Land Use Planning

Lesson Focus: Land use affects water quality

Learning objectives:

- To develop an understanding of how to use an aerial photograph to determine land cover type
- To use an identification key to aid in interpreting satellite images
- To use land cover type to infer land use possibilities
- To predict what impact local land use might have on both groundwater and surface water at the school site

Enduring Understandings for the lesson:

- Human choices and actions have consequences for the environment
- The way land is used affects the quality of water that flows across and through it.

Georgia Performance Standards Addressed:

- S4L1c Predict how changes in the environment would affect a community (ecosystem) of organisms.
- S5E1b Identify and find examples of surface features caused by destructive processes (erosion)
- S5E1c Relate the role of technology and human intervention in the control of constructive and destructive processes
- S4 and 5 CS3 Use computers, cameras and recording devices for capturing information
- S4 and 5 CS4a Observe and describe how parts influence one another in things with many parts
- SSMap and Globe skills11: Compare maps of the same place at different points in time and from different perspectives to determine changes, identify trends, and generalize about human activities

Grade level: 4th, 5th

Materials:

1. key of satellite images that represent common ground cover
2. worksheet of image characteristics
3. copy of local map that students can color code

4. worksheet of water quality associations
5. digital projector or smartboard, internet connection

Time needed: two class sessions

Background information:

