure that biosolids land application activities are beneficial and not detrimental. Remind them that rules can be extensive and specific or broad and general. For example, a general rule would be one that addressed the weather during land application. An example of a specific detailed rule would be one that states how much nitrogen may be applied to each acre used for land application during the year. They may be as specific or as general as they wish.

Reconvene the class and then have a spokesperson for each group reveal what rules they would like to see enacted for their interests. Let the class discuss the potential rules and then vote on what rules should be passed.

At this point assign the students the task of reading F.A.C. 62-640 which is the State of Florida Rule regulating the use of biosolids. Have the students compare and contrast what is in the Florida Rule with the class biosolids rule. Have the class discuss the similarities and differences. Lastly, discuss with the students that rule making is a continuous process and all rules may be revised, expanded, or limited as time goes by. For example, input from any lobbying group may be politically sufficient to obtain a review and revision of the rules.

# Student Activity

## Activity 2:
## *Rule Making* (continued)

| | |
|---|---|
| SCIENTIST | ENGINEER |
| LAND DEVELOPER | TOWN OR CITY MANAGER |
| MEMBER OF PROMINENT ENVIRONMENTAL GROUP | COLLEGE PROFESSOR |
| MEMBER OF LOCAL TOURISM BOARD | LAND APPLICATION COMPANY |

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# Student Activity

## Activity 2:
## *Rule Making* *(continued)*

**COUNTY EMPLOYEE**
(Local Government)

**FDEP OFFICIAL**
(State Government)

**HOME OWNER**

**HOME OWNER**

**WASTEWATER TREATMENT FACILITY EMPLOYEE**

**CATTLE RANCHER**
(Application Site)

**GOLF COURSE MANAGER**

**FARMER**

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blank!!

# Student Activity

## Activity 2:
## *Rule Making* *(continued)*

**Evaluation Options:**

1. Quantitative evaluation of the students on a quiz.

2. Qualitative grading of class participation.

3. Mastery evaluation by each student successfully listing at least five things regulated in F.A.C. 62-640.

**Florida Standards:**
SS.8.G.3, SS.8.G.5, SS.912.G.3, SS.912.G.5, SS.912.G.6, SS.8.C.1, SS.8.C.2, SS.912.C.1, SS.912.C.2, SS.912.C.3, SC.8.P.9, SC.8.N.1, SC.8.N.4, SC.912.L.14, SC.912.L.17, SC.912.L.18, SC.912.P.12, SC.912.E.6, SC.912.E.7, SC.912.N.4, LAFS.8.RI.1, LAFS.8.RI.2, LAFS.8.SL.1, LAFS.8.SL.2, LAFS.8.W.1, LAFS.8.W.2, LAFS.8.L.1, LAFS.8.L.2,
LAFS.910.RI.2, LAFS.910.W.1, LAFS.910.W.2, LAFS.910.SL.1, LAFS.910.SL.2, LAFS.910.L.1, LAFS.910.L.2, LAFS.910.L.3, LAFS.910.RH.2, LAFS.910.RST.1, LAFS.910.RST.2, LAFS.1112.WHST.1

# Notes

# Student Activity

## Activity 3:
## *Build Your Own Resource Recovery Facility*

**Subject Areas:**
English Language Arts; Environmental Science; Government and Public Administration; Social Studies; and Visual Arts.

**Behavioral Objectives:**

1) The students will learn some of the processes used to treat wastewater and which of those processes are designed to separate the solids from the liquid stream.

2) The students will use practice using their fine motor skills to assemble or build a wastewater treatment plant.

3) The students will appreciate the complexity of wastewater treatment as it incorporates all aspects of STEM (Science, Technology, Engineering and Mathematics).

**Activity:**
Begin the class by explaining to the students that in order to create biosolids, we must be able to separate out all the solids from the wastewater. One of the oldest and simplest concepts is based upon density, or the idea that substances can be separated based upon differences in their mass per unit volume. To illustrate this, ask students what happens to oil when you add it to water—does it sink or float? Follow up by asking a tougher question—what happens to honey when you add it to room temperature water without stirring— does it sink or float?

Since the wastewater stream is 99% water by weight, density is commonly used to treat the wastewater stream. Solids that are denser than water sink to the bottom and are scraped out in large tanks called clarifiers. Oils and other substances less

# Student Activity

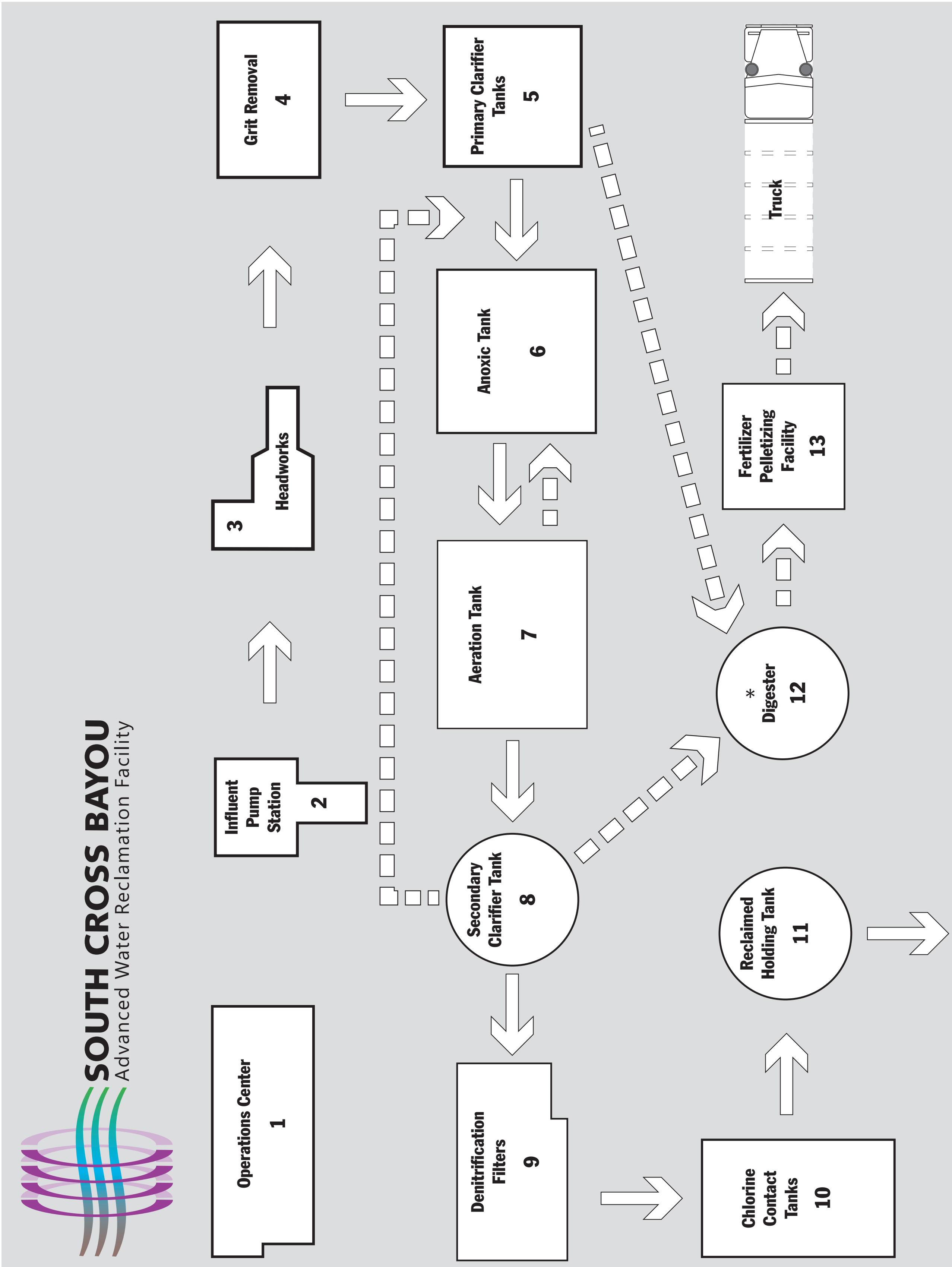
## Activity 3:
## *Build Your Own Resource Recovery Facility* *(continued)*

dense than water are skimmed off the top in the primary or **secondary clarifiers**. Both the primary and secondary clarifiers are essential to removing solids (or the sludge) from wastewater. These sludges are recovered from the wastewater and made into beneficial resources like fertilizer.

The goal of a resource recovery (or **treatment facility**) is to recover resources like water and solids (made from excrement) for reuse. An example of this would be the South Cross Bayou Advanced Water Reclamation Facility (SCBAWRF) in St Petersburg, FL. Each day this 35 acre facility treats an average of ~24 million gallons of wastewater. This facility produces over 3 billion gallons of reclaimed water and 6,000 tons of biosolids fertilizer from the "wastes" it recovers in the wastewater stream. Tell the students that they are going to build a miniature replica of part of the SCBAWRF to learn about the processes used at this facility for treating wastewater and recovering resources. In this activity, you will find a foot print of the facility's major processes that visually demonstrates where the water and solids go as they move through the facility and its treatment processes. Included in the following pages are templates of the buildings or tanks used. These templates can be assembled using scissors and glue or tape. We also recommend having the students color the contents of the tanks (brown, blue/green, or blue) as they go through the processes to visually "see" the treatment processes in action!

