Piloting SoilCalculator™ in Ontario: Exploring tools for predicting the effectiveness of erosion control options

September 1, 2017

For information regarding this pilot, please contact

S. Cooke, Senior Water Quality Supervisor
Grand River Conservation Authority
scooke@grandriver.ca
OR
K. McKague, Engineer - Water Quality
Ontario Ministry of Agriculture, Food, and Rural Affairs
kevin.mckague@ontario.ca

TABLE OF CONTENTS

Piloting Soil Calculator in Ontario

Private sector Certified Crop Advisors (CCA) and other soil conservation specialists offer soil conservation planning and soil health check-up services to field crop producers in the Lake Erie and South Lake Huron Watersheds. Current tools available to CCAs for assessing soil erosion and soil organic matter depletion rates on farm fields require significant effort in both in-field data collection and in-office data analysis. Consequently, the current approaches used by CCAs are demanding and challenging. Tools and approaches that can simplify this challenge are worthy of investigation.

Consequently, the web-based SoilCalculator™ is a standardized, existing, and convenient on-line tool that could reduce the time required for a CCA or soil conservation specialist to complete a consistent and science-based analysis of existing erosion rates occurring on a farm field as well as prepare a set of options for the land manger to consider to reduce those rates and in turn improve a farm's soil health. By reducing the time required to prepare such a field erosion analysis, the cost for CCAs or other farm advisors to offer this service to their clients is significantly reduced.

SoilCalculator™, developed by Agren, Inc, an Iowa-based company, is currently operational in the Midwest United States. SoilCalculator™ calculates rainfall and runoff induced sheet and rill erosion rates two-dimensionally, using high-resolution digital elevation models (DEMs) as input for slope length and steepness across a field. The resulting precision maps, similar in look to a GIS-based yield map, pinpoint areas of high erosion across the field landscape. By entering details describing existing tillage and cropping practices, as well as potential options or proposed changes to these tillage and cropping practices a land manager is considering, the effect that different tillage and management decisions will have on the field's erosion rates and ultimately soil health can be predicted. Land managers can then combine this knowledge with other considerations such as equipment costs/availability, yield effects, crop preferences, and markets to identify erosion control options for their land that will maximize productivity while conserving soil and reducing nutrient losses from the field.

This pilot project was set up in two Phases to avoid the potential for unnecessary cost expenditures. Given that SoilCalculator™ was built to accommodate American-sourced geographic datasets, Phase I evaluated whether Ontario datasets could even be used as input and resources to drive the Iowa-based Agren SoilCalculator™ tool. If Phase 1 showed the Ontario datasets were compatible, then Phase II could proceed. Phase II involved building the SoilCalculator™ Tool so that it could be operated within two pilot areas in southern Ontario, thus providing a “proof-of-concept” that the tool has application and functionality in the Ontario context.

The following sections, summarize the main outcomes of this pilot project and includes a summary of feedback from practitioners, who were invited to a workshop, held on February 7, 2017 to test the pilot version of the Soil Calculator tool that was ultimately developed through Phase II of this project.

Phase I: Dataset Compatibility

Phase I of this project determined the feasibility of using, adapting, and incorporating Ontario’s geospatial and RUSLE2 datasets into the Agren web-based platform. Phase I objectives included:

1. Identify and assemble and characterize the RUSLE2 and geospatial databases that were both needed to operate the SoilCalculator™ tool and available to describe the Ontario context.
2. Assess the compatibility of Ontario’s existing public-domain data (both RUSLE2 and GIS-spatial datasets) for use within Agren’s SoilCalculator™ platform.

The key geospatial datasets identified by Agren needed to operate or "drive" SoilCalculator™ as "behind-the-scenes" data resources included the following:

- orthoimagery
- digital elevation model (minimum 9m x 9m resolution, with preference for 3m x3m resolution for ease in accommodating future upgrades to SoilCalculator™)
- contour map layer (preference 1 m to 2 m contour intervals)
- soils layer (including soil name, surface soil texture)

SoilCalculator™ uses the USDA-ARS RUSLE2 (revised universal soil loss equation, version 2) model behind-the-scenes to estimate sheet and rill erosion rates on each field grid area. As a result, datasets used to drive the Ontario-adapted version of RUSLE2 were needed for SoilCalculator™ in order to supply:

- RUSLE2 monthly 'R' values for rainfall and runoff (including snowmelt)
- 'K' values to characterize the soil erodibility of each mapped soil series in Ontario
- Descriptions of common cropping and management practices used in Ontario (i.e. input specific to Ontario that is used to determine RUSLE2's Cropping and Management Practice factor)

SoilCalculator™ also includes an optional routine that estimates the long-term production cost of the soil erosion estimated to be occurring on a field. Ontario-specific economic data related to the cost of soil erosion would also be useful if these algorithms were to be modified to be more Ontario-centric.