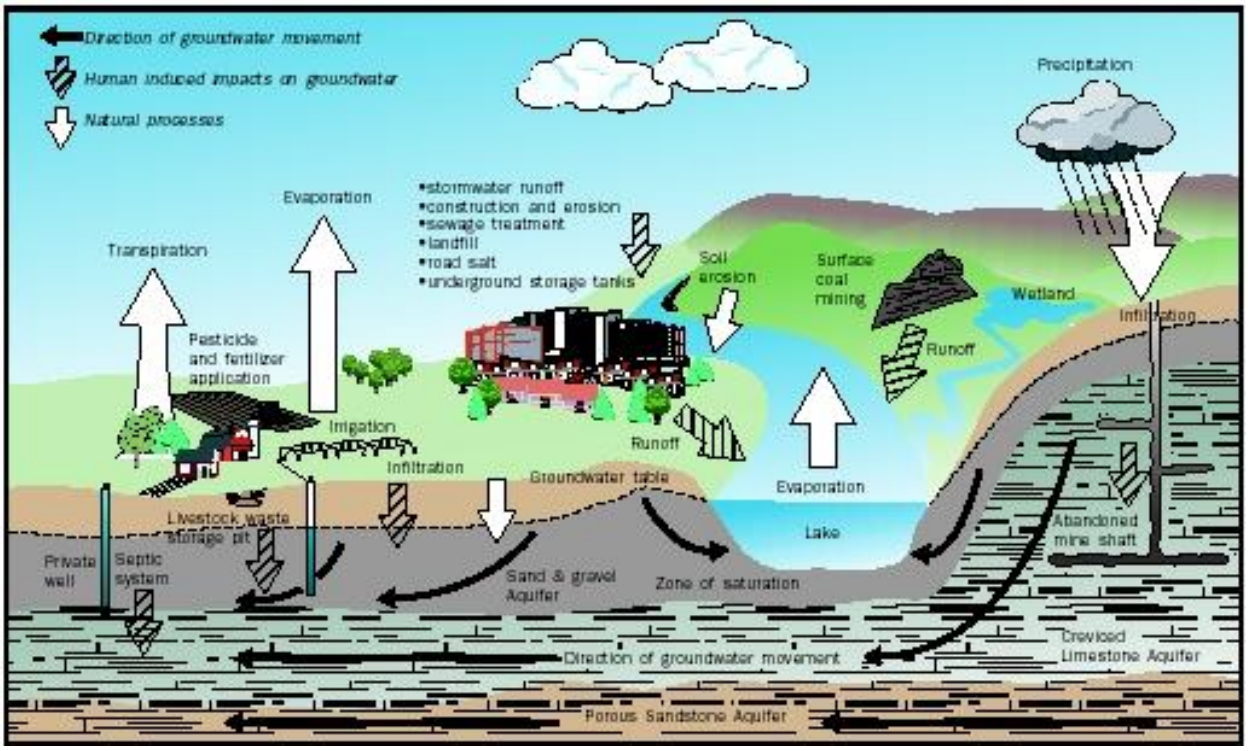
Land cover and land use

Land cover refers to the features present on the surface of the Earth. For example, farm fields, lakes, rivers, forests, roads, and parking lots are all types of land cover. Land cover can refer to a biological category, such as grassland or forest, or to a physical category such as concrete. Land cover includes the type and quality of vegetation, water, and earth materials. Land cover is influenced by land use due to human cultural, social, and economic activities. Land use refers to the purposes that are associated with the land cover, such as raising cattle, recreation, or urban living. A single category of land use can be associated with a variety of land covers, and a single land cover may support multiple uses. For example, residential land may have tree cover, grass cover, road cover, and roof cover while a forest may be used for timber production, recreation, or wildlife habitat.

Land use and water quality

Streams, rivers, and lakes are an important part of the landscape, as they provide water supply, recreation, and transportation for humans, and a place to live for plants and animals. Groundwater also is an important water resource that serves as a source of drinking water.

Fresh water sources are fed by rain water. Rain falls not only on rivers, streams, lakes, and oceans but also on the land. Water quality is affected by the cover and use of the land it drains from. In turn, water quality can also impact the siting of land use activities. Land use is partly determined by environmental factors such as soil characteristics, climate, topography, and vegetation. It is also determined by human activity such as agriculture, recreation, and urban living.



This diagram shows examples of land use and land cover that introduce foreign matter to streams, lakes, and underground aquifers. Naturally occurring contaminants are shown by white arrows, and those produced by human activities are shown with hatched arrows.

Pollution sources that affect surface water may be separated into two categories: point and nonpoint. Point sources include sewage treatment plants, industrial discharges, or any other type of discharge from a specific location (commonly a pipe) into a stream. Underground point sources may be difficult to locate and identify, such as buried septic systems and leaking underground fuel tanks. By contrast, nonpoint sources—which include runoff from lawns, roads, or fields—are diffuse sources of contaminants that are not as easily identified or measured as point sources.

Movement of contaminants is often affected by rainfall that results in runoff and infiltration. Typically, the contaminant concentration from nonpoint sources will increase as flow increases during storm runoff; conversely, concentrations from point sources generally decrease through dilution during storm runoff. Contaminants can travel from a variety of sources through multiple pathways into nearby stream channels or lakes. Scientific assessments of the origin of a nonpoint-source contaminant can be difficult because its source(s) usually is dispersed throughout a landscape. If

contaminants are found in water, it is assumed that the source can be found in the surrounding watershed. Sometimes these sources can be inferred from the type and intensity of land use in the contributing area.

Land Use and Groundwater

Relationships have been found between land use and five common groundwater contaminants: nitrogen, bacteria, road salt, pesticides, and volatile organic compounds.

- Nitrate (a form of nitrogen) is essential for plant growth, but too much can contaminate wells and groundwater. Nitrate can come from domestic sewage and lawn fertilizers in residential areas, and from crop fertilizers and manure in agricultural areas. Land-use data that shows housing density and agricultural practices can indicate the likelihood of nitrate contamination.
- Bacteria are present in human sewage and manure form cattle, hogs, chickens or other animals. It contains pathogens that can cause human illness. Land-use data on densities of septic tanks and animals are useful indicators of the possible presence of bacteria.
- Road salt used to treat winter iced roads can carry sodium and calcium chlorides into the groundwater. Data on road density, salt application rate, and locations of salt storage piles can be indicators for detection of elevated chloride concentrations in water.
- Pesticides are used to kill unwanted pests, such as termites, ants, and rodents around homes and businesses; nematodes in soil, and fungi and insects in crops. Similarly, herbicides are used to kill weeds and grasses in lawns, along roads, and in agricultural areas. Types and amounts of pesticides can be related to land-use factors such as population and housing density, number of roads, and type of cropland. In recent studies, the concentrations of most pesticides in water have rarely exceeded state or federal standards for drinking water; however, the effects of chronic, low-level exposures to pesticides on ecological and human health have not yet been fully assessed.
- Volatile organic compounds (VOCs) have affected groundwater locally throughout the United States. Many VOCs are carcinogenic; so their presence in groundwater creates a serious problem. VOCs are commonly found in groundwater in industrial and commercial areas where petroleum fuels and organic solvents are used. A major source

is leaking fuel tanks, which contaminate the underlying aquifers with an additive used in gasoline to reduce smog-producing emissions. The presence of VOCs in groundwater is directly related to urban and suburban development.