An alternative to assembling this facility using the included templates is to 3D print your own facility or create a collage from images gathered on the internet or from visiting a local facility. Please note, due to national security reasons or bioterrorist threats, many facilities do not readily provide images on the internet.

# Student Activity




Dotted arrows represent the flow of solids/sludge whereas solid arrows represent liquids/water.
*For simplicity, not all processes are graphically represented.

# Student Activity

## Activity 3: *Build Your Own Resource Recovery Facility* *(continued)*

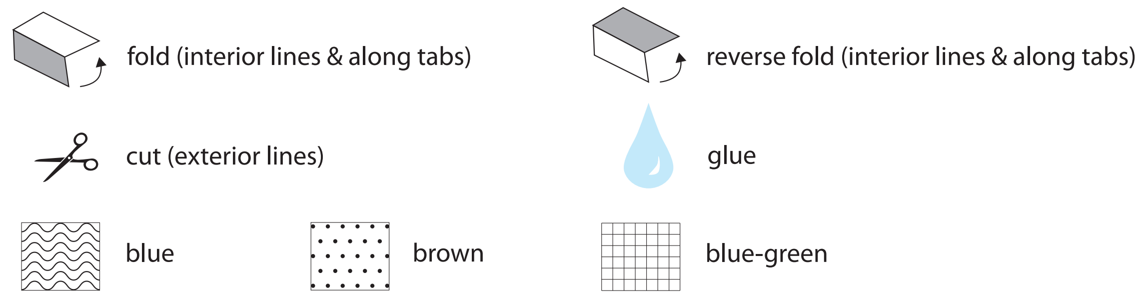
The following templates are based on real buildings or tanks involved in the treatment of wastewater. Wastewater is all of the used water that goes down a drain from a sink or shower as well as water flushed down a toilet. All this wastewater must go to a facility, like South Cross, to be treated (or cleaned) before it can be used again for watering lawns, trees and plants. This is called reclaimed water.
To complete this activity, you will need:

- Scissors
- Glue or a glue stick
- Crayons, colored pencils or markers
- Tape (optional but helpful if you make a mistake with cutting)

Each page contains a few symbols worth noting. Wastewater can vary in color based on where it is in the treatment process. When it first enters the facility, its brown but as it travels though the facility and gets cleaned (or treated) it becomes blue, sometimes it is even a bit blue green from chlorine.

# Student Activity

## Activity 3:
## *Build Your Own Resource Recovery Facility* *(continued)*




At the top of each page there is also a picture of what the finished building or tank should look like when complete. The name of the building will be on top of the structure and a number printed on the bottom. The number also corresponds to the order of the building or tank and a brief description of its function (next page). Please note, all cuts should be along the perimeter of each building or tank.

# Student Activity

## Activity 3:
## *Build Your Own Resource Recovery Facility* *(continued)*

**1. Operations Center-** Houses the control room where staff monitor the wastewater treatment processes 24 hours a day, 7 days a week, 365 days a year, using computers.

**2. Influent Pump Station-** Continuously pumps incoming wastewater from the sanitary sewer system to the facility's headworks (Building #3).

**3. Headworks-** Screens capture large pieces of physical trash like toys, rags, clothing, and "flushable" wipes, which could otherwise damage machinery and clog pipes. Once removed, these wastes are deposited into a dumpster and sent to Solid Waste.

**4. Grit Removal-** This building houses what are called the "teacups." The teacups spin water in a circle really fast, causing the heavier materials like corn, seeds, soil and rocks to "drop out" from the wastewater. Hence, the pile of grit on the side of the building- these wastes are also sent to Pinellas County's Solid Waste to be burned for energy.

**5. Primary Clarifier-** These tanks allow heavy organic solids (think about the "solids" you flushed) to settle. As these solids settle to the bottom of the tank, called sludge, this sludge is collected by scrapers and pumped out of the tanks. Lighter materials that float on the surface of the water can be skimmed off or removed.

**6. Anoxic Tank-** Not all bacteria are bad! These tanks use bacteria and other microorganisms to remove nitrogen (or here, nitrate NO3-). Too much nitrogen can harm the environment and we make a lot when we go to the bathroom!

**7. Aeration Tank-** These tanks are also full of hungry microorganisms that feast on our #2! In this tank, they are helping to remove ammonia-based nitrogen (lots in urine).

# Student Activity

## Activity 3:
## *Build Your Own Resource Recovery Facility* *(continued)*

**8. Secondary Clarifier-** Like the primary clarifiers, these tanks also permit the settling of solids (including the now heavy microorganisms, stuffed from eating our #2). These solids, now called sludge, will be removed from the water to become fertilizer!

**9. Denitrification Filters-** This is why South Cross is called an advanced facility. These tanks help remove most remaining nitrogen from the water using filters filled with sand, gravel and more hungry bacteria! See, not all bacteria are bad!

**10. Chlorine Contact Tank-** One of two technologies we use to kill bacteria or any other disease-causing microorganisms (a process called disinfection) is to use chlorine (think pool water). The other technology is UV light. After adding chlorine, we must dechlorinate (or remove the chlorine) using sulfur dioxide.

**11. Reclaimed Holding Tank-** Once disinfected, up to 6 million gallons of treated water can be stored in a tank. This water is called reclaimed water and is safe to be reused.

**12. Digesters-** All of the solids from the clarifiers are sent to these giant "stomachs" full of hungry bacteria. These bacteria special, called anaerobes, oxygen can kill them! As they eat the solids, called sludge, they produce gases like methane which we use as energy in our fertilizer facility! These bacteria break down the solids which will soon become fertilizer, a source of food for plants which we'll sell to help keep us open!

**13. Fertilizer Pelletizing Facility-** This is where we turn the sludge into fertilizer pellets!

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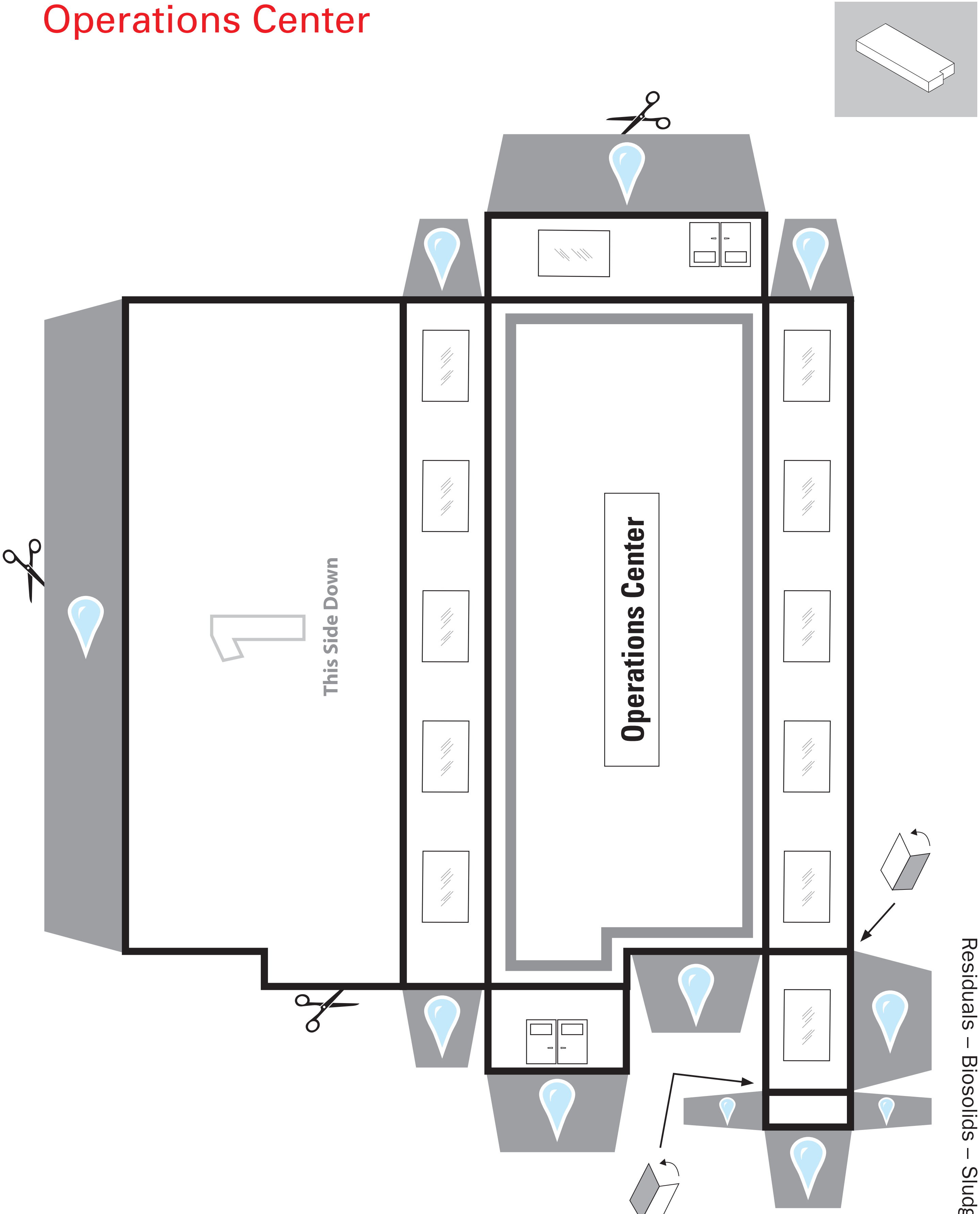
# Operations Center