Phase I concluded with a report prepared by Agren that summarized the availability, compatibility and feasibility of building SoilCalculator™ to operate using Ontario datasets. The full Phase 1 report can be found in Appendix 1. In summary, however, Agren did not come across any issues with Ontario datasets that were significant enough to preclude the use of the SoilCalculator™ tool in Ontario. Further, some of the issues that were pointed out by GRCA and OMAFRA staff such as poorly georeferenced or low quality/inaccurate soil data in some areas of the province, were not considered issues by Agren. They indicated that similar soil mapping concerns exist in the United States and that, in the end, the important thing to remember is that SoilCalculator™ is best able to show the "relative changes" in soil loss that soil conservation practice alternatives can have across a field as opposed to absolute loss values. This makes it less important that the absolute values of soil loss estimated for a particular field be accurate.

Aside from the paper authored by Battison et al (1987) titled "Soil Erosion and Corn Yield in Ontario. I. Field Evaluation" there is very little data from Ontario that relates soil erosion losses with changes in crop yield that could be provided to Agren to estimate the long-term cost associated with the soil loss estimates generated by SoilCalculator™. This is a data gap that Ontario researchers could undertake to fill to ultimately enhance the output generated by SoilCalculator™. Lack of this data, however, would not prevent building the SoilCalculator™ tool for use in Ontario. For this pilot, it was decided to illustrate the soil erosion cost estimation capabilities of SoilCalculator™ by using the Iowa-based erosion cost algorithms and datasets as a means of illustrating the potential of the tool in the event Ontario-centric soil-loss cost data could be gathered in the future for integration into SoilCalculator™. It is therefore important to note that the soil loss cost data output by SoilCalculator™ in this pilot is based on data collected in Iowa and may not fully reflect the cost of soil erosion experienced in Ontario.

Overall, upon concluding Phase 1, the project team felt that the datasets largely existed and were sufficiently compatible enough to proceed with the tasks of using them to build the SoilCalculator™ tool for a pilot area within Ontario.

Phase II: SoilCalculator™ for Ontario

Piloting of the SoilCalculator™ tool in Ontario was undertaken in the Upper Nith and Conestogo River basins (Figure 1) as this area was the focus for creating a large-scale, three dimensional (3-D) vector hydrology layer which provided the foundation for creating a high resolution Digital Elevation Model (DEM).

The DEM was created by the Grand River Conservation Authority (GRCA) using a softcopy photogrammetry system and ESRI software (ArcGIS Desktop 10.3.1). The layer is a raster representation of a Pixel Auto-Correlation (PAC) point collection, derived from spring 2010 aerial imagery (SWOOP 2010), that was created and processed using softcopy photogrammetry software. Using ESRI software, errors within the PAC point collection (typically areas with dense tree canopy cover and surface water features) were removed and supplemental data was incorporated to fill the resulting gaps. Supplemental data included: 3D vector hydrology, and SWOOP 2010 mass points

Agren assembled all the necessary datasets needed, many of which were obtained through the Land Information Ontario (LIO) data warehouse, and completed the reformatting and software programming steps necessary to build SoilCalculator™ for Ontario. Once a draft of the on-line tool was completed, Agren provided selected GRCA and OMAFRA staff with access to the on-line, password protected, tool as well as some introductory training on its use via webex. Once trained the GRCA staff (Anne Loeffler, John Palmer) and OMAFRA staff (Kevin McKague) were encouraged to test out the tool and provide feedback on its performance and suggest improvements as well as demonstrate its use to others interested in the product. Farms known to the testers within the pilot area (Upper Nith and Upper Conestogo watersheds) were used to test and generate output using SoilCalculator™ . Examples of Soil Savings Reports are in Appendix 2.