Land Use and Surface Water

- Natural and human factors also affect the quality and use of streams, lakes, and rivers, known as surface water. Residential, commercial, and agricultural use can affect the concentration of the same contaminants as found in groundwater; nitrogen, bacteria, road salt, pesticides, and volatile organic compounds. Surface water is also impacted by the introduction of sediment and nutrients, which are filtered out of groundwater by the natural process of infiltration, and by wastewater discharges.
- Sediment is eroded and transported mostly during heavy rainfall events and high stream flows during resulting floods. Sediment can become a problem because its deposition in streams and lakes can ruin the habitat of aquatic plants and animals. It can also fill in stream channels, lakes, and harbors, which then need expensive dredging. Many contaminants can attach (adsorb) and move with the sediment particles. Different types of contaminants can be transported with sediment, such as phosphorus, a nutrient which can cause excessive plant growth in rivers and lakes, and persistent organochlorine compounds such as PCBs and DDT. Persistent compounds have been shown to be present 40 years after the initial release. The amount of suspended sediment in rivers can be related to natural factors such as soil type and local geology. However, the most important factor for sediment transport is the amount of land cleared of vegetation. Sediment sources are often lacking in highly developed areas with large areas under pavement, but during tillage or construction, exposed soil can easily be eroded during storms and deposited in downstream waterways.
- Wastewater discharges from municipal sewage treatment plants, from industrial and commercial sources, and from confined animal feedlots can impair the quality of the receiving waters. Municipal sewage, for example, contains high concentrations of organic compounds that may deplete the dissolved oxygen content of water downstream from the discharge. Depleted oxygen levels are toxic to bottom dwelling fauna and fish. Wastewaters also contain significant amounts of phosphorus

and nitrogen. The volume of wastewater discharges is often directly related to land use within the contributing watershed.

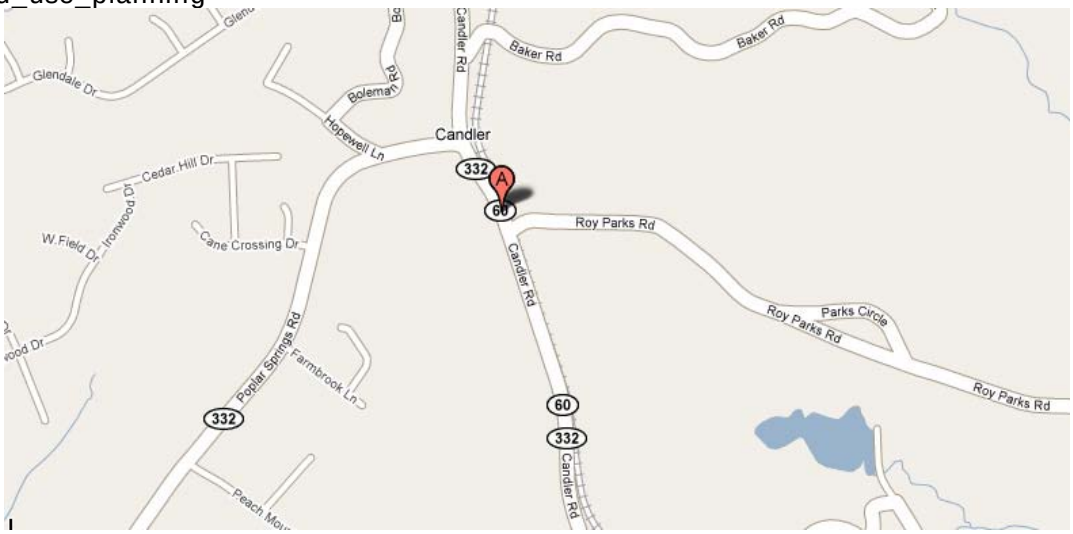
- The category of “emerging contaminants” has been added to water studies since the 1990s. These newly identified contaminants include human and veterinary pharmaceuticals, industrial and household wastewater products such as caffeine, detergent byproducts, and insect repellants, and reproductive and steroidal hormones. Studies have shown that these organic wastewater contaminants can persist in water bodies far downstream of their discharge points, which are commonly found in cities and livestock production areas. Concentrations of these compounds are typically low, often at trace levels, but they were found in rivers and aquifers that supply drinking water. The significance of these contaminants is unknown, particularly for the effects of long-term exposure at low levels.