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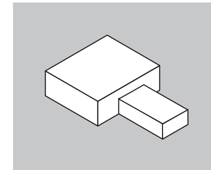
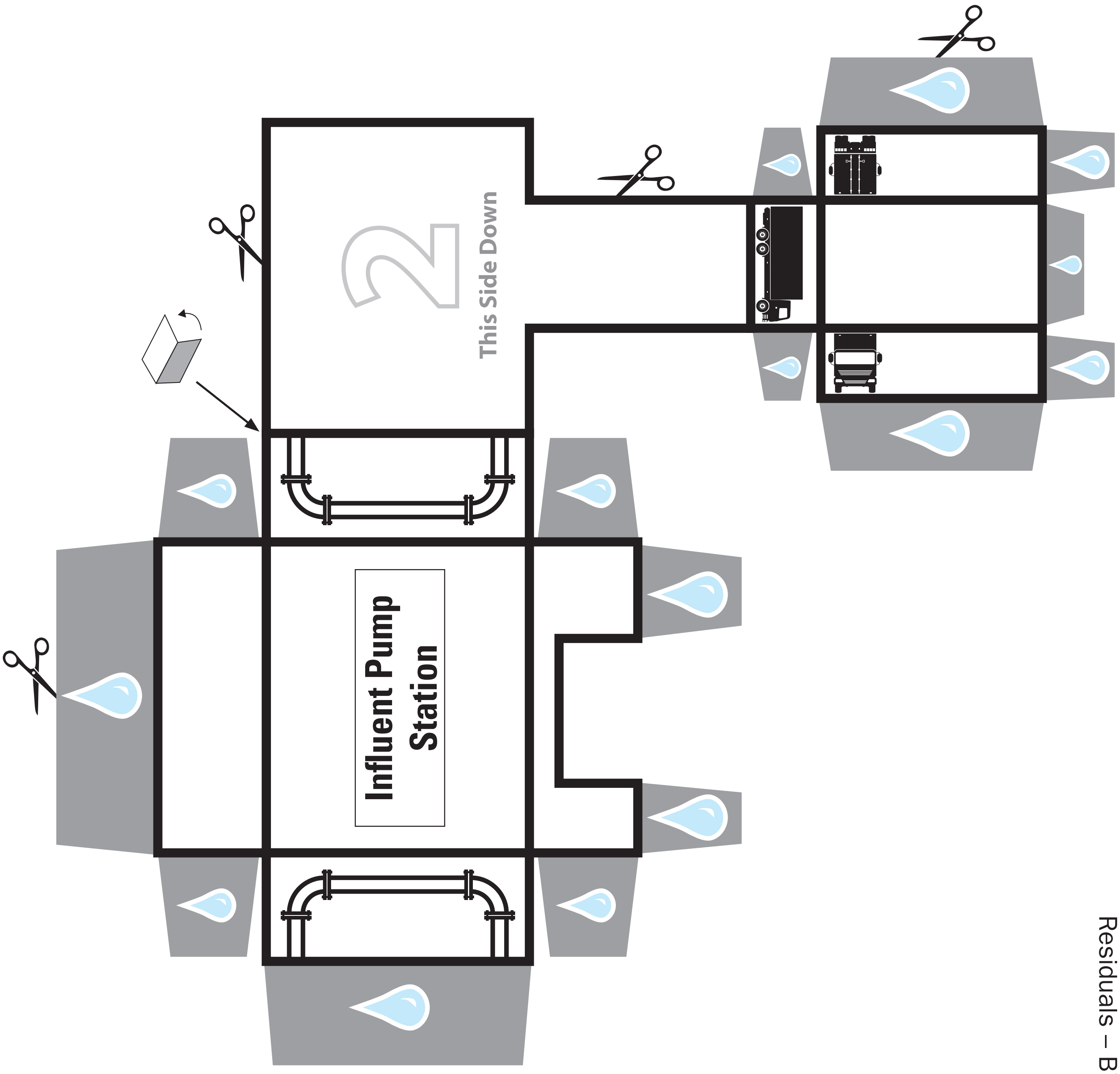
# Influent Pump Station





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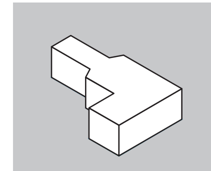
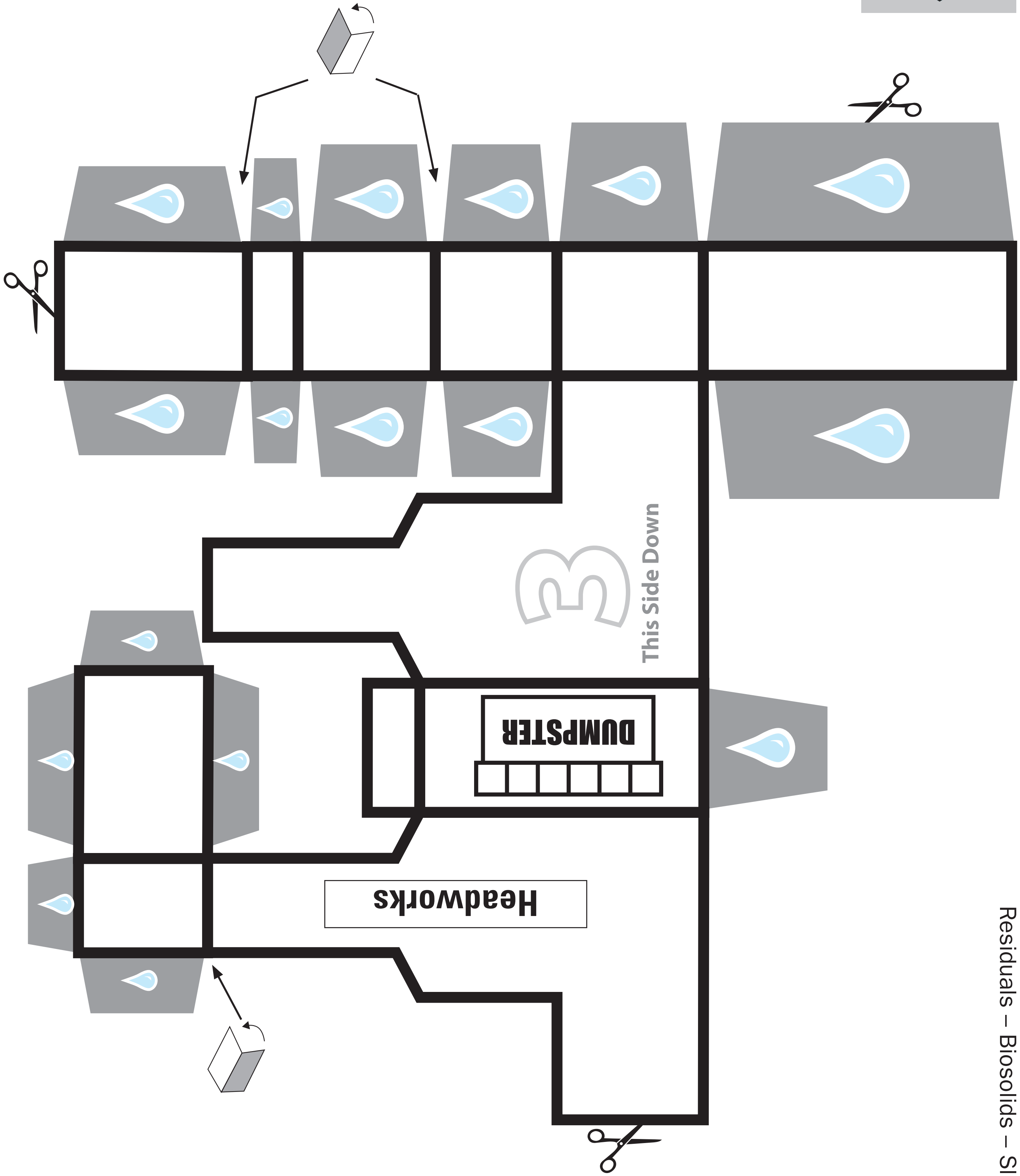
# Headworks





