# The Small Rural School's Guide
# To Developing School and Community
# Geographical Information Systems

Swan Valley Elementary School District 33

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**Preface**

At the Swan Valley Elementary School we believe that we must prepare our children for life in the 21st century. We also believe that the school's role in increasing knowledge and learning extends to our greater community of family members and adults and that the school plays an important role in the life of the community. Information technology is an area where the Swan Valley Elementary School works hard to ensure that our children and our community doesn't end up on the wrong side of the digital divide. Toward that end the school has over the years been a leader bringing new technology into its curriculum and the community.

This booklet describes our pathway for developing a Geographical Information System (GIS) for the school and community. It offers a road map of sorts for other schools interested in this technology. It together with the companion video are available at http://swanvalleyelementary.org and are products of a Montana Land Information Advisory Council (MLIAC) grant supporting our efforts. The MLIAC grant provided the resources and incentive to undertake this journey.

John K Mercer

**Acknowledgements**

**Introduction**

GIS stands for geographical information systems. It is a collection or set of tools that grew out of the computer revolution of the 70's and 80's. In the simplest terms, a GIS joins a relational database with spatial information. In a GIS almost any kind of data can be related to other data and also to physical locations either as a point, or as a collection of points in the form of lines and/or a polygon. Google Maps are an example of a GIS.

As personal computers became more powerful, GIS systems that were once the domain of high tech and big mainframe computers migrated to mini-computers and then desktops. Recently it became available through the Internet, becoming what is often called "cloud based." In this last iteration, the software resides on server farms accessible through the web browser software and the Internet. With each step, the technology has become more sophisticated, powerful and easier to use. This has profound implications for small rural schools.

Many organizations and agencies heavily use and rely on GIS tools, data and models. Schools are relative newcomers to this technology. Larger school districts use it to plan and manage bus routes and develop enrollment projections as well as building and grounds maintenance and project coordination. Students use it as a diverse tool organizing and presenting many different kinds of information with spatial context and location.

Outside of schools, GIS is a maturing tool assisting land management in much of Montana. It is becoming commonplace and prevalent throughout many work environments and applications. Geospatial technology, reasoning and information systems, sometimes collectively referred to as "GIS" is used in rural communities in a variety of ways.

For example our community is in a long narrow rural valley 75 miles South of Glacier Park, with the Swan Range and the Bob Marshall Wilderness Complex to the east and Mission Mountains Range and Wilderness to the west.  Here there are at least six different federal, state and county agencies and nearly that many

again private national organizations with well-developed GIS programs for the Swan River Valley, Clearwater River Valley and all the lands surrounding the Bob Marshall and Mission Mountains.

GIS is often used in developing management policy and implementing resource use decisions. For example, when seeking a building permit, GIS technology is applied extensively to both collect and present information about the proposed project as well as to model the potential impacts associated with the project. It plays a major role for counties in deciding whether land can be subdivided. It is central to federal and state natural resource planning. GIS models and data presentations often drive agency decisions about road closures, grizzly habitat, other endangered species, as well as a host of other resource decisions.

Given the prevalence of its use, our local elementary school, students, parents and community, were at a distinct disadvantage when it came to GIS information and tools. It was hard to access and use the vast amount of information available for teaching students, for local community planning efforts, and private land management. In our community and school we had very limited capability to use these tools and data in the classroom and community activities. The biggest barrier was that most people didn't "speak GIS," and if they did, there was no available infrastructure to support them or the community.

**Taking on the GIS challenge**

Swan Valley Elementary School recognized the need to develop GIS technology in the school and community.  And we realized early on that our focus was not to introduce GIS technology as a stand-alone subject matter in the curriculum.  Our goal was to see our students using GIS tools and geospatial reasoning on a regular basis across the curriculum facilitating the learning process of already established curricula. We wanted the tool to be used, not studied. With this in mind, we submitted a grant request to the Montana Land Information Advisory Council (MLIAC). We requested MLIAC support in introducing GIS data, tools and training for the Swan Valley Elementary School and Community. The school provided matching funds and in-kind support to bring the project to fruition.  This project met the goals of the MLIAC by promoting the use of GIS tools and data layers within the school and community.

