**My Digital Watershed**

***Analyzing Watersheds in Google Earth***

**Overview** Students perform a computer lab activity to answer basic geographic questions about the watersheds in which they live.

This module is an opportunity for students to:

* Understand how to read topographic maps
* Use computers and GIS to visualize topographic information
* Learn how to draw using a computer
* Learn how to measure area and distance using a computer
* Learn how to interpret satellite imagery to answer basic questions about land-use

**Module Type** computer lab activity

**Duration** 2-hrs

**Key Materials**

* The introduction to watersheds Power point, “DJWatershedsIntro.pptx”
* The My Digital Watershed Power point, “DigitalWatershed\_Lecture.pptx”
* A class set of the help/instruction sheets, “GE\_Help.docx”
* The My digital Watershed lab worksheet, “DigitalWatershed\_LabWorksheet.docx”
* The “Watsonville.kmz” file for Google Earth®
* One computer with Google Earth® installed for each pair of students

**Concepts** Topography, Contour, Watershed, Geographic Information System (GIS)

**Skills** Map Reading (shape of land and water flow); Computer Drawing; Measure Distance and Area on a Computer Map (GIS); Computer Help Files.

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**Science Education Standards**

**National:** A. Science As Inquiry; E. Science and Technology; F. Science in Personal and Social Perspectives

**California:** Investigation and Experimentation 1.a. and 1.h. Geology 9.c. Students know the importance of water to society, the origins of California freshwater, and the relationship between supply and demand.

**Next Generation Science Standards (NGSS)**

HS-ESS2: Earth’s Systems (HS-ESS2-5)

HS-ESS3: Earth and Human Activity (HS-ESS3-6)

NGSS science and engineering practices: Practices 3 (investigating), 4 (analyzing and interpreting data), 6 (constructing explanations), 7 (argue from evidence), and 8 (obtaining, evaluating and communicating information)

**Field tested** 9th grade Integrated Science 1 students, Watsonville High School, Watsonville, CA (Fall 2012)

**Starting Point for Inquiry**

This module is designed to help students think about where their water comes from; not just from rainfall, but how the rainfall travels through the landscape – Will has a great Power point called “Drippy the Raindrop” about the water cycle that is useful for introducing this idea. The real starting point for inquiry is: how can we use GIS to help us better manage Drippy as he moves through a landscape that is used by society in a variety of ways? In Watsonville it is particularly important to think about agricultural, urban, and forested landscapes and how these different land uses might influence Drippy’s journey.

Basic questions might be: How might different kinds of land use have different effects on water quality in a watershed? How might the size of a watershed affect water quality in the watershed?

**Background for Teachers**

Most students have used some kind of map prior to 9th grade (most likely a street map), yet many do not know what a **contour** is or how contours represent the three-dimensional shape of the landscape on a flat piece of paper (or flat screen of a computer). In addition to reading a topographic map, interpreting **satellite imagery** is becoming an important skill for many professions in earth and marine sciences as well as for a diversity of life experiences and careers (like outdoor recreation, surveying, construction, and agriculture). This module helps students develop map reading skills for both contours and the interpretation of satellite imagery. The module builds upon basic map reading skills, that include the recognition of the **compass rose** (north arrow), **legend**, and **scale** on maps, as well as understanding **GIS** (geographic information systems) as a tool for inquiry. This module is designed to be used as a follow up (second part) to the SCWIBLES “Contour What?” module, in which reading topographic maps and measuring distance are introduced.

**Analyzing Watersheds and Geographic Information Systems (GIS):**

A **watershed** is defined as the drainage area that contributes water from precipitation to a lake, stream or river. Another name for watershed is **drainage basin**. Human societies have long organized governance of natural resources based on watershed boundaries and continue to do so to this day. Examples of this include how political and property boundaries are often based on watershed divisions; water districts are almost always based on watershed boundaries.

Water always flows downhill; it can flow in streams, rivers or lakes as **surface water** or it can flow underground through the soils and rocks that make up the surface of the earth as **groundwater**. An underground lake, where groundwater accumulates, is called an **aquifer**. The depth from the surface of the earth to the groundwater is called the **water table**. When there are smaller streams that flow into larger rivers, the small streams are called **tributaries**.

A **Geographic Information System (GIS)** (review from the “Contour What?” module) is a way of organizing and displaying **geographic information** which is information that includes place or location (anything we might see on a map). Generally we use computers to construct, store and display geographic information systems. Layers of geographic information are stored and displayed together in various combinations as **map overlays**. We can also use paper maps and transparencies to construct and visualize a GIS.