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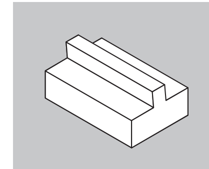
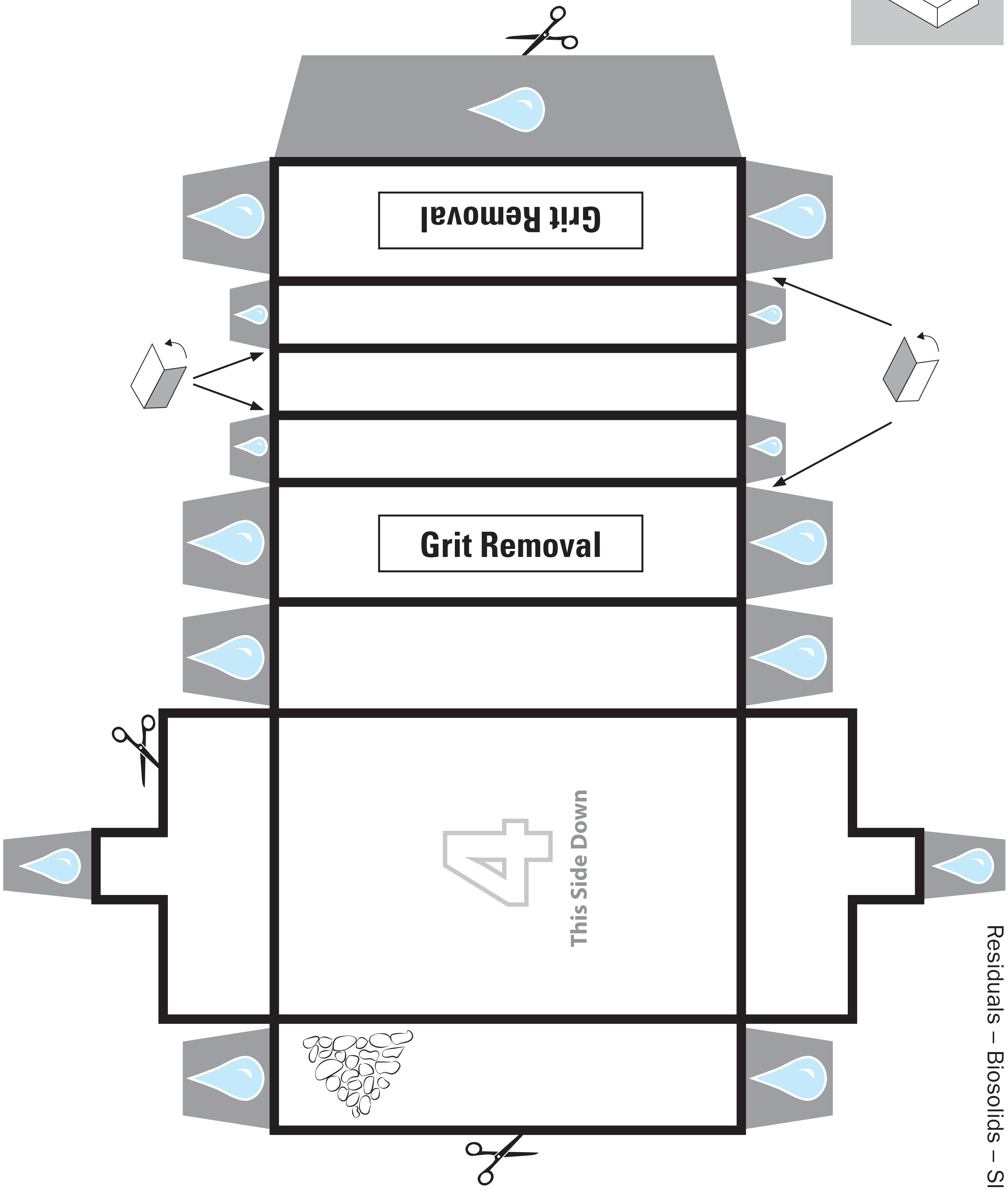
# Grit Removal





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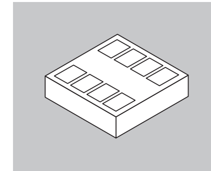
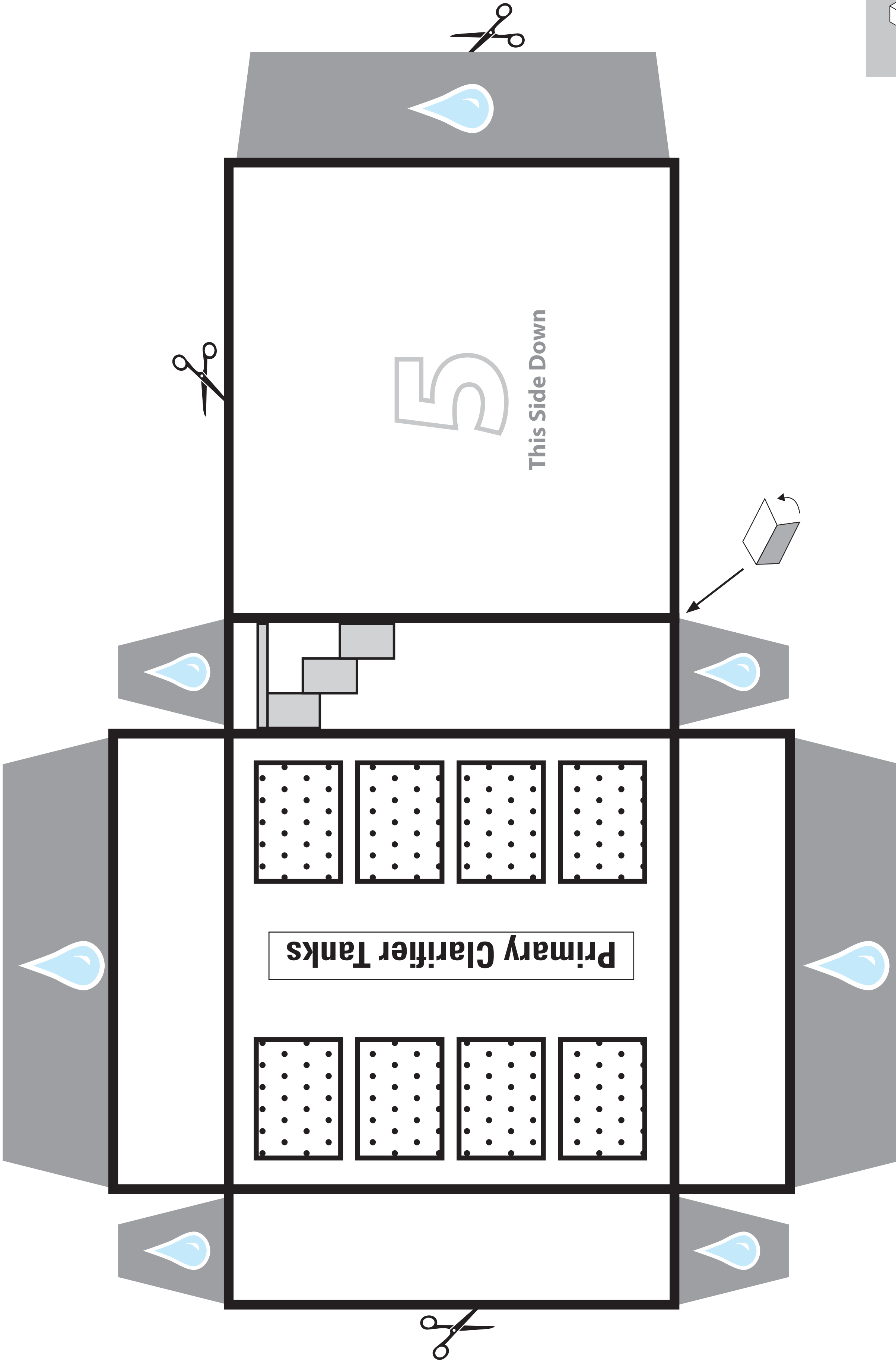
# Primary Clarifier Tanks



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Residuals – Biosolids – Sludge