This project is called: *Increasing the awareness and use of Geospatial data and Technology in Small Rural Schools and Communities*, and has the following goals:

Goal 1. Develop onsite capacity to operate a geographical information system for teaching and community access.

Goal 2 – Develop capabilities of teachers, and select community members to understand and transmit knowledge about geospatial tools and data.

Goal 3 – Complete curriculum development incorporating geospatial reasoning and tools in the school and develop GIS applications to real life community problems.

Goal 4 – Provide a model prototype process and make presentations on how small rural communities can use their local schools to develop better GIS resources, access and uses within the community.

**What is GIS?**

Environmental Systems Research Institute (ESRI) is the leading company providing GIS products to a global market. ESRI provides us with the following definition:

> *A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.*
>
> *GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.*
>
> *A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.*
> *(http://www.esri.com/what-is-gis/)*

A GIS is a powerful tool for organizing data into meaningful information about relationships with other data and locations in time and space. It allows an individual reading a map to select specific data related to a specific set of criteria. The criteria can be organized into themes with a table of contents so the user of the map can add layers of information to a real world base map. All of this can be presented interactively in real time.

For example students at SVES located all of the historical homesteader schools that ever existed in the Swan Valley. This was placed in a layer on top of a base map showing topographical features. Each school site has a specific location with historical data of the year(s) the school was operating and the name of the school. Pictures, images, and audio video clips can be attached also. From this map the students analyzed the historic data. Conclusions or theories about the schools were inferred from their location. For example, the historical schools are about a couple hours ride by horseback from each other. The inference from this is that

they are close enough so that the kids can get to school and back home during daylight hours in the wintertime and do their chores.

GIS is a powerful tool that for use in any field of knowledge that deals with data located in time and space. It can integrate data from many different sources and process it, producing maps organizing and displaying the data and transforming it into information. These maps are interactive. On screen the user can scroll a map in different directions, zoom in and out to view data at different scales, click on points or polygons to reveal more information.  Maps can be layered and made visible or invisible and visually combined with other layers.

This interactivity stimulates an intuitive and cognitive grasp of the information through asking "what if" questions that reveals relationship and connections between the data and its location.  This is illustrated in one student project that mapped the meteor impact in Russia last year. From the map, the students noticed that the lakes in the region were similar in size and shape and began to wonder about their origin.

Thinking about things and places oriented in time and space is a basic skill. At a fundamental level it is practiced daily as we decide where to go, and how to get there. More complex questions about how things fit together require more advanced reasoning. For example students working on a school project asked how did the eruption of Mount St. Helens in 1980 change the landscape, or where did the hurricane Katrina do the most damage?  Students used geospatial reasoning when developing different scenarios for managing a forest in the Swan Valley, or making a map of events in a historical novel about World War II. These are all questions that GIS can help students answer. And in fact some students in SVES have used GIS to make maps answering these and many other questions.

 For more information on GIS see:
http://www.esri.com/what-is-gis/~/media/Files/Pdfs/library/bestpractices/essays-on-geography-gis.pdf

### *What is geographic reasoning?*

ESRI offers the following thought:

> *Geography is the science of our world. Coupled with GIS, geography is helping us to better understand the earth and apply geographic knowledge to a host of human activities. The outcome is the emergence of The Geographic Approach—a new way of thinking and problem solving that integrates geographic information into how we understand and manage our planet. This approach allows us to create geographic knowledge by measuring the earth, organizing this data, and analyzing and modeling various processes and their relationships. The Geographic Approach also allows us to apply this knowledge to the way we design, plan, and change our world. ([http://www.esri.com/what-is-gis/overview - geographic_panel](http://www.esri.com/what-is-gis/overview - geographic_panel))*

There are five basic steps in the geographic approach and geographic reasoning involves using these steps to address a problem.

1) The first step is to ask a question from a spatial or location based perspective. This means that the question is framed in the context of location and involves the use of "where" questions.

2) Once the question is stated then it is necessary to identify what is needed to answer the question. The scope and extent of the question and geographic area under consideration will help determine what data is needed and how it is tied back to location and what is the best way to collect the data.