**Satellite imagery** is useful for understanding how land is used for different activities by human societies. With the advent of computer technologies such as Google Earth, satellite imagery for most parts of the United States (and the world) is readily available for those that can “read” the images. The **interpretation** of satellite imagery is done automatically by computers, or it can be done manually by humans. Often **manual interpretation** is better than **automatic interpretation** because humans can recognize patterns better than computers. We can use data from satellite images as evidence in arguments about resource locations (such as mineral deposits), resource degradation (such as water pollution), land use (such as farming or housing), and resource conservation (such as restoration efforts and parks).

**Curriculum Notes (how this fits into the larger curriculum picture)**

Previous teaching concepts (suggested):

Map Basics: maps as stories, map elements (scale, direction, title, and legend) [ NOTE: there is some developed curriculum for this in Will Federman’s “Mapping Basics” folder ]

Water cycle: evaporation, condensation, clouds, rain, rivers, lakes, groundwater, ocean [NOTE there is already developed curriculum for this in Will Federman’s “Watershed Basics” folder]

Contour Lines: “Contour What?” module and the “Topo Map of My Island” activity [NOTE: see Will’s curriculum on this (the file is also included with this module)]

Teaching objectives for this module (from above)

**Concepts:** topography, contour, watershed, Geographic Information System (GIS)

**Skills:** read topographic maps (shape of land and water flow); draw on a computer; measure distance and area on a computer map (GIS); use help files on a computer

Next teaching concepts (suggested):

Water Quality: see the “What’s in our Water” module (Yiwei and Dan)

California Water: see the “California Water Puzzle” module (Tim and Will)

**Project Description**

This module is formed around two activities in which the students will acquire and use computer based tools to answer simple geographic questions about watersheds near their homes.

**Materials**

1. Lecture: The introduction to watersheds powerpoint, “DJWatershedsIntro.pptx”
2. Lab Activity:
	1. The My Digital Watershed powerpoint, “DigitalWatershed\_Lecture.pptx”
	2. A class set of the help/instruction sheets, “GE\_Help.docx”
	3. The My digital Watershed lab worksheet, “DigitalWatershed\_LabWorksheet.docx”
	4. The “Watsonville.kmz” file for Google Earth®
	5. One computer with Google Earth® installed for each pair of students

**Preparation**

1. Teachers should cover map basics one or two weeks prior to using this module.
2. It is very useful to have some computer lab time before using this module (during which students learn about logging in to their computer, finding basic programs on the desktop, computer lab rules, etc.).
3. Teachers need to have Google Earth® installed on all of the laboratory computers AND their own personal computer. Google Earth® is a free program and can be downloaded from <http://www.google.com/earth/index.html>.
4. Teachers should open the file “Watsonville.kmz” (<http://scwibles.ucsc.edu/Products/ProductsDocuments/Norris_ContourWhat_supporting/Watsonville.kmz>) on their own computer before going into the lab and become familiar with the controls in Google Earth®
5. Teacher prep time is approximately 30 minutes including the installation of Google Earth®, opening the “Watsonville.kmz” file, exploring a little, and measuring one watershed using the instructions found in the Word® document “GE\_Help.docx.”

**Timeline**

1. (20 min) Lecture: The introduction to watersheds Power point, “DJWatershedsIntro.pptx”
2. (90 min) Lab Activity: - remainder of two hour block period
	1. (10 min) Screens off – Contour review, GIS review, load custom layer demonstration (“I do” – question 1 on worksheet)
	2. (10 min) Screens on – load custom layer, explore contours, fill in worksheet questions (“we do, you do” – question 1 on worksheet)
	3. (10 min) Screens off – measuring watershed area demonstration (“I do” – worksheet question 2 and 3)
	4. (20 min) Screens on – measure watersheds worksheet (“you do” – worksheet 3, 4 and 5)
	5. (10 min) Screens off – brainstorm on questions (worksheet 6 and 7 – together as a class, “I do, we do”)
	6. (30 min) Screens on – students formulate question and answer using Google Earth (worksheet questions 8, 9 and 10, “you do”)