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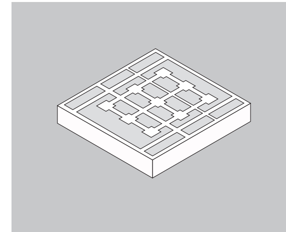
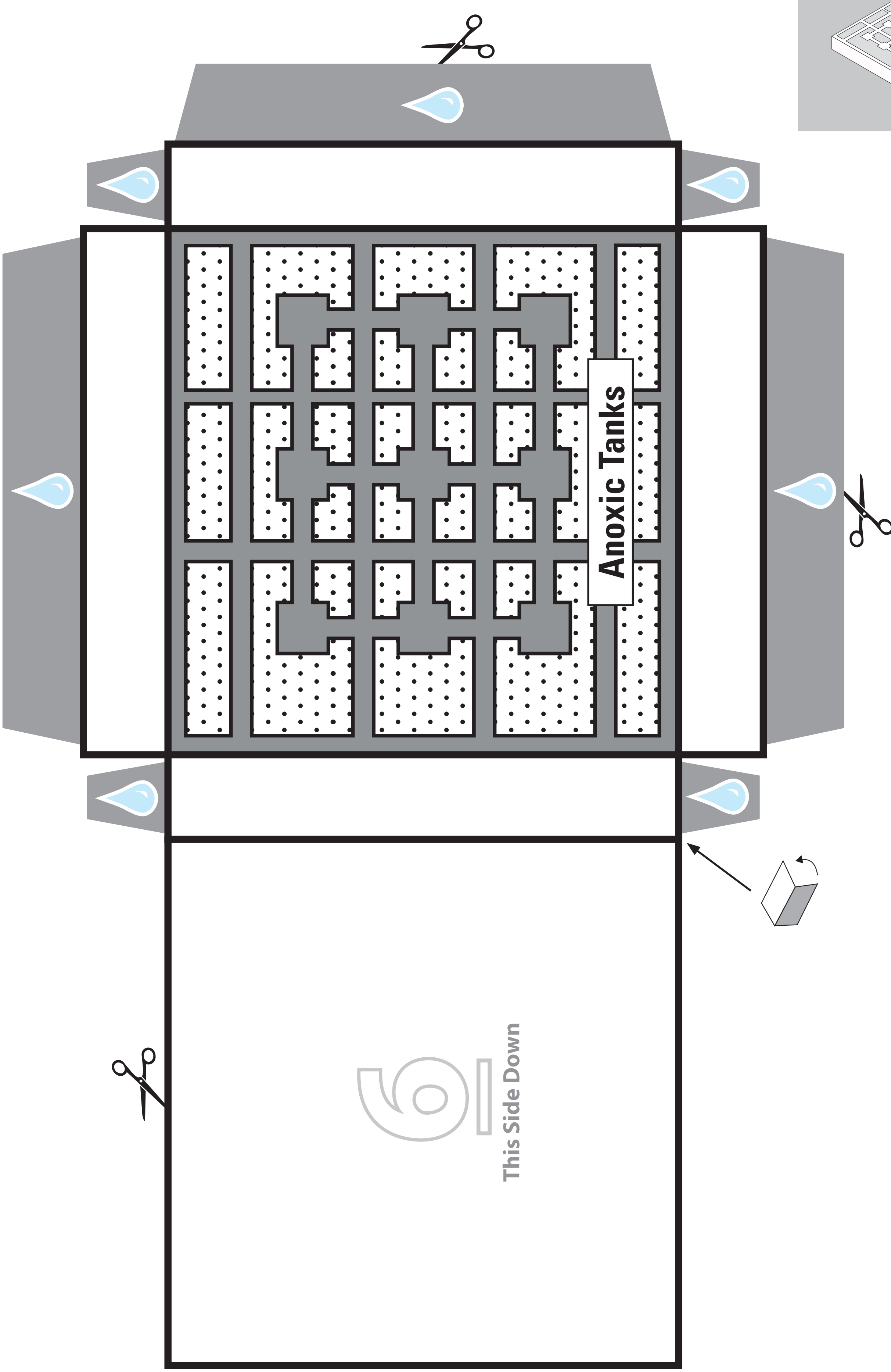
# Anoxic Tanks



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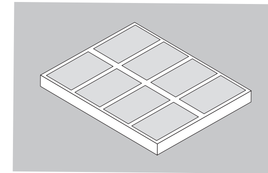
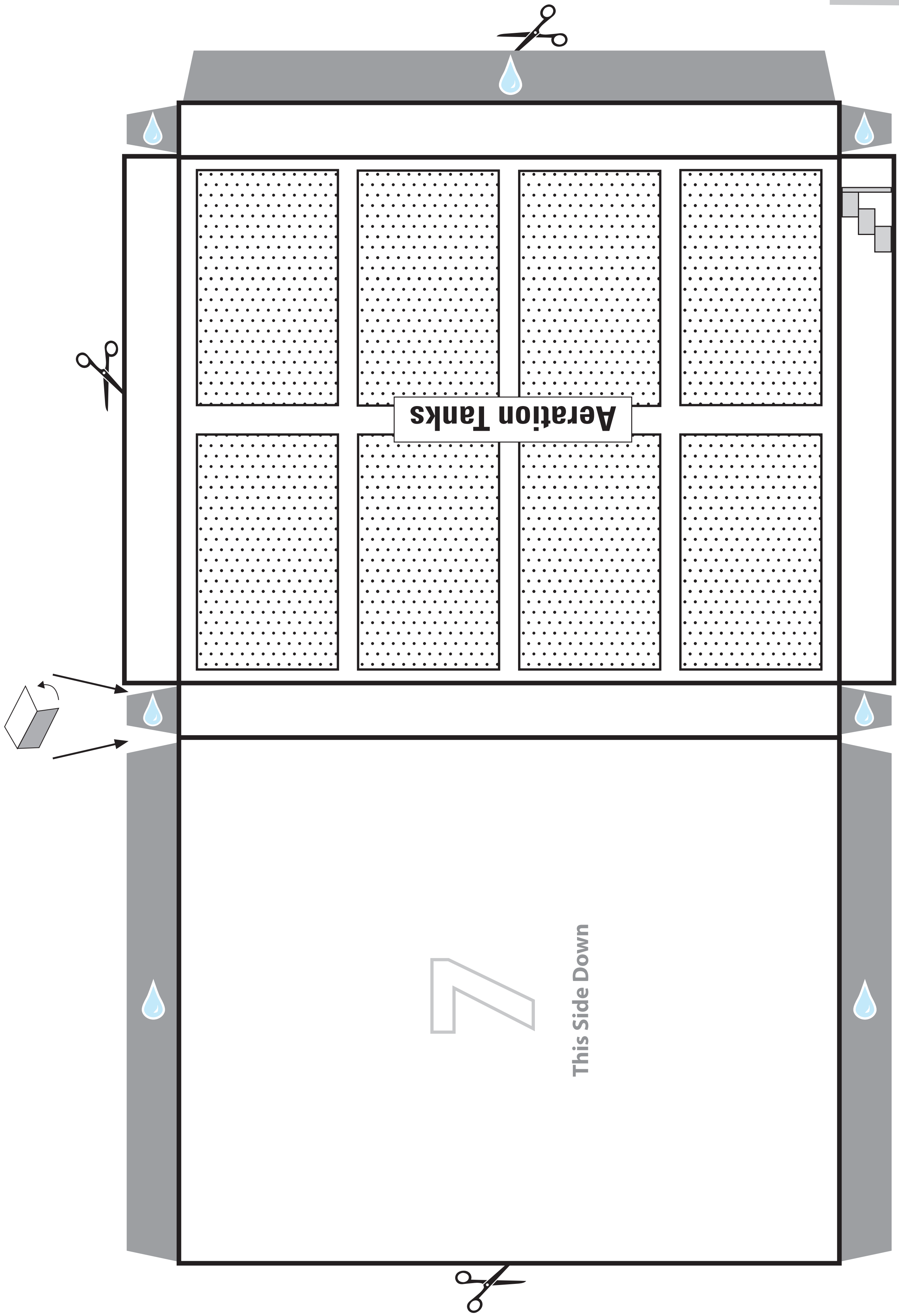
# Aeration Tanks



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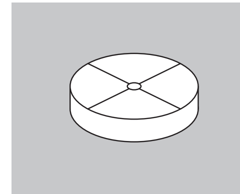
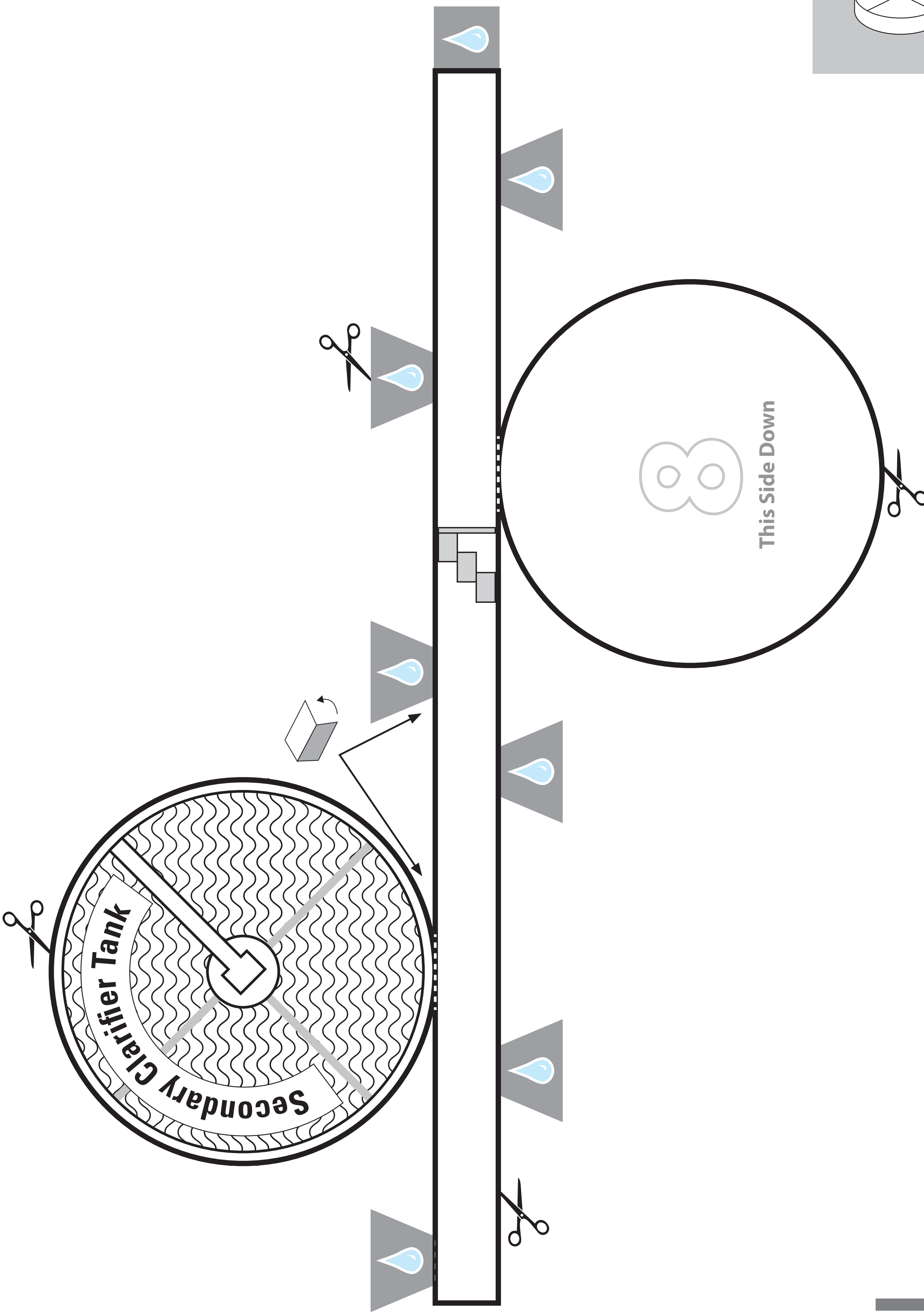
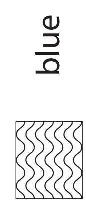
# Secondary Clarifier Tank





