

Elementary School Benchmarks

1st Grade:

MN Standard	Content Area	Wastewater Treatment Topic
1E.4.2.1.1 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* (P: 8, CC: 4, CI: ESS3) Examples of human actions that impact the land may include cutting trees to produce paper, using resources to produce bottles, and using water for bathing and brushing teeth. Examples of solutions may include reusing paper and recycling cans and bottles.	Earth and Space Science	What is Wastewater?

4th grade:

MN Standard	Content Area	Wastewater Treatment Topic
4E.1.1.1.2 Ask questions about how water moves through the Earth system and identify the type of question. (P: 1, CC: 5, CI: ESS2) Emphasis is on the processes of evaporation, condensation, and precipitation. Examples of types of questions may include those that can be tested by an experiment, and questions that may answered from a text.	Earth and Space Science	Wastewater vs storm water vs drinking water
4E.3.2.2.1 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* (P: 6, CC: 2, CI: ESS3, ETS1) Emphasis is on cause and effect relationships to explain change. Examples of solutions may include designing an earthquake-resistant building and improving monitoring of volcanic activity.	Earth and Space Science	Flooding - ensuring stormwater doesn't mix with wastewater and cause overflows
4E.4.2.1.1 Read and comprehend grade appropriate complex texts and/or other reliable media to describe that energy and fuels are derived from natural resources and their uses affect the environment. (P: 8, CC: 2, CI: ESS3, ETS2) Examples of information about natural resources should include details about those found in Minnesota. Examples of renewable energy resources may include wind, water behind dams, and sunlight; non-renewable energy resources include fossil fuels and fissile materials. Examples of environmental effects may include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution and global warming from burning fossil fuels.	Earth and Space Science	Anaerobic digesters – Combined Heat and Power (electricity generation)

HRSD Clean Water Curriculum (Hampton Roads Sanitation District)

<https://www.hrsd.com/sites/default/files/assets/Documents/pdfs/classroom/CleanWaterCurriculum-WastewaterUnitsPilot.pdf>

Middle School Benchmarks

6th grade:

MN Standard	Content Area	Wastewater Treatment Topic
<p>6E.3.2.1.3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* (P: 6, CC: 2, CI: ESS3, ETS1) Emphasis of the practice is on applying scientific principles about Earth’s natural processes (like how water moves through the ground and air) to designing solutions to problems caused by human activity. Emphasis of the core idea is on how human activity impacts Earth’s environments. Examples of parts of the design process may include assessing the kinds of solutions that are feasible, and designing and evaluating solutions that may reduce those impacts. Examples of human activities that impact the environment may include withdrawing too much water from aquifers, altering stream flow by building dams or levees, increasing runoff caused by impermeable surfaces like parking lots, or adding undesirable materials to the air, water or land.</p>	<p>ESS: Earth and Human Activity</p>	<p>Evaluate success of WWTP</p>

7th grade:

MN Standard	Content Area	Wastewater Treatment Topic
<p>7L.2.1.1.1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** (P: 4, CC: 2, CI: LS2) Emphasis is on cause and effect relationships between resources and growth of individual organisms and the number or organisms in ecosystems during periods of abundant and scarce resources. Examples may include populations of MN deer, moose, wolf, scavengers or aquatic populations in Lake Superior or algal blooms in lakes and ponds. Examples of evidence may include the use of flow charts to organize and sequence the algorithm, and to show relationships.</p>	<p>LS: Ecosystems: Interactions, Energy, and Dynamics</p>	<p>Food to Mass ratio in reactor deck Or too many nutrients in waterways and importance of wastewater treatment</p>
<p>7L.3.1.1.2 Develop and use a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. (P: 2, CC: 5, CI: LS1) Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released. Examples may include models of sugar breakdown into molecules of glucose that power our bodies, or protein breakdown into amino acids that are later reassembled to create body structures.</p>	<p>LS: From Molecules to Organisms: Structures and Processes</p>	<p>Flow of carbon: food to poop to microbes to co2/ch4</p>
<p>7L.3.1.1.3 Develop and use a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (P: 2, CC: 5, CI: LS2) Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems.</p>	<p>LS: Ecosystems: Interactions, Energy, and Dynamics</p>	<p>Flow of carbon: food to poop to microbes to co2/ch4</p>

Water Resource Recovery Connections to MN Standards

<p>7L.4.1.2.1 Construct an argument supported by empirical evidence that changes in physical or biological components of an ecosystem affect populations.* (P: 7, CC: 7, CI: LS2) Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes and/or impacts to ecosystems. Examples of physical components may include human-built structures like urban developments or dams.</p>	<p>LS: Ecosystems: Interactions, Energy, and Dynamics</p>	<p>Conditions in WWTP impact microbes Fish counts before and after WWTP</p>
<p>7L.4.1.2.2 Evaluate competing design solutions for maintaining biodiversity or ecosystem services.* (P: 7, CC: 2, CI: LS2, ETS2) Emphasis is on evaluating a solution that reduces environmental harm while still benefiting humans. Examples of ecosystem services (natural processes within ecosystems that humans also benefit from) may include water purification as it cycles through Earth’s systems, nutrient recycling, climate stabilization, decomposition of wastes, and pollination. Examples of design solution constraints may include scientific, economic, and social considerations.</p>	<p>LS: Ecosystems: Interactions, Energy, and Dynamics</p>	<p>Bacteria/decomposition - 'free' way to decompose</p>
<p>Cells?</p>		<p>Microscopes and wastewater microbes</p>