3) Once the data is collected then it is necessary to examine it and make sure it is appropriate for answering the question.

4) The data is analyzed. Sometimes this involves "looking" at the data as displayed visually through maps or at times it may involve more sophisticated modeling using interactive GIS tools.

5) After the analysis, the information is shared through maps, narratives, story maps and other visual tools. These can be published to work groups or over the web to larger community of users.

***What can GIS do?***

GIS lends itself well to the classroom and students working on projects and assignments. With GIS you can map people, plants, animals and items of interest, locating them in time and space. This helps you identify places where you can find those things and see patterns of how they are located. You can map numbers or amounts, and identify places with a higher or lower density of occurrence. You can map what is inside of an area and/or find out what is outside or nearby and finally you can map changes in an area, looking at historical change or using modeling tools to project future changes.

For example, in the Swan Valley, students and teachers in SVES used GIS tools and resources for student community mapping projects throughout the 2012-13 school year. Teachers integrated GIS maps into different curricular areas such as social studies and reading.

The seventh and eighth graders built maps based on their history unit of World War II. Each student studied a different aspect of the war and put significant locations into the map.  They also built maps based on books they read that were in different parts of the world. They would add descriptions of each location as it was described in the book. These students also developed GIS projects about a variety of natural disasters and presented them at open houses for the community (examples are shared in the companion video).

The fifth and sixth graders used ArcGis for Social Studies.  They mapped Russia and some European countries, pinpointing important locations and adding information and pictures to the pins.  They created interactive geographic quiz maps of Montana and the Swan Valley modeled after geographic quiz maps created by the National Geographic Society. These are base maps with questions about pinned locations scaled to be hidden until the user applies their local knowledge to zoom into the vicinity of the correct answer.

Outside of the school, a community member used GIS compiling data layers for the local planning committee.  He said about his progress:

> *"We now have accurate and complete Cadastral information for every private land parcel and Conservation Easement in the Swan Valley Study Area. And we have accurate and complete CAMA data records for every residential dwelling in the Swan Study Area. We can tabulate, map, and visualize where and how growth has occurred over the last 100 years. This allows us to paint a picture of growth by year or other suitable time period, organized by different characteristics of the parcels/dwellings. (John Keller, Personal Communication)*

Another community member is developing a fire history data layer documenting fire control efforts along with photographs. She says*:*

> *"In 2012 I used GIS to create the first draft of an interactive fire history map in a learn-as-I-go process. I am continuing to work on my fire "History Map for the Swan Valley" as an interactive tool that allows people to easily compare conditions on the land from 1899 – present, using photos and text from the U.S. Geological Survey for the Lewis and Clark forest Reserve by H.B. Ayers (1899), 1934 aerial photography, and photos of recent fires, all overlaid on a fire history map, an ownership grid, and the most current satellite imagery for the valley. Residents can learn about the effects of wildfire over time on their private land, on adjoining public and private properties, and throughout the watershed." (Anne Dahl, Personal Communication)*

**What are the components of a GIS?**

GIS is not just hardware, software, data or electronic maps. It is a system with primary components that interact to produce answers to questions and products. These help solve problems or tell stories about places, things and people. It helps elucidate and illuminate relationships. The system includes hardware, software, data, and the people that use them. All four of these components are important to consider when thinking about GIS.

Hardware is the physical equipment that houses the GIS. Originally this was on large mainframe computers. Today GIS can be operated on desktops, laptops, tablets, pads, and even phones. Central to this is the computer network, including both the local area network and the Internet. Other hardware is also important and includes input devices, such as keyboards, scanners, pen tablets etc. Storage devices such as hard drives are used to store data. In the Swan Valley we have a dedicated server and onsite hardware resources, a local area net and high-speed fiber optic Internet access.

Software directs and controls the actions of the hardware. Software changes rapidly, with several updates each year and annual release of newer versions. There is a multitude of software GIS options available that will run on a variety of hardware platforms and serving differing purposes. In the Swan Valley we are using ERSI software, ArcGIS desktop 10.1, ArcGIS explorer and ArcGis online.