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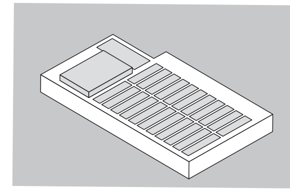
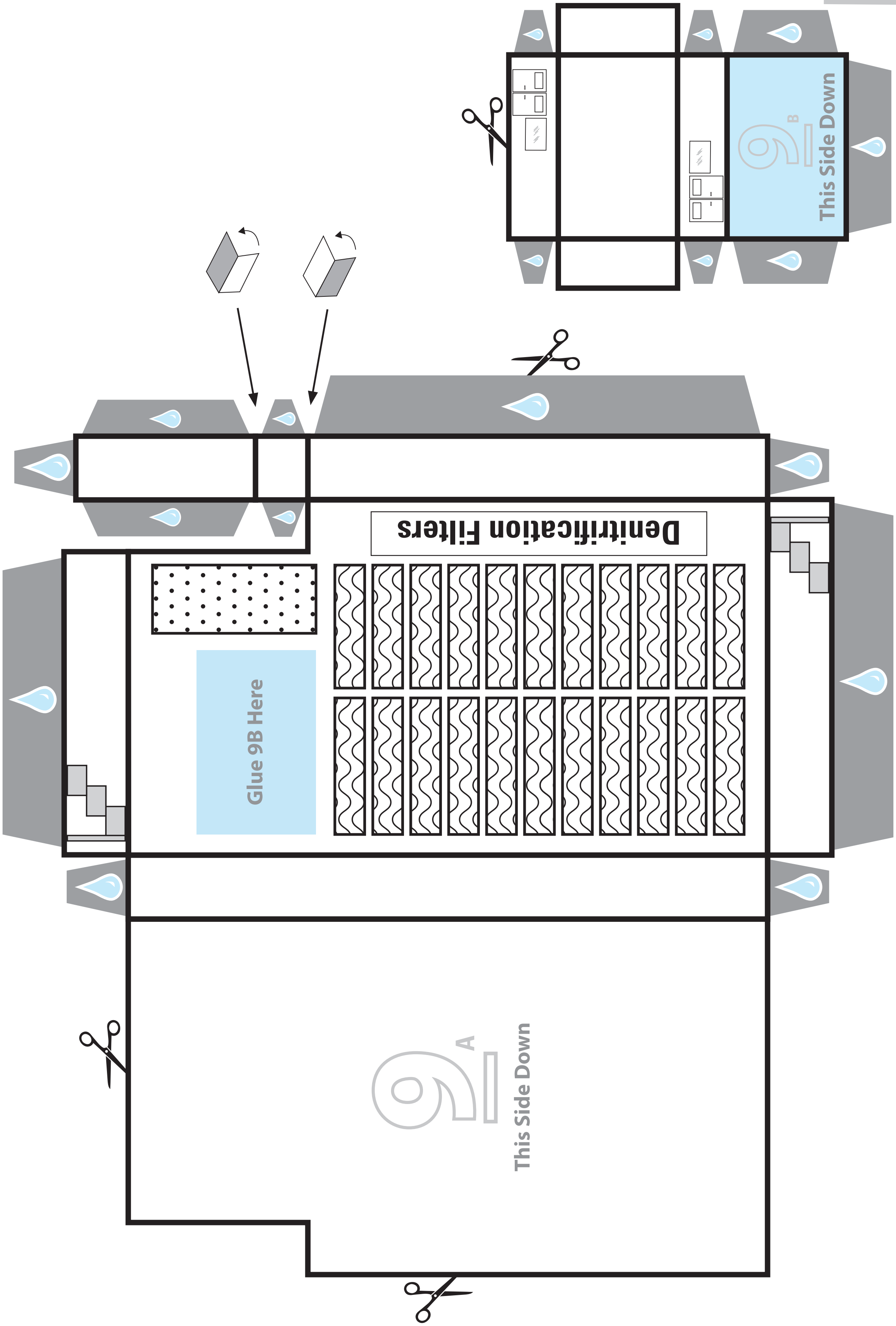
# Denitrification Filters



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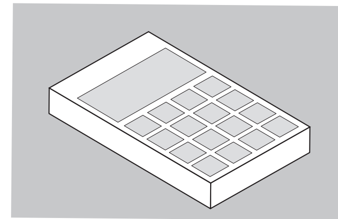
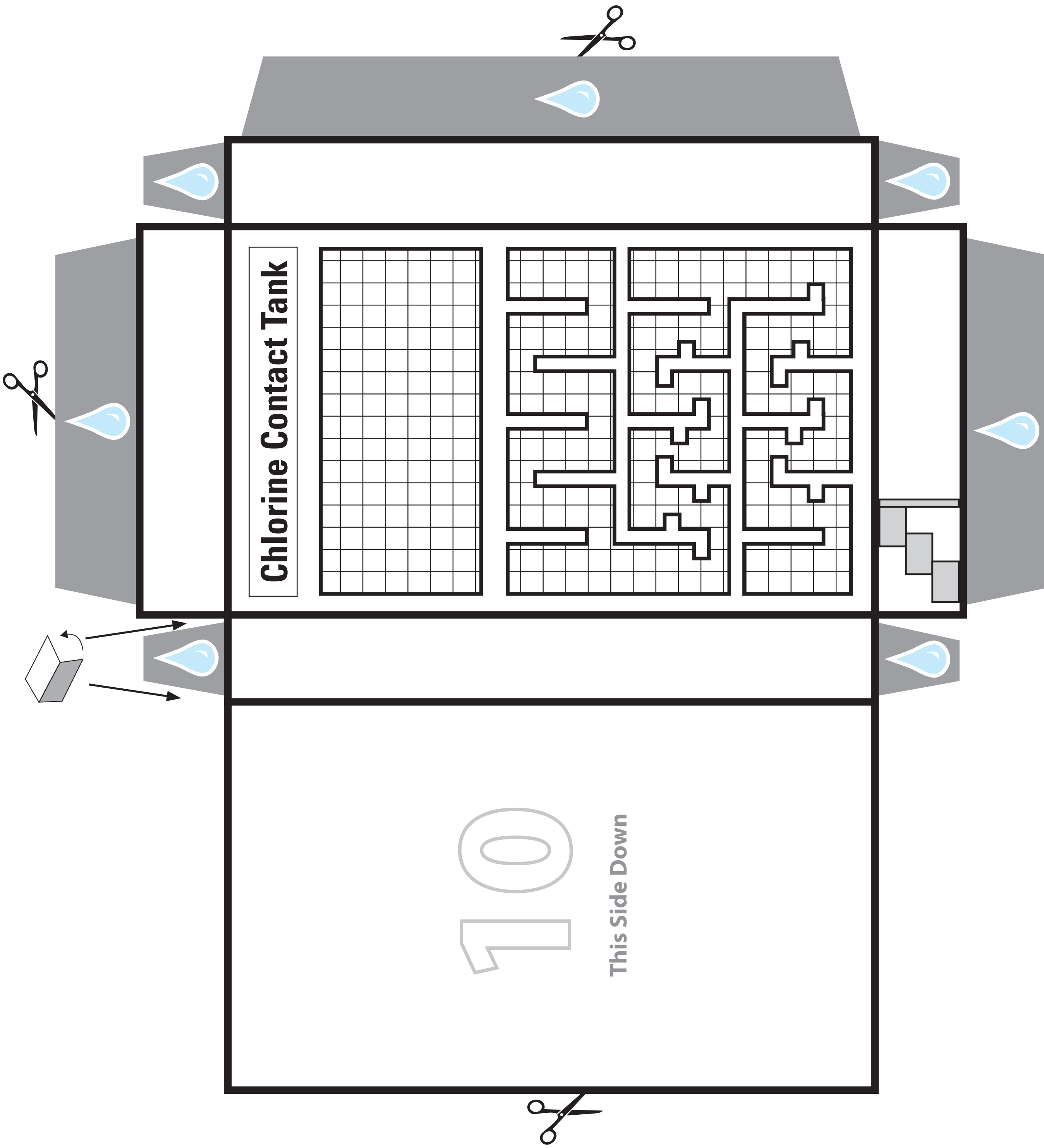
# Chlorine Contact Tank