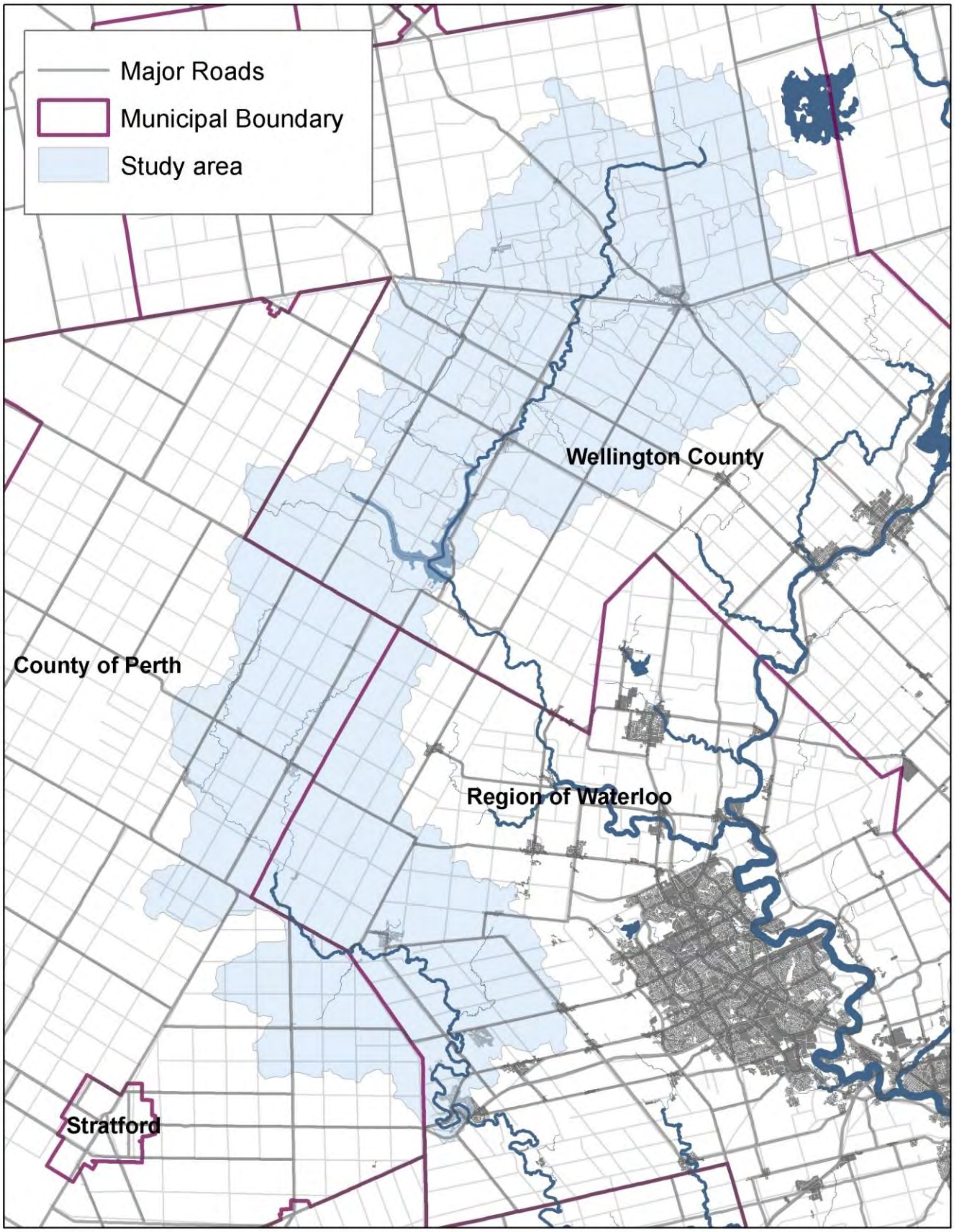


Figure 1 Pilot area for the SoilCalculator™ in Ontario - the upper Nith and Conestogo River basins.

The following are highlights, comments or observations that were compiled from the initial internal beta testing of SoilCalculator™ for Ontario:

Navigation within the software screen to find a farm or field of interest proved to be fairly intuitive and easy to manipulate. It proved very easy to delineate fields of interest.

There were some instances where the orthophotography used to build SoilCalculator™ had cloud cover which then made it impossible to delineate some fields as they could not be seen. This could be overcome, however, by providing Agren with orthoimagery where no cloud cover was present.

SoilCalculator™, as built for the use in the United States, operates using imperial units and in the English language only. In this project, output was converted to metric units to illustrate that metric output could also be produced. Input, however was in imperial units only and it was not possible to convert output with the click of a button from metric to imperial or vice-versa. Agren also stated there would be no plans or any interest on their part to translate the tool into French if that was needed.

A 9 m X 9 m DEM grid was used as the basis for building Soil Calculator™ for Ontario. We would have preferred to have seen a 3 m X 3 m grid as this would also set it up better for operating future tools such as the EphGEE (Ephemeral Gully Erosion Estimator) being developed for SoilCalculator™. The disadvantage of using a more detailed DEM however is the processing time required to complete the soil loss calculations across a field. Reducing the grid size significantly increases the calculation time (by approximately 9 times) significantly slowing down the software.

For the workshop testers particularly, the approach used by SoilCalculator™ to describe or define the crop rotation and tillage practices used on a field was not intuitive. The user interface used in the draft tool was the same as the interface used by the US product. It therefore asks the user under the "ROTATION

BUILDER" screen to "search for crop rotations and operations". (see screen capture in Figure 2)