A GIS system is useless without data. GIS works with data that is either spatial or attribute. Spatial data is a specific location or where something occurs, while attribute data describes the what, when, who or how characteristics link to specific things or events. Data is organized, sorted, analyzed and selected through relational databases. There is a tremendous amount of data that is available for use by schools in GIS. Data can also be generated through student research and projects and entered into and used in GIS.  In the Swan Valley we have data sets specific for the valley that are available as well as a plethora of information available through the Montana State Library GIS portal and other national and international data sets.

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The final component required for a true GIS is the people who use it. The term "user" refers to any individual, group or organization that will use GIS to support project or program goals, or even to an entire organization that will employ GIS in support of its overall mission. In the Swan Valley we designed our GIS for use by students, teachers and community members.

**How does a school develop GIS technology?**

The answer to this question is it depends. The technology is changing so rapidly that in the duration of the SVES project new options for cloud based GIS became available and it is likely they will become increasingly more attractive for schools seeking GIS technology.

There are two differing approaches to bringing GIS technology into a school. One involves having the software and much of the data resident or associated with existing hardware, desktop computers, networks, servers and workstations in the school facility. SVES implemented this approach using ArcGIS Desktop 10.1 on stand alone desktops attached to a local are network and the school's server. At one point, we considered using ARCGIS Server software so that we would have greater capacity to publish maps to the school's network and the Internet.

The other approach is to use GIS through a cloud based subscription, where data is hosted on remote servers and accessed locally with desktop software or web browser software. When the cloud based ArcGIS online subscriptions was released by ESRI in the middle of the project, we began to move in this direction. The advantages of this approach allow members of an organization such as a school, the functionality of a resident desktop/server based system without the need for the supporting infrastructure to be hosted and maintained locally.

It does require web access and a reasonable bandwidth, but is not location dependent. This means that students can access both the software and their data from anywhere, at anytime and almost through any device that can access the Internet. This results in true portability and lets students and community members use, build and save maps without having to come to the school. For

more information see: http://resources.arcgis.com/en/help/arcgisonline/index.html -//010q00000074000000

When weighing the pro and cons of these two different approaches the school may want to consider the following.

| Lean toward on-site resident system | Lean toward offsite cloud-based system |
|---|---|
| Have server, desktops, etc. | Lacking hardware |
| Have tech support onsite | Lacking onsite tech support |
| Lacking suitable internet access | Have good internet access |
| Intend to teach GIS as a content area | Intend GIS as tool to support curriculum |
| Mostly use unique data sets | Mostly use web based data sets |
| Generous technology funding | Very limited technology funds |
| Unique map authoring and analysis | Authoring maps using base maps |

For many small rural schools, it will be hard to find compelling reasons to develop a stand-alone GIS system. The problems associated with hard and software upkeep tends to outweigh any advantages that come from having the stand-alone system. Basic GIS analysis procedures are now added to ArcGIS.com map viewers, and more are being planned for upcoming software releases.   Examples include buffers, overlays, geo-enrichment tools and spatial and database filters and queries. The web viewers and map templates also allow mash-ups, combining data from multiple sources.  More advanced geospatial processing is available on the desktop, but elementary and middle school grade levels usually do not require these more advanced analysis.

The exception to this would be the small rural school that does not have Internet access or has very slow poor quality or unreliable access.  See the following link for comparison chart of different tools.
http://edcommunity.esri.com/~/media/Files/EdCommunity/ESRI_sw_quickview_201305.pdf

Either way, the school will need the following to develop a GIS program. The first is a champion that is willing to work hard to bring GIS into the school. This can be a teacher, administrator, trustee or community volunteer. They need to be

committed and if not knowledgeable, very willing to learn. If the school's GIS champion is not an advisor/expert that is knowledgeable about GIS and can answer questions and help problem solve with both hard and software as well as teach basic GIS, then the school will need to find such an individual.  This person can be either a paid consultant or a community volunteer. Next the school needs a core group of teachers willing to bring GIS into their classroom. It is helpful to have community members also involved as they can help spread the word. Finally the school needs to establish a budget that supports the GIS project.

**What the Swan Valley Elementary School did**

At the Swan Valley Elementary School we implemented our GIS program through four key steps.