Analysis of land use and associated human and livestock densities in watersheds will be a tool for scientists as they work to define and control the diverse sources of water contaminants.

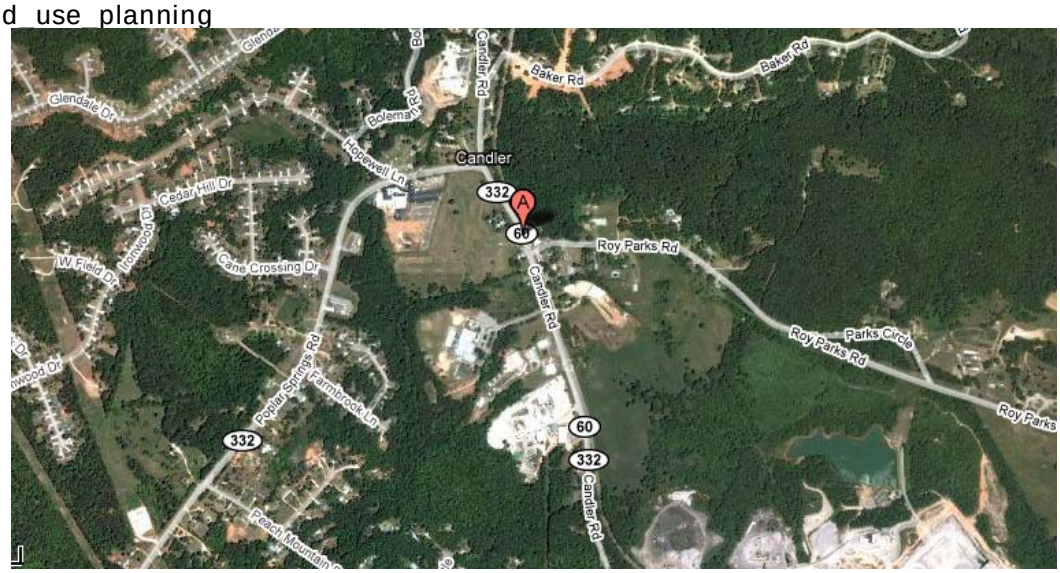
Learning Procedure:

In this lesson, students will use satellite images to identify land use. The "bird's-eye" view of the earth that aerial photographs and satellite images offer is valuable. Studying the Earth from above allows students to see things and how they relate to each other. Students will learn to recognize familiar landmarks from this “birds-eye” perspective. All types of maps use this orientation.

1. Open Google maps. The first screen shows a political map of the whole United States. Locate Georgia. Type in the name of the town where your school is located.
2. Use the local map to locate the school property. You can type in the name and address of the school. If you don’t have a digital projector, you can pull the map ahead of time, enlarge it and make copies for student groups. Have students identify the main roads around the school.



3. Identify any local water source. Small creeks and streams will typically not be shown on a road map. Have student indicate where a creek or stream would be if there is one in the school area.
4. Use worksheet 1 to discuss the characteristics used to identify the features on a satellite image. Review the key to identify common land use features. Use worksheet 2 to show what aerial views of various types of land use look like for practice.
5. Use the tabs on Google maps to switch to the satellite image. Zoom out to look over the town. Zoom in until you can see rooftop features. Use the key of groundcover features and the worksheet of image characteristics to identify various features of the hometown. Road names and highway numbers are superimposed on the Google satellite images. Ask students to identify streets where they live, to “drive” the roads and pass landmarks as they visually explore the map.
6. Return to the school address in the satellite view. Identify the roof of the school building. What are the land uses of the area around the school?