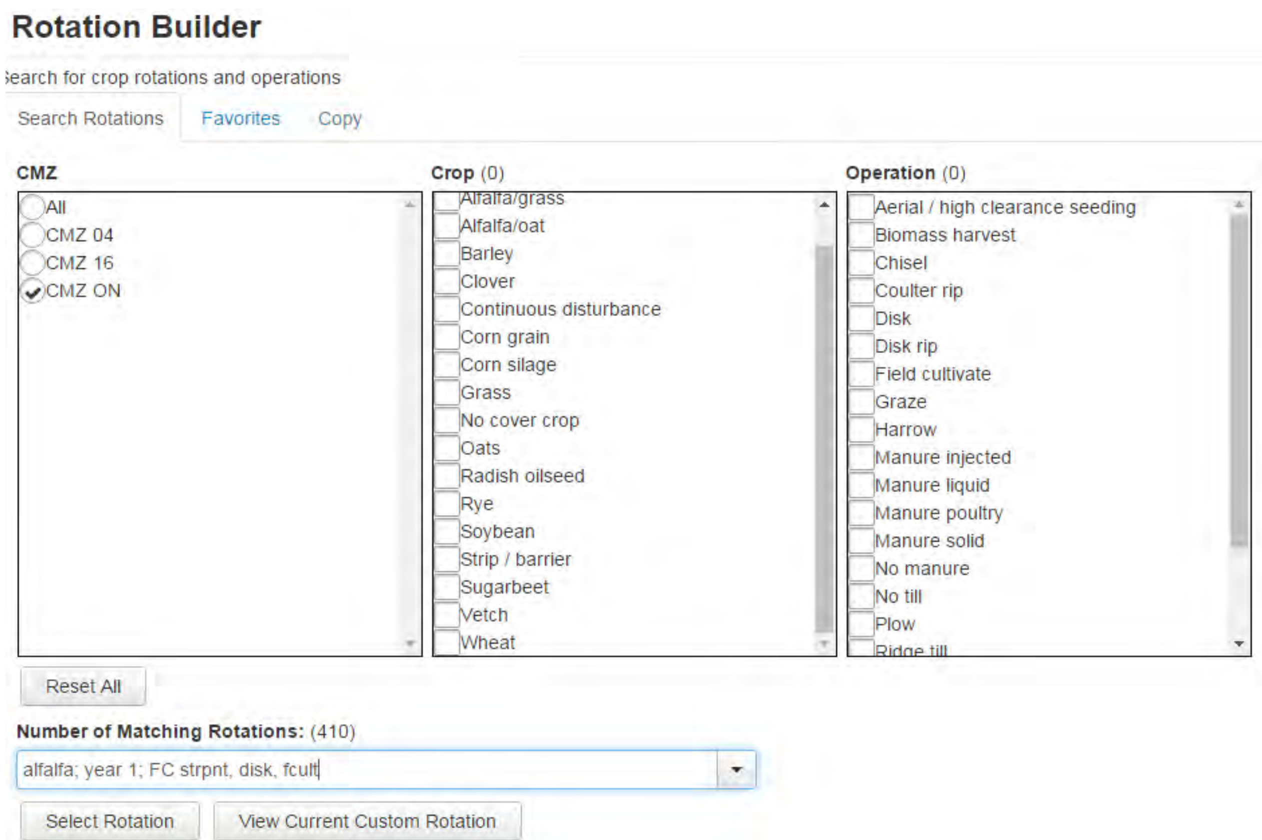


Figure 2 SoilCalculator Interface for selecting cropping and tillage practices

Using the term "Rotation Builder" on this screen proved confusing to Ontario users as the screen was only showing the ability to select single crop years, not rotations. The reason only single crop years were listed on this screen within the crop management zone (CMZ) for Ontario (ON) is a function of how the RUSLE2 software datasets were prepared for Ontario compared to how they were prepared for the US crop management zones (eg. CMZ 04 = Iowa). In Ontario, the group that adapted RUSLE2 to Ontario, made a decision to create descriptions of only single crop years and have the users of RUSLE2 create and save their own rotations by combining the descriptions of these single crop years to form a custom rotation. In the US, however, soil conservation specialists decided to define common complete rotations for RUSLE2 users, saving the user from having to build the rotation from single crop year information (also available in the US datasets). There are advantages and disadvantages of each approach. Nevertheless, SoilCalculator™, recognizing that some choices in the US dataset may be complete rotations and not just single crops, called this pop-up view as the “Rotation Builder” screen and asks the user to “search for crop rotations and operations”. For Ontario users, it could be more aptly called the “Cropping and Tillage Practices” screen and users would be asked to “search for a cropping and tillage practice combination” to arrive at the single year cropping and tillage practice of interest. The window on this same screen, titled in the US version “Number of Matching Rotations” (see Figure 2) could be more accurately named “Number of Cropping Practice Options” in the Ontario version of this tool. This difference in operation and nomenclature is not a limitation of the SoilCalculator™ tool itself, but rather a difference in the philosophy of how the behind-the-scenes RUSLE2 databases were prepared between the USA and Canada. OMAFRA could readily work with Agren to develop consistent nomenclature and naming conventions that end users in Ontario would find more intuitive if this project were to expand.

An advantage of using the single crop year approach employed in the Ontario version of RUSLE2 is that it allows the user to take advantage of combining single year crops to form custom rotations using the rotation building tool embedded in RUSLE2 and also in SoilCalculator™. Rotations that are common to a farm or field could be built and then saved as a “Favorite” for use in future runs of the software on other farm fields under a similar rotation. This also cuts down on the number of permutations and combinations of crop rotations and practices that need to be developed and stored in the RUSLE2 or SoilCalculator™ database. For further explanation of the strengths and weaknesses of the two general approaches, the reader is encouraged to contact one of the authors of this report.