1) We developed onsite capacity to operate a geographical information system for teaching and community access (Goal #1).

This required upgrades and additions to our current computer systems. SVES had 20 computers linked through an Ethernet network to a server and to the Internet with a high speed DSL through Blackfoot Co-op. In addition, we added four SMART Boards, which are linked to each teacher's computer. To develop the capacity to operate a GIS using ESRI software we needed to increase the RAM in our student systems, build two additional workstations and add a new server. We acquired ESRI ArcGIS Desktop 10 software, ESRI ArcGIS for Server, ArcGis Explorer and MS Server 2008 and 2008 Server Client Access Licenses. The server uses a RAID for data redundancy and security. Additionally, it is backed up monthly on a third stand-alone drive and stored off site.

For data, we have a set of 31 SVCC data layers developed by GeoData Services Inc. for the Swan Valley Community Council. These layers are an important resource for the school and community. They are designed to accompany the Swan Valley Growth Planning Committee's Swan Valley and Community Profile and support the community envisioning process http://www.co.missoula.mt.us/rural/communitycouncils/SwanValley.htm. These were produced through a grant from MT FWP sponsored by Missoula Rural Initiatives and provided to the community council. A number of these layers have

unique data. An important purpose of this grant was to make these layers available to the students, the community, SVCC, the planning committee and agencies. These data layers also form the basis for future work with community and county organizations.

2) We developed capabilities of teachers, and select community members to understand and transmit knowledge about geospatial tools and data (Goal #2). This required a core group of teachers and influential community members who became our first GIS learners and ambassadors of geospatial reasoning and information systems. These individuals needed instruction in fundamental GIS concepts, how and when to use GIS tools, and workflow design. They received an introduction to the SVCC data layers, and how to use them in the training sessions. Training was a combination of in-class course work as designed by ESRI, and additional instruction via online courses, WebEx, group and individual coaching. In addition to training, we provided each learner with a copy of ArcGIS for Home Use. Training services, coaching, and project design oversight was provided by Ken Wall of GeoData Services, Inc. and delivered in Missoula at the School of Forestry GIS training lab and/or onsite at SVES.

3) Our next step was completing curriculum development incorporating geospatial reasoning and tools in the school and developing GIS applications to real life community problems (Goal #3).

We provided coaching and directed support for our GIS learners about project design and implementation. During this time, teachers developed GIS lesson plans and resources. For grades 5-8 they developed lesson plans in multiple subject areas using Spatial Reasoning and GIS resources as adjunct teaching tools supporting the school's curriculum.  Community learners used GIS to address specific community problem such as developing a fire history map or completing data layers and generating maps for the planning committee to display important information relevant to community concerns and issues generated through the visioning process.

4) Our next step was articulating our prototype process and making presentations on how the school developed and used GIS resources building awareness and support of the GIS program.

We held open houses for the community, showcasing the student projects. We documented the project and its steps and wrote *The small rural school's guide for developing school and community geographical information systems.* We develop a video webinar/podcast to accompany the booklet. These are available on line at http://swanvalleyelementary.org

We presented this information at conferences, and submitted articles to local newspapers. This information is available electronically for the many small communities like the Swan Valley found all over the state with names like Bynum, Cardwell, Paradise, Lustre, and Helmville. They stand to benefit from developing GIS knowledge and tools in many of the ways we do in the Swan Valley.

## Conclusions

Developing a GIS system was challenging and was a risk in the sense that it required an investment in time and resources for the school district. But it was also rewarding and stimulating for the school, the teachers, students and the community as a whole. For a small rural community like the Swan Valley, it opens up doors to a much larger and greater world encouraging our students to learn in ways that they did not have before. This next year we will be using the GIS across the general curriculum as well as for specific projects, including developing an experimental school forest with permanent research plots. We will produce a second volume to this booklet and video after we have had a full year of using the GIS that describes in more detail the outcomes and benefits of using GIS in a small rural school.

In closing, we encourage educators, administrators, and trustees to work with their schools to acquire this technology.  We invite schools and educators to come and visit and see the GIS program in action and please contact us if you have questions.