7. Take a paper copy of the area surrounding the school and color code the surrounding land cover as commercial, residential, or agricultural.
8. Discuss the possible water contaminants that are associated with each type of land use. Use worksheet 3 to identify possible water contaminants that could affect ground or surface water at the school.

Evaluation: Student maps show the use of surrounding land. Possible sources of water contamination are listed.

Extensions: Go to the terrain tab on Google maps to see topographical elevation lines. Trace the high points around your school to identify the watershed flow area. Contaminant infiltration is affected by gravity flow from surrounding areas, not just what is adjacent.

Resources: Worksheets 1, 2, 3

Lesson developed by: Caye Guidry, Myers Elementary

This product of the Rivers to Reef Teacher Workshop sponsored by the Georgia Aquarium and NOAA Gray's Reef National Marine Sanctuary, in which the authors participated. For more information about this workshop, Georgia Aquarium, or Gray's Reef National Marine Sanctuary, please visit our websites at www.georgiaaquarium.org or http://graysreef.noaa.gov/

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

National Marine Sanctuaries Gray's Reef

Georgia Aquarium at Pemberton Place

Worksheet 1

Characteristics of Satellite Images

Six characteristics in satellite images can help in identifying natural and manmade land cover features.

1. Tone (also called Hue or Color) – refers to the relative brightness or color of objects on an image. It is the most basic of the interpretive elements. Vegetation appears green, while water looks blue.

2. Size – The size of objects must be considered in the context of the scale of an image. How close is the image zoomed in? The scale will help you determine if an object is a stock pond or a large lake.

3. Shape – refers to the general outline of objects. Regular geometric shapes usually indicate human presence and use, whether of buildings, lots, or fields. Some objects can be identified simply on the basis of their shapes, such as cloverleaf highway interchanges or airport runways.

4. Texture – the impression of "smoothness" or "roughness" of image features is caused by the way the frequency of tone changes. Grass, cement, and water generally appear "smooth", while a forest canopy may appear "rough".

5. Pattern (also called spatial arrangement) - The patterns made by objects in an image can help identify features. Think about the difference between the random pattern formed by a natural forest area and the evenly spaced rows formed by an orchard.

6. Association – Some objects are always found *in association with* other objects. The context of an object can give clues to what it is. For instance, a factory is not usually going to be found in the midst of single-family housing. But, a playing field with baseball diamonds might be in a residential neighborhood.

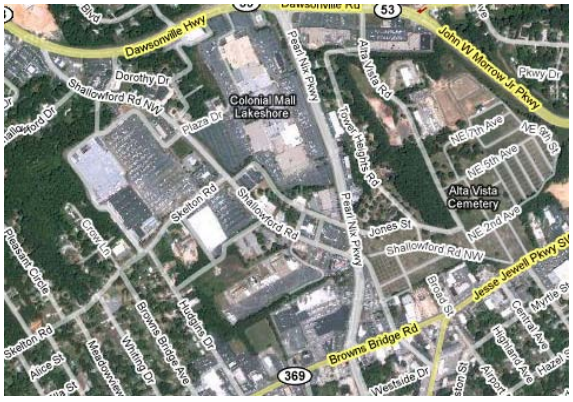
Worksheet 2

Satellite Image Key

Forest

Lake

Commercial use



Mall

Airport

Residential

Worksheet 3

Ways Land Use Can Affect Water Quality

Residential / Housing

- oil and fuel run-off from paved roads
- salt from iced roads in winter time
- nitrates from fertilizer from lawn care
- septic tank leakage
- pesticide or herbicide
- eroded sediment if there is no grass cover
- wastewater discharges from sewage treatment plants

Agriculture

- nitrates from fertilizers or manure
- bacteria from cattle, hogs, chickens or other animals
- pesticide or herbicide
- eroded sediment after plowing

Commercial / Business

- industrial discharges depending on the type of business
- petroleum leaks
- organic solvents
- temperature increases in discharge water