A couple glitches in the software were present at the outset and were never really resolved over the course of the project. When checking off the crop of interest to be grown (see column 2 in Figure 2), SoilCalculator™ did not always properly sort and screen the RUSLE2 database to list only those practice in the database pertinent to the crop selected. For example, when selecting “soybeans” the “number of matching rotations” listed in the drop down window included other crops like raspberries and blueberries. Further programming would be required to clean up these database sorting issues.

Overall, General observations from beta testing the SoilCalculator™ by GRCA and OMAFRA staff were positive. This then led into holding a demonstration workshop for the pilot product for potential users of the tool in the province.

SoilCalculator™ Workshop

A Workshop was held on Tuesday February 7th, 2017 at the Grand River Conservation Authority (GRCA) administrative office in Cambridge. In total, 27 people participated in the workshop including Certified Crop Advisors (11), Conservation and Technical Specialists (10), and GIS specialists (6)). The agenda for the workshop can be found in Appendix 3.

Gabe Ferguson, OMAFRA provided the context for the workshop and highlighted the need for managing soil erosion, especially as it relates to the delivery of phosphorus from fields downstream to waterbodies like Lake Erie.

Kevin McKague, OMAFRA provided background on soil erosion estimation tools available for use in Ontario, specifically the history and adaptation of the USDA’s universal soil loss equation (USLE), and more recently RUSLE2 for application in Ontario. Later, he also provided users with a walk through demonstration of the Soil Calcualtor™ tool as piloted for Ontario.

Jill Marshall and Anne Loeffler provided a high level summary of the development of terrain analysis tools to identify gully erosion and the use of these map products to engage the farming community.

Tom Buman, Agren, provided an overview of the Agren Toolset including the SoilCalculator™ via an online session using AdobeConnect. He provided participants with the background to why SoilCalculator™ was developed and how it is currently being used in the US.

Agren facilitated access to the on-line SoilCalculator™ tool for the participants of the workshop by providing each participant with a temporary license (password) through which to access SoilCalculator™ on-line. After receiving an overview on the operation of the software, workshop participants were provided example exercises to work through in order to gain experience using SoilCalculator™ on their own. They were also encouraged to explore and complete conservation plans for fields within the pilot area that they may be familiar with in order to critique output from SoilCalculator™. A copy of the materials given to each of the workshop participants as well as the main slide decks used as part of the workshop presentations can be found in Appendix 3.

Workshop Participant Feedback

At the end of the instructional portion of the workshop, a discussion was facilitated to receive some preliminary feedback on SoilCalculator™. The following were some general comments provided by participants:

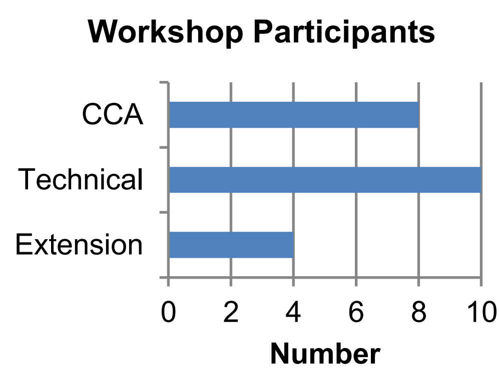
- Doesn’t interface well with iPad (more Windows based)
- Language doesn’t always make sense (eg. Rotation vs. crop to add to rotation)
- Rotation builder- right column on operations not functional
- Can you add additional field boundaries through importing them?
- Could cover crop be listed as separate crop so that it can be used to illustrate the difference cover crops make?

- Runoff from edge of field vs. within field - focus should be on keeping it within field however, tillage erosion can affect productivity so it does matter within field boundaries. Erosion on top of slopes still matters.
- Want to know how we use this field map data to apply it to yield maps as the farmer already knows where erosion issues are. He needs something to join the yield reduction with the erosion problem. If problem area in field- take it out of production since it doesn't make any money, and maybe solve erosion problem.
- Maybe this tool can help with identifying where a farmer can get more yield
- Another feature to this could be identifying the loss of water-holding capacity of the soils.
- Maps allow for a deeper conversation to happen with a farmer. SoilCalcualtor has numbers behind the map so it can be a more informed conversation.
- Biggest impact from Precision Ag is in seeing yield difference in tile installation.
- Perhaps farmers don't need maps but CA staff do
- We have yield maps- show the bottom line and the exact location in a field. How much return does it make? Environmental effect too?
- Precision Ag and yield maps- how can we maximize yields- prescriptions on specific areas.
- Digitizing maps made an impact- but not sure if this map adds anything new to what farmers already know and can learn

- Where the exit points of nutrients/sediment are on a field, as shown through the stream power index, is important and is not covered through other mapping systems
- Farmers are interested in erosion on their fields and got a sense from the participants that farmers are asking more questions about it now than previously.