**Possible Pitfalls**

* Using the computer lab is exciting andstudents get distracted very easily by the ‘coolness’ of what is happening on their screens. When you want to speak, have them turn off their screens and turn around to listen to instructions or lecture.
* Once they open Google Earth® many students start looking for their house and surrounding area right away instead of doing the assigned task. If you have a group of students who are not familiar with using Google Earth® make addition time of 5-7 min for students to find their house and look around their street after you explain the basics of how to navigate and zoom in and out on the map during the first block period.
* Computers are tools that only follow our directions; they do not do the thinking for us. Students often miss a small detail in the instructions and the expected result does not appear. Make sure students understand that all computer commands have to be exactly the same as they appear in the directions or the projected instructions. This is particularly important when adding the custom layers of water and topographic data.
* Google Earth® will go to “street view” or “ground view” if you double click too many times. This can be good (it is a more intuitive way to ‘see’ the landscape) and bad (students end up spending too much time on the street or ground). When in street or ground view there is a button at the top right that says “exit street view.” It is useful to show students this when they are exploring.
* Initially it is hard to identify watershed boundaries using contours, but there are a few tricks to teach. First, ridgelines that form watershed boundaries appear as fingers pointing towards the bottom of the watershed. Second, identify hilltops as closed circles (or something close to circles) and use the hilltops as points on the watershed boundary. Third, between hilltops try to identify the lowest point in the “saddle” or “pass;” draw the boundary from hilltop to lowest point in the saddle to the next hilltop. Try to visit with every student (you can have three student pairs looking at one computer while you show them how to identify the boundaries using the tricks above). Leave about 20 minutes for visiting all the students (3 minutes per groups of 4-5 students).

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**“fingers”**

**Saddle**

**Hilltops**

**Procedure**

1. **(20 min) Lecture:** The introduction to watersheds Power point, “DJWatershedsIntro.pptx”
2. **(90 min) Lab Activity**: - remainder of two hour block period
	1. (10 min) Contour review, GIS review, load custom layer demonstration

Use slides one through four (1-4) of the Power point “DigitalWatershed\_Lecture.pptx” to review loading custom layers in Google Earth. Also show the students how to get information from a feature in the custom layer. Zoom to Pinto Lake (by double clicking), find the highest hill at the top of the watershed, move the cursor over the contours and when the cursor is an arrow, click on the contour. A dialog will pop up showing the contour as “500 ft” (I do – question 1 on worksheet).

* 1. (10 min) Screens on – load custom layer, explore contours, fill in worksheet questions

Let the students load the custom layers from the file “Watsonville.kmz” and explore a little. This should be review. Encourage them to use the help sheet in the “GE\_Help.pdf” file before asking questions. Have them open the help file in a web browser on their screen so that they can work in Google Earth® and read the help file at the same time (<http://scwibles.ucsc.edu/Products/ProductsDocuments/Norris_DigitalWatershed_supporting/GE_Help.pdf>).

* 1. (10 min) Screens off – measuring watershed area demonstration

Demonstrate how to use the polygon tool (same as the measure tool, but it draws polygons). Demonstrate how to draw the polygon that represents the watershed boundaries for Pinto Lake. Make sure to name the polygon (Pinto Lake Watershed). This exercise will bring together how to read a topographic map – look for hilltops, and how to interpret river flow from topographic maps. At first this is difficult for the students, but once they get it, the exercise goes quickly. Demonstrate how to save the polygon to the desktop (as a KML file) and then how to measure the area using the web based tool (see the instruction sheet). Once again make sure they follow instructions and are aware of units (I do – worksheet question 2 and 3). When discussing the land use in the watershed emphasize the multiple uses that are visible (for example pasture, trees, farms, recreation).

* 1. (20 min) Screens on – measure watersheds

The students will measure two watersheds (we do, you do – worksheet 3, 4 and 5). Make sure to visit each student pair (or groups of pairs). This is where they show whether they understand the interpretation of contours (in a fun and interactive way). Suggest that they look at the satellite image and try to tell what kind of land use is within each watershed (forest, farms, urban, etc.).

* 1. (10 min) Screens off – brainstorm on questions

Suggest (worksheet 6 and 7 – together as a class) a few questions for inquiry (how much? how many? how big? how hilly or flat?) and let the student pairs brainstorm on questions that they can answer using these tools in Google Earth. Suggest combining the measuring tools with the interpretation of the satellite images. For example how much forest? How much urban area? Etc.

* 1. (30 min) Screens on – students formulate question and answer using Google Earth

Let them go . . . see what happens (worksheet questions 8, 9 and 10).

* 1. Flight simulator – if they have time

Introduce the flight simulator (menu “Tools->Enter Flight Simulator”). Give them a quick demo, let them loose (see the instruction sheet for some of the more common controls).