8th grade:

MN Standard	Content Area	Wastewater Treatment Topic
<p>8P.2.1.1.1 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (P: 4, CC: 1, CI: PS1) Examples of reactions may include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. Examples of properties may include density, melting point, boiling point, solubility, flammability, and odor.</p>	<p>PS: Matter and Its Interactions</p>	<p>Phosphorus testing</p>
<p>8P.2.2.1.2 Create a computer program to illustrate the transfer of energy within a system where energy changes form.** (P: 5, CC: 7, CI: PS3) Emphasis of the programming skills is the use of sequences, events and conditionals. Examples of a system may include a roller coaster, a pendulum, an electric water heater, and a solar electric collector.</p>	<p>PS: Energy</p>	<p>Combined Heat and Power (electricity generation)</p>
<p>8P.3.1.1.4 Develop and use a model to qualitatively describe that waves are reflected, absorbed, or transmitted through various materials. (P: 2, CC: 4, CI: PS4) Emphasis is on both light and mechanical waves. Examples of models may include drawings, simulations, a storyboard/diagram and written descriptions.</p>	<p>PS: Waves and Their Applications in Technologies and Information Transfer</p>	<p>The way the phosphorus test works? Spectrophotometer and wavelengths of light</p>
<p>8P.3.2.2.3 Design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* (P: 6, CC: 5, CI: PS3, ETS1) Emphasis is on using scientific principles to design the device. Examples of devices may include an insulated box, a solar cooker, and a foam cup.</p>	<p>PS: Energy</p>	<p>Geothermal Study Duluth Lincoln Park – design a way to transfer energy from warm wastewater over to Lincoln Park neighborhood</p>

High School Benchmarks

HS Bio:

MN Standard	Content Area	Wastewater Treatment Topic
9L.2.2.1.2 Use a computational model to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** (P: 5, CC: 5, CI: LS2) Examples of claims about matter cycles may include how carbon, nitrogen, or water cycles through the environment and/or how disruptions to those systems affect matter cycling. Examples of energy flow may include the transfer of the Sun’s energy into and among organisms and/or connections between fossil fuel burning and the carbon cycle	LS: Ecosystems: Interactions, Energy, and Dynamics	Connections to water, carbon, nitrogen cycles
9L.3.1.1.4 Use a model to illustrate that cellular respiration is a chemical process in which energy from food is used to create new compounds. (P: 2, CC: 5, CI: LS1) Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.	LS: From Molecules to Organisms: Structures and Processes	Anaerobic Digestion and the aeration tanks
9L.3.2.1.3 Construct and revise an explanation based on evidence about the role of photosynthesis and cellular respiration (including anaerobic processes) in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (P: 6, CC: 7, CI: LS2) Emphasis is on the importance of biological processes in the global scale cycling of carbon and on a conceptual understanding of the role of aerobic and anaerobic respiration in different environments.	LS: Ecosystems: Interactions, Energy, and Dynamics	Anaerobic digestion (and composting process)
9L.4.1.1.3 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (P: 7, CC: 2, CI: LS4) Emphasis is on determining cause and effect relationships for how (1) changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and (2) the rate of change of the environment affect distribution or disappearance of traits in species.	LS: Biological Evolution: Unity and Diversity	Wastewater Microbes – changes in populations with bugs counts based on conditions at wastewater treatment plant Eutrophication Biosolids fertilizers
Cells?		Microscopes and wastewater microbes

HS Enviro Sci:

MN Standard	Content Area	Wastewater Treatment Topic
9E.1.2.1.1 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (P: 3, CC: 6, CI: ESS2) Emphasis is on physical and chemical investigations with water and a variety of solid materials to provide the evidence for how processes in the water cycle and rock cycle interact. Examples of physical investigations may include transportation and deposition of various sediment types and sizes, erosion of surfaces with varying amounts of soil moisture content and/or ground cover, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations may include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids). Examples specific to Minnesota may include chemical weathering of limestone to create karst topography.	ESS: Earth's Systems	Biosolids regulations
9E.1.2.1.2 Plan and conduct an investigation of the properties of soils to model the effects of human activity on soil resources. (P: 3, CC: 2, CI: ESS3, ETS2) Emphasis is on identifying variables to test, developing a workable experimental design, and identifying limitations of the data. Examples of variables may include soil type and composition (particularly those found in Minnesota), erosion rate, water infiltration rates, nutrient profiles, soil conservation practices, or specific crop requirements.	ESS: Earth and Human Activity	Biosolids and soil types? Infiltration rates, conservation practices (setbacks) apply at nitrogen rate of crop
9E.3.2.2.1 Evaluate or refine a technological solution to reduce the human impacts on a natural system and base the evaluations or refinements on evidence and analysis of pertinent data.* (P: 6, CC: 7, CI: ESS3, ETS1, ETS2) Emphasis is on prioritizing identified criteria and constraints related to social and environmental considerations. Examples of data for the impacts of human activities may include the quantities and types of pollutants released into air or groundwater, changes to biomass and species diversity, or areal changes in land surface use (for surface mining, urban development, or agriculture). Examples for limiting impacts may range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).	ESS: Earth and Human Activity	Evaluate success of WWTP Case Study
9E.4.1.1.3 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* (P: 7, CC: 5, CI: ESS3, ETS1) Emphasis is on the conservation, recycling, and reuse of resources (such as minerals, metals or soils) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for fracking sand, iron ore, and rare metals), and pumping (for oil and natural gas).	ESS: Earth and Human Activity	Use of biosolids as fertilizer
9E.4.2.1.1 Compare, integrate and evaluate sources of information in order to determine how specific factors, including human activity, impact the groundwater system of a region. (P: 8, CC: 2, CI: ESS2, ETS2) Emphasis is on making sense of technical information presented in a variety of formats (graphs, diagrams and words). Examples of sources of information may include student experimental data. Examples of factors may include porosity, permeability, sediment or rock type, recharge or discharge factors, and potential energy. Examples of human factors may include usage rates, runoff, agricultural practices, and loss of wetlands.	ESS: Earth's Systems	Use of biosolids as fertilizer

HS Chemistry:

MN Standard	Content Area	Wastewater Treatment Topic
9C.1.2.1.2 Plan and conduct an investigation of acid-base reactions to test ideas about the concentrations of the hydronium ion in an aqueous solution (pH). (P:3, CC: 3, CI: PS1) Emphasis is on developing an understanding of pH scales and various ways to measure pH. Also included is understanding the relative strength of acidity based on periodic properties of elements, the electronegativity model of electron distribution, empirical dipole moments, and molecular geometry. Examples of investigations may include household chemicals and ocean acidification analogs.	Chemistry - PS: Matter and Its Interactions	pH measurements in lab
9C.2.1.1.1 Analyze patterns in air or water quality data to make claims about the causes and severity of a problem and the necessity to remediate or to recommend a treatment process. (P: 4, CC :2, CI: PS1) Emphasis is on the scale of the problem and appropriate use of concentration units. Examples of pollutant data may include ozone, lead, particulates, nitrates, or microorganisms. Examples of remediation may include physical, chemical or biological processes.	Chemistry - PS: Matter and Its Interactions	Pollutant data analysis for patterns
9C.3.2.1.1 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (P: 6, CC: 1, CI: PS1) Examples of chemical reactions may include synthesis, decomposition, or combustion.	Chemistry - PS: Matter and Its Interactions	Anaerobic Digestion and Combined Heat and Power
9C.4.2.1.1 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* (P: 8, CC: 6, CI: PS1) Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples may include why electrically conductive materials are often made of metal.	Chemistry - PS: Matter and Its Interactions	Molecular Structure and function of PFAS (lead into Pollutant data analysis and are PFAS worth it...)
9C.4.2.2.1 Communicate and evaluate claims by various stakeholders, including Minnesota American Indian Tribes and communities and other cultures, about the environmental impacts of various chemical processes on natural resources. (P: 8, CC: 2, CI: PS1) Examples of cultures may include those within the local context of the learning community and within the context of Minnesota. Examples of natural resources may include wild rice harvesting, mining of minerals, and access to clean air and water. Examples of chemical processes may include sulfate in water/soil, acid mine drainage, and air and water pollution.	Chemistry - PS: Matter and Its Interactions	Sulfate standard and Wild Rice

HS Physics:

MN Standard	Content Area	Wastewater Treatment Topic
9P.2.2.1.3 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in or out of the system are known.** (P: 5, CC: 4, CI: PS3) Emphasis is on explaining the meaning of mathematical expressions used in the model for systems of two or three components. Forms of energy may include thermal energy, kinetic energy, and elastic potential energy. Computational models may include the creation or use of a simulation or the analysis of a data set.	Physics - PS: Energy	Thermal energy at WWTP
9P.3.2.2.2 Evaluate a solution to a complex energy-related problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, aesthetics, and maintenance, as well as social, cultural, and environmental impacts.* (P: 6, CC: 2, CI: PS3, ETS1) Examples of energy-related problems may be drawn from alternative energy, manufacturing, and transportation systems.	Physics - PS: Energy	Thermal energy at WWTP