Following the informal feedback time, and responses to questions such as those presented above, participants were asked to complete a written survey. A copy of the survey can be found in Appendix 4. Twenty–two participants completed the workshop survey. The following summarizes the feedback that was solicited from workshop participants through the survey.

Area of Expertise: Participants at the workshop were grouped into three main categories: Certified Crop advisors, Technical specialists such precision agriculture specialist, water quality, GIS or government; and Extension specialists such as Conservation Specialists. List of Participants is in Appendix 5.

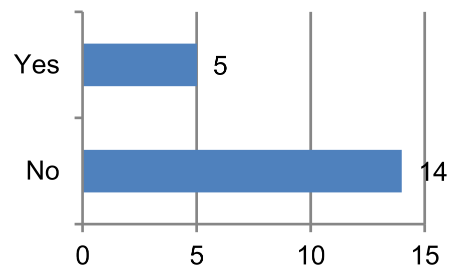


Are farmers asking for assistance with soil erosion issues? Many (10) respondents indicated that farmers were asking for soil erosion information whereas 8 indicated that they were not and 4 did not respond. The kind of information they were seeking included:

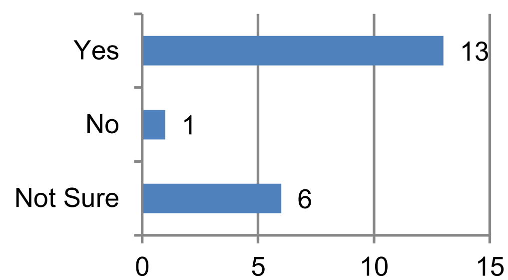
- grant system to retire land/take out of production. People on ground to run Agren-like tools OR connect similar outputs from retail to CA's
- Modelling- predictions, spatial analysis
- On a general scale, I think farmers are interested in mitigating erosion issues as they relate to economics on the farm
- Discussion of cover crops, funding

- Should I keep this land in production? How much P am I losing in my sediment?
- Design of erosion control structures
- Determine where it is worst and what is the best/most efficient solution?
- I want to improve soil mapping and zone management creation
- usually funds to support erosion control structures (water quality specialist comment)
- Requests have been minimal in past, but more interest has been recently expressed. Interest is usually expressed as wanting help with erosion control design and cover crop types.
- I don't think they're thinking of other options than no-till, residue

Are you currently using any erosion prediction tools?
Of those who are, they are using AgSolver, RUSLE2, USLE(2), GIS approaches such as SPI and SWAT



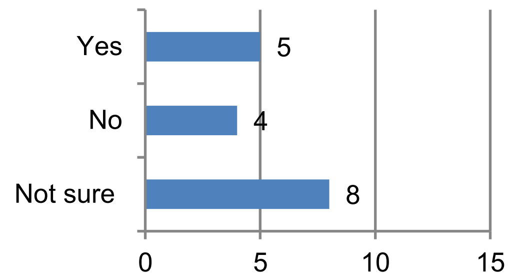
Would you use the SoilCalculator™?
Many (13) of the participants indicated that they would use the SoilCalculator™ if they had access. They indicated that they could use it up to 20-25 times in a single year however it did range among participants to 'when approached' to maybe once a month.



- 20x on another project
- Possible link/layer on Ag-maps? Need access to better contour interval information to capture slope and slope complexity
- When I come across fields with issues that are not related to fertility
- To policy as a potential tool, perhaps in presentations
- Once a month

- Less than a dozen, when approached
- 5-10 times
- Fall/Spring- daily, run through fields to be sampled
- Depends on how convincing we can be to get farmers to address erosion issues
- I would take printouts with me to site visits, approx 25 per year
- Presentation/awareness tool

Would you use RUSLE2?



Most participants would not or were unsure whether they would use RUSLE2. For those that would use it, it would range from a client to client basis up to 10-20 times. Other comments included:

- There would likely need to be programs/ incentives to encourage producers to access/ utilize RUSLE2 and Soil Calculator information
- I have access but so far there is no interest
- 10-20 times
- more frequently on a client by client basis
- When I have specific questions from growers about erosion rates from simple slope fields. 2-5 times per year.
- Presentation and awareness tool

Which outputs from the SoilCalculator™ do you find most useful?

- costs/economic returns for farmers of soil/nutrient/yield loss, options to buy into to remediate (4)
- sediment would be great
- I see potential value in most output from the Soil Calculator
- Interesting to see gains/loss areas in the field
- scenarios that compare soil loss using different management practices
- Zone creation= better farm management
- Export maps to other platforms
- 10 year average, custom rotation, within and off field soil loss

- Tons/acre soil loss- cm/10 years (3 comments)
- Field loss spatial differences on a map. Yield loss and nutrient loss if accurate
- Shapefiles of economics of the alternatives/ slope steepness
- Not sure yet. I haven't worked with it yet.
- Soil savings plan
- The mapping showing zones of high and low erosion and the bar graph showing percent of field at each erosion rate.
- Show different crop rotation impacts

Which outputs from the SoilCalculator™ do you find least useful?