**Question Generation (and/or Design/Refinement)**

Question development would be based on what they can see on the satellite images that might be measurable and compared within several watersheds. Ideas might include thinking about how proportions of agricultural land, forest land and urban areas might vary across two watersheds.

**Assessment Methods**

1. The worksheet “DigitalWatershed\_LabWorksheet.docx” should be turned in by each student and evaluated by the teacher. If the worksheet is not completed in the lab time, the last 4-5 questions can be assigned as homework.
2. Each group should drop a copy of their watershed polygon in the teacher’s email mailbox for evaluation on the computer.

**Science Education Standards Addressed**

This module focuses on reading topographic maps and using computer geographic information systems to answer simple geographic questions. The module addresses the following NSES, SCSCPS, and H-SSCSCPS standards

National Science and Engineering Standards (NSES):

(<http://www.nap.edu/catalog/4962.html>)

A. Science as Inquiry; E. Science and Technology; F. Science in Personal and Social Perspectives.

Science Content Standards for California Public Schools (SCSCPS):

(<http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf>)

Investigation and Experimentation 1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept in the other four strands, students should develop their own questions and perform investigations. Students will:

1.a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

1.h. Read and Interpret topographic and geological maps

Earth Sciences: California Geology 9. The geology of California underlies the state’s wealth of natural resources as well as its natural hazards. As a basis for understanding this concept:

9.c. Students know the importance of water to society, the origins of California freshwater, and the relationship between supply and demand.

Next Generation Science Standards (NGSS)

(<http://63960de18916c597c345-8e3bed018cb857642bed25a591e65353.r63.cf1.rackcdn.com/Combined%20DCIs%205.15.13.pdf>)

HS-ESS2: Earth’s Systems (HS-ESS2-5: Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth’s systems. P 91)

HS-ESS3: Earth and Human Activity (HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. P 93)

Appendix F – Science and Engineering Practices in the NGSS:

(<http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20.pdf>)

Practice 3: Planning and carrying out investigations

Practice 4: Analyzing and interpreting data

Practice 6: Constructing explanations

Practice 7: Engaging in argument from evidence

Practice 8: Obtaining, evaluating and communicating information

History-Social Science Content Standards for California Public Schools (H-SSCSCPS):

(<http://www.cde.ca.gov/be/st/ss/documents/histsocscistnd.pdf>)

Chronological and Spatial Thinking 4. Students relate current events to the physical and human characteristics of places and regions.

National Standards for History

Historical Thinking Standards (<http://www.nchs.ucla.edu/Standards/>)

Standard 2: **The student comprehends a variety of historical sources (draw upon data in historical maps)**

**Appendices**

**Glossary**

**watershed:** the drainage area that contributes water from precipitation to a lake, stream or river.

**drainage basin:** same as watershed

**surface water:** water that flows on the earth’s surface (rivers, streams, lakes, etc.)

**ground water:** water that flows or resides beneath the earth’s surface.

**aquifer:** an underground lake or accumulation of water underground

**water table:** the depth from the earth’s surface to the groundwater.

**tributaries**: secondary creeks or streams that feed into larger rivers.

**Geographic Information System (GIS)**: a tool for visualizing, analyzing and displaying geographic information

**geographic information**: information that includes place or location (anything we might see on a map)

**map overlays:** layers of geographic information

**satellite imagery:** images of the earth’s surface captured by sensors on satellites.

**image interpretation**: determining what can be seen in a satellite image

**manual interpretation**: image interpretation done by humans

**automatic interpretation**: image interpretation done by machines (computers)

**KML**: Keyhole Markup Language: a special text language for storing geographic information in a format that Google Earth® can understand (a KML file can be opened in a text editor as well as Google Earth®). KMZ is the binary (zeros and ones) equivalent.

**Lectures**

DJWatershedIntro.pptx

NOTE: there is no copyright information for the image in DJWatershedIntro.pptx

DigitalWatershed\_Lecture.pptx

**Graphics**

With the exception of the DJWatershedsIntro.pptx (as noted above) and slide three (3) of the DigitalWatershed\_Lecture.pptx (the image on this slide is in the public domain at: http://www.cibolasar.org/minilessons/nav\_lesson/USMC\_mapfigs.jpg), all graphics are copyright free screenshots created by Timothy Norris using Google Earth®.

**Labs (or activities)**

GE\_Help.pdf (Google Earth help sheet)

**Worksheets**

DigitalWatershed\_LabWorksheet.docx

**Reference List**

Google Earth® website: <http://www.google.com/earth/index.html>