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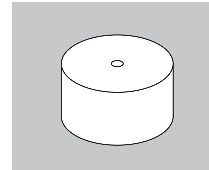
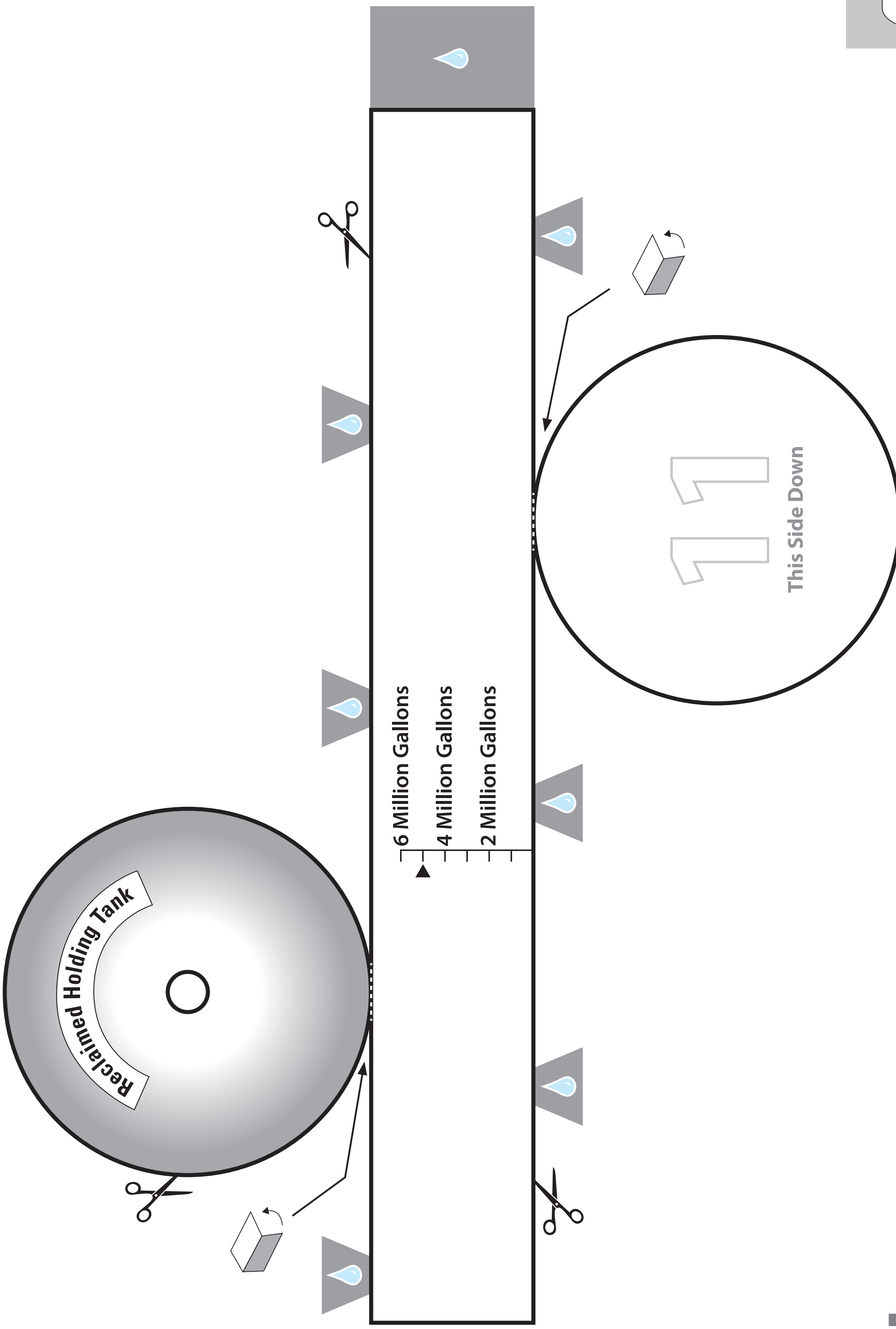
# Reclaimed Holding Tank





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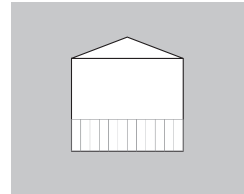
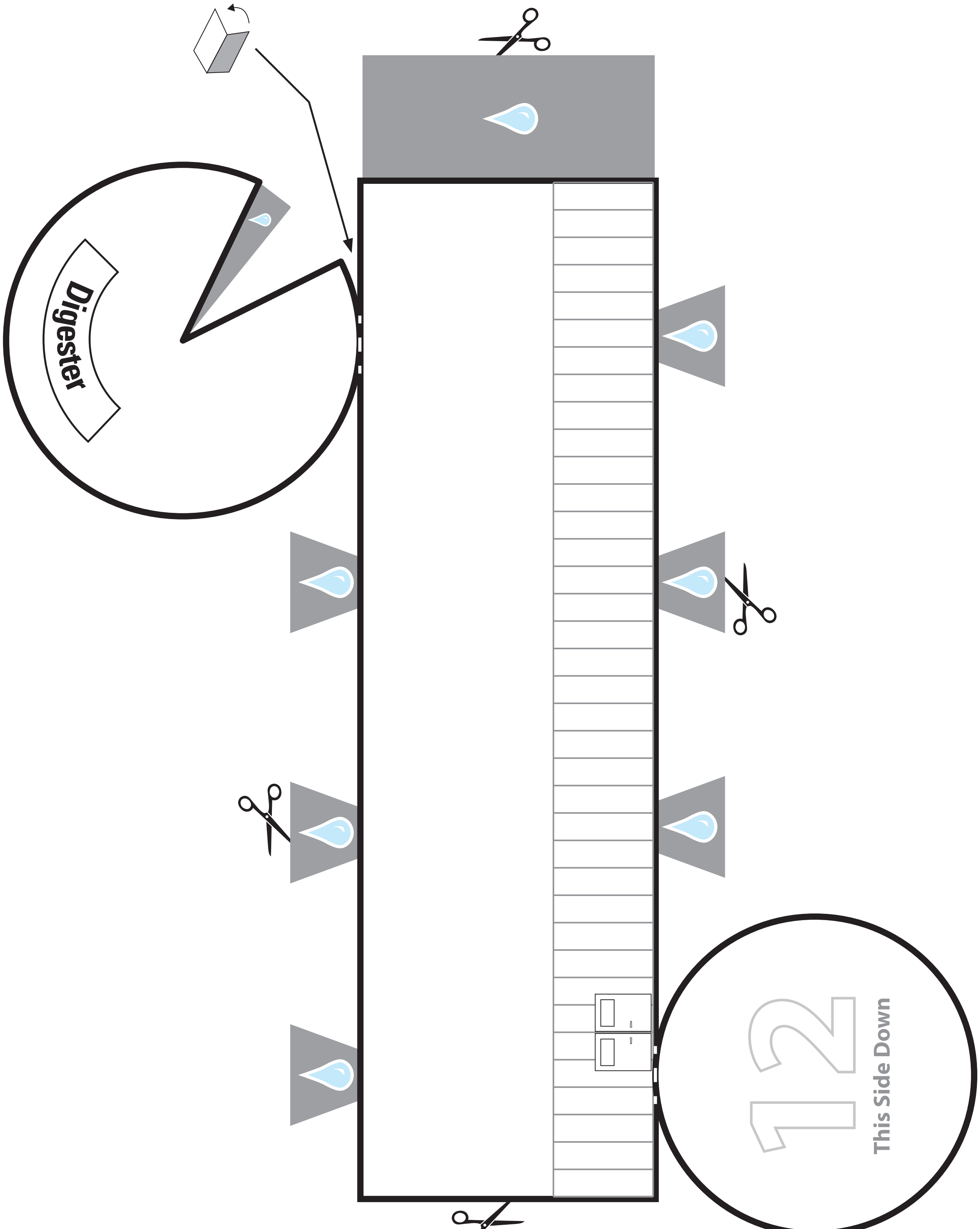
# Digester