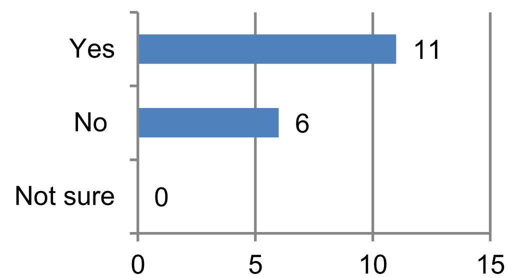
- Limit to 1 field, doesn't showcase point of exit on the field
- Tonnes of soil' means nothing to farmer unless it is taken to nutrient loss or yield loss ($$)
- Economics- $ figures not correct for ON- will be more useful with Ontario data
- Received error message on my first soil savings plan, couldn't figure out how to fix it
- The slope steepness map/chart isn't extremely useful in its current state
- Unsure if field loss average is delivery which is the useful calculation
- Not sure yet, need to play with it (2 comments)
- Soil map layer- usually already know this
- It would be great if it could grab more data automatically- soil type, elevation maps, crop rotations incorporated with other software.

What are your ideas on using output from SoilCalculator™?

- Reduced P runoff by reducing erosion. Demonstrate different practices and their input on erosion control
- Include yield parameters
- Identify areas and quantify spacial loss
- Need to take it to economic response to drive farmer uptake
- Will there be the ability to overlay a soil map from Soil Calculator with other software
- Prioritizing BMP placement

- Show benefit of incorporating cover crops
- I would see this being used in targeted situations ie. Specific subwatershed- approach farmers and do soil calculator with them. Emphasize BMPs
- Demonstration but confidence in economic impact is still lacking
- Economics- build management zones
- Economic losses will sum up the effects of soil loss.(4 comments)
- Although farmers often know when their gully erosion is occurring, they have less knowledge of where rill or sheet erosion is occurring: this tool will help with onsite consultations.

Is there value in developing in the SoilCalculator™ for Ontario?



Once respondent indicated that if SoilCalcualtor were to be developed for Ontario, there is a need to focus on the ‘so what’ and why would a grower invest or change current practices.

If yes, how do you think the SoilCalculator™ tool could be funded to expand it across Ontario?

Most (8) respondents indicated that government should partially cover the cost of having this tool available while 5 indicated that government should pay for development and access to the tool whereas only 2 respondents indicated that licenses or private ownership would be preferred.

Partnerships could include OMAFRA/CA/Conservation Ontario; Retail Outlets; MOECC; Farm Association, SMS Incorporated.

Who might pay for a license or subscription to have access to the SoilCalculator™?

Most responded were not sure whether CCAs, Crop Input Supply / Service Companies, Extension staff or Conservation Authorities would pay for a subscription however, many respondents indicated that farmers were unlikely to pay for a license.

Other comments:

- Input farmers yield potential index or map and link to economic cost of loss balance sheet under each alternative
- Quality of output is only as good as the quality of the input data and credibility
- Need to integrate gully/ephemeral erosion output
- What are the connections to off-farm sediment delivery?
- The functioning needs to improve more- drop-down menu options to select crop, tillage, etc. Too much to sort through otherwise
- Tool is very interesting to quantify movement in a field. Does not show where it exits the field
- Need to look further at economics
- Add cover crop options
- Ag groups (eg. Farmer representatives) are interested in what does this mean for policy? How confident can they be in the data behind the calculations? Will max soil loss become a regulation?
- Need to demonstrate the value before CCAs and crop input suppliers would see the use. Could see it being a tool for CAs and extension staff when approached by farmers, they could whip up a map and pick BMPs tailored to the land.
- The productivity goals of a producer need to be related to erosion rates to make the application of this technology most applicable
- Import boundaries or google earth images; export contours; depending on accuracy of imagery, erosion mapping can be an added layer for management zones
- The underlying data drives the application. Elevation model and soils- tied to elevation. Until the province has good consistent elevation models and updated soils using elevation then it is not worth it. Spend money here first to get good data (GIS survey respondent)
- I am thinking that yield maps are what management decisions might be based on. The maps are in the 'growers' heads already. The people that need these maps might be the CCAs or the extension people to know where to 'target' the BMPs. So it is not clear to me what 'benefit' there is to the producer at this stage.

- To get wide-scale adoption of a tool of this nature, it would be best to tie its use to existing programs, or develop a new provincial program with technical advice/extension to deliver it to farm community
- Realistically, the farmer, CCA, etc. knows where there is erosion and will be hard to sell software to calculate how much. Too much work, should be incorporated with other software to automate.