**Resources**

There are a tremendous amount of GIS resources available online through ESRI. The gateway to these resources is http://www.esri.com

http://www.esri.com/industries/education is a link dedicated to education and education resources.

http://www.esri.com/industries/k-12 Resources specific to k-12 education

http://edcommunity.esri.com this is the link to the online education community. This is a great place to become familiar with the community maps and projects sponsored by schools using GIS.

http://edcommunity.esri.com/Resources/ArcLessons A link to lesson plans for a variety of grade levels and subjects using GIS tools. These are complete fully developed out of the box plans that teachers can implement.

http://edcommunity.esri.com/Resources/Webinars This is a link to a variety of instructional "how to" sessions designed for teachers. These can be downloaded for free and viewed at your convenience. We recommend that any educator interested in GIS view *Where Do You Start with GIS in Education?* Featuring Charlie Fitzpatrick of the ESRI Education team for a good introduction and overview introducing the technology.

http://edcommunity.esri.com/Resources/ebooks This link lists a number of white papers or ebooks that can be downloaded. We recommend *What is GIS?* This is a useful collection of essays for schools to have introducing GIS.

http://edcommunity.esri.com/software-and-data is a link to the page that describes the different GIS platforms and their advantages and disadvantages for schools, including ArcGIS for Desktop, ArcGIS Explorer and ArcGIS Online. http://edcommunity.esri.com/~/media/Files/EdCommunity/ESRI_sw_quickview_201305.pdf is a chart that compares the different options.

http://www.esri.com/~/media/Files/Pdfs/industries/university/academic_programs/pdf/site-license-overview.pdf Describes the educational Site license program through ESRI. This can provide schools with ArcGIS software at no cost through the State Site License Program. The State Site License Coordinator is Jeff Crews who can be reached at jeff@spatialsci.com The Site License link for Montana is http://www.spatialsci.com/index.php/sID/aa017b03/fuseaction/programs.cms.htm

http://training.esri.com/gateway/index.cfm This link is to the training resources offered through ESRI. Many are available online and some may be offered free to educators through the school's site license.

http://www.magip.org This is the link to Montana Association of Geographic Information Professionals. This is a good resource to locate a GIS consultant or expert to help with the implementation of GIS in the school. It is also a good resource for information about various GIS conferences, training sessions etc.

http://about.montanastatelibrary.org/commission_councils/mliac/ This is the link to the Montana Land Information Advisory Council. Stewart Kirkpatrick is the State GIS Coordinator and can be reached at: mailto:SKirkpatrick@mt.gov

This is the link to the Montana Cadastral that has tremendous amount of data about land ownership, tax information and developments http://svc.mt.gov/msl/mtcadastral/

http://nris.mt.gov/gis/default.asp This is the link to the Montana Geographic Information Clearinghouse that is the "Most comprehensive collection of geospatial data for Montana."  http://geoinfo.montanastatelibrary.org is the link to the new upgraded web portal to geospatial information hosted by the Montana State Library. This is a good data source for schools seeking to develop local community maps.

http://nris.mt.gov This is the link to the Montana Natural Resource Information System (NRIS). This is a good data source for schools seeking to develop community maps about local natural resources.

http://fwp.mt.gov/doingBusiness/reference/gisData/dataDownload.html This is the link to the Montana Fish Wildlife and Parks GIS data.

http://www.geodataservicesinc.com/Pages/default.aspx This is the link to the company that contracted with SVES. Ken Wall is very knowledgeable about GIS and can answer technical questions about the implementation of the SVES GIS program. He can be contacted at mailto:kwall@geodataservicesinc.com

This is the link to the web maps developed specifically for the Swan Valley http://geodataservices.maps.arcgis.com

http://swanvalleyelementary.org This is the link for the Swan Valley Elementary School.

mailto:jkmercer@mac.com This is the contact link for John K Mercer, the trustee who championed the GIS project for Swan Valley Elementary School.

mailto:awilliams@swanvalleyelementaryschool.com This is the contact link for Angie Williams, the Supervising and Junior High Teacher who championed the GIS project for Swan Valley Elementary School. She is also the Technology Coordinator for the school.