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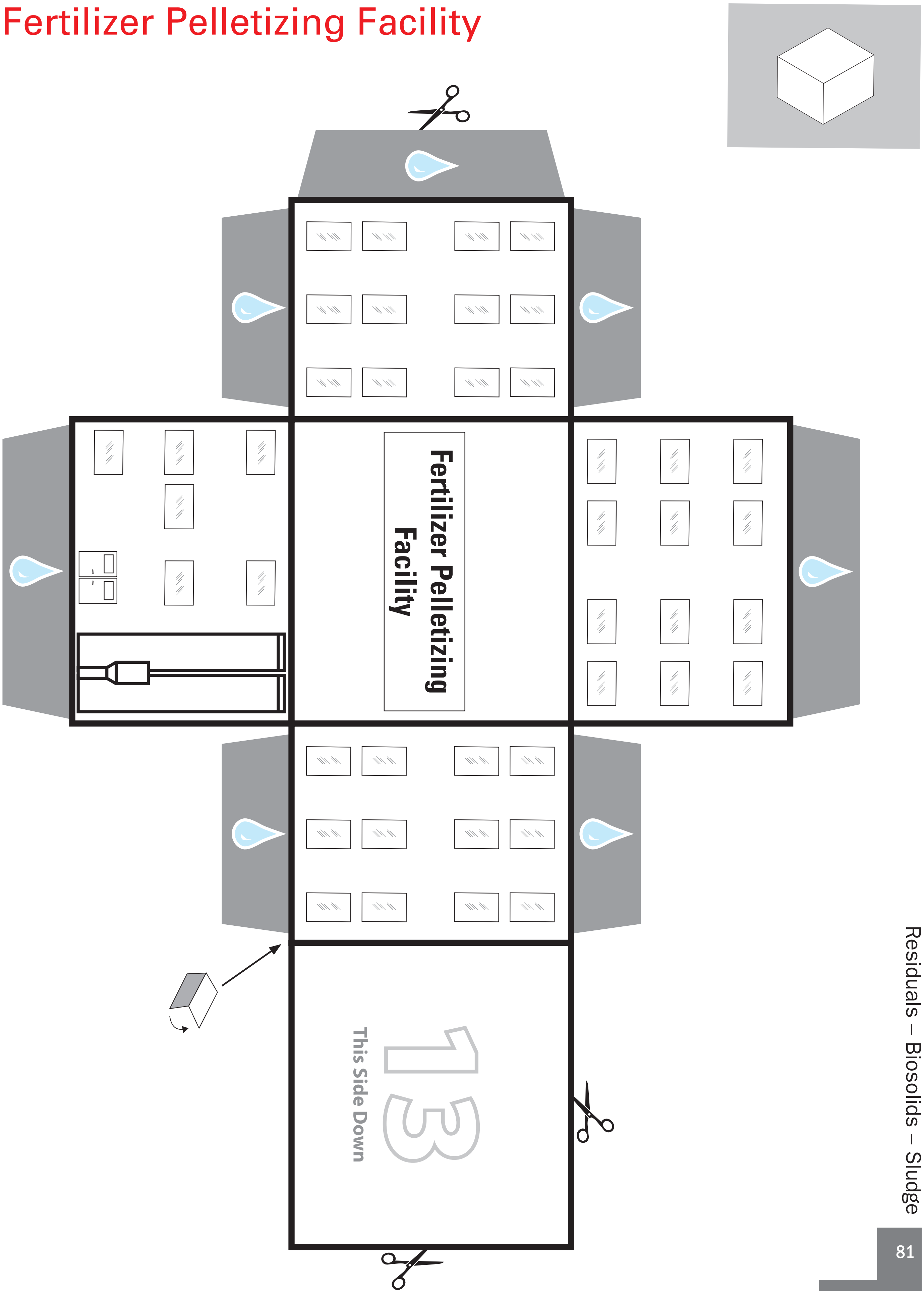
# Fertilizer Pelletizing Facility



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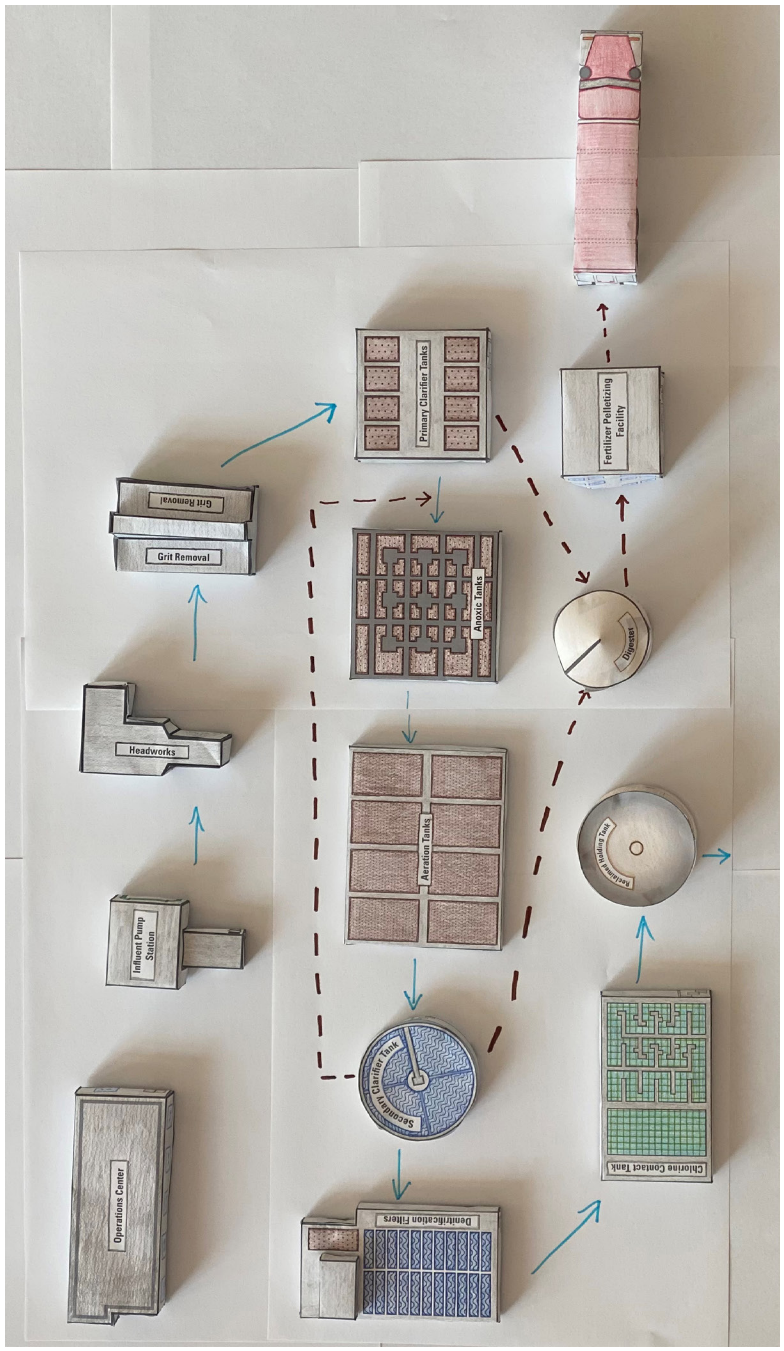
# Student Activity

## Activity 3:
## *Build Your Own Resource Recovery Facility* (continued)

ANSWER KEY

An example of a finished project



# Student Activity

## Activity 3:
## *Build Your Own Resource Recovery Facility* *(continued)*

**Evaluation Options:**

1. Quantitative grading of the students assembled products.

2. Qualitative evaluation could be observation and notes on the creative process.

3. Mastery evaluation would be demonstrated by the successful creation of wastewater/resource recovery facility replica.

**Florida Standards:**
LAFS.8.RL.1, LAFS.8.RI.1, LAFS.8.RI.2, LAFS.8.RI.3, LAFS.8.L.3, LAFS.910.RL.1, LAFS.910.RI.1, LAFS.910.RI.2, LAFS.910.L.3, LAFS.910.RST.1, LAFS.910.RST.2, LAFS.912. RL.1, LAFS.912.RI.1, LAFS.912.RI.2, AFS.912.L3, LAFS.912. RST.1, LAFS.912.RST.2, ELA.8.R.3, ELA.8.C.4, ELA.9.R.3, ELA.9.C.4, ELA.10.R.3, ELA.10.C.4, ELA.11.R.3, ELA.11.C.4, ELA.12.R.3, ELA.12.C.4, SS.8.G.3, SS.8.G.4, SS.8.G.5, SS.8.G.6, SS.8.C.1, SS.8.E.1, SS.912.G.3, SS.912.G.4, SS.912.G.5, SS.912.G.6, SS.912.E.1, SS.912.C.2, SS.912.H.3, SS.912.S.6, SS.912.S.8, VA.68.C.1, VA.68.C.2, VA.68.S.1, VA.68.S.2, VA.68.H.3, VA.912.C.1, VA.912.C.2, VA.912.S.1, VA.912.S.2, VA.912.H.3, SC.8.L.18, SC.8.N.1, SC.8.N.4, SC.912.L.14, SC.912.L.17, SC.912.L.18, SC.912.P.12, SC.912.N.3, SC.912.N.4

# Notes