Comments from the roundtable discussion from the workshop:

- Doesn't interface well with iPad (more Windows based)
- Language using in the SoilCalculator™ doesn't always make sense (eg. Rotation vs. crop to add to rotation); Rotation builder- right column on operations not functional
- Is there provision for field boundaries import to be imported?
- Runoff from edge of field vs. within field. Focus on keeping it within field. Farmers have indicated that tillage erosion is affecting productivity so erosion does matter within field boundaries. Erosion on top of slopes still matters.
- How can we use this field map data and apply it to a yield map? Farmers already know where erosion issues are, he needs something to connect the yield reduction (dollars and sense) with the erosion problem. If problem area in field- take it out of production since it doesn't make any money, and maybe solve erosion problem.
- Or on the other hand, farmers may ask how can I get more yield? SoilCalculator™ could be used to try different scenarios to see what works best.
- Loss of water-holding capacity could be another feature to add to SoilCalculator™ as not all issues are erosion based.
- Farmers generally know where drainage issues are on their field so what value is a map? The visual tool allows for a deeper conversation to happen- now we have a tool with some numbers behind it. Does it actually bring the conversation to a higher level or not?
- Yield maps are important. Biggest impact from Precision Ag is in seeing yield difference in tile installations

- Farmers don't need soil erosion map but CA/Extension staff do so they can engage the farmers
- We have yield maps- show the bottom line and the exact location in a field. How much return does it make? Environmental effect too?
- Precision ag and yield maps- how can we maximize yields- prescriptions on specific areas.
- Digitizing maps made an impact- but not sure if this map adds anything new to what farmers already know and can learn
- The stream power index showing gully erosion shows where there are exit points of nutrients/sediment from the field. This is important and is not covered through other mapping systems
- Can this tool be used in the same way as yield maps are used in precision agriculture? Can we use cover crops as a rotation to see how it can influence erosion rates. Answer- include seeding rates, fertilizer, etc. and some areas are just not worth farming. This concept will sell it for farmers.

Further follow up with the SoilCalculator™ maps with the farming community through GRCA Conservation Services staff indicated that many farmers in the Grand River watershed do not have yield maps largely because of the complexity of the technology and they have given up trying to generate maps for practical purposes. Informal feedback from the directors of the Waterloo Soil and Crop Improvement Association indicated that yield maps are rarely used locally.

Summary and Next Steps

Agren SoilCalculator™ is a proprietary web-based tool so it is difficult to detail the exact steps needed to have this tool or a similar tool operational in Ontario. In the United States, Agren Inc. issues licenses to groups or individuals interested in using the software (e.g. Land-o-Lakes Cooperative). Annual cost for the license can vary but a rough estimate would be $2000/year/county of interest. Different possible options or models exist for servicing Ontario and potentially include, but are not limited to the following possibilities:

- The Ontario government expand development of this tool for use across the agricultural regions of the province and purchase licenses from Agren for selected users across the province to use at no charge (or possibly charge them on a cost recovery basis).

- The Ontario government develop parallel software on their own and service, maintain and distribute it as they see appropriate. This is similar to the approach used for other software tools such as AgriSuite (Nutrient Management Planning software, MDS software) and AgErosion that were developed internally by OMAFRA staff. The disadvantage of this approach however, is the cost to develop and subsequently maintain and keep the software current.

- Conservation Authorities in the province could partner with Agren Inc. to develop the tool for use in their jurisdiction (or even portions of their jurisdiction). They could take advantage of publically available data as much as possible but also possibly customize it for their own watershed needs. Agren would support the software using a license agreement made with the Conservation Authority. The Conservation Authority may request the option of being able to issue sub-licenses to key field agents within their jurisdiction (providing the license at no cost or on a cost recovery basis).

- Private-sector farm service providers could partner with Agren to incorporate SoilCalculator™ into their service software tools. They would license directly with Agren Inc. Some support may be necessary from the provincial government to ensure that the best publically – available datasets are used and maintained to properly operate SoilCalculator™ (e.g. provision of provincial LiDAR data.)

- Commodity groups (e.g. Grain Farmers of Ontario) may see value in providing grain farmers with a tool for identifying options to reduce soil erosion of Ontario cropland and could partner with Agren Inc. to develop the tool and offer it up on-line as a service to their members.

- Agren Inc. could develop the tool for Ontario and undertake their own product marketing for sales and use in the province. Potential clients could include, Conservation Authority extension staff, provincial extension staff, Certified Crop Advisors, other farm service providers in the province.

Regardless of the model that could be used, for SoilCalculator™ to see province-wide operation, a provincial DEM layer of sufficient accuracy would need to be made available. At the time of writing this report, detailed LiDAR DEM coverage is being prepared for the Ontario Lake Erie watershed lands. Expansion of a similar product across Ontario would be needed for all farms in the province to have equal access to this tool.

Data sharing arrangements would be a necessary but tedious task if all involved in this work were to feel their contributions to the overall product were recognized. Ideally, it would be nice if SoilCalculator™ could access key datasets it needs from Ontario-based servers. Currently, however, Agren's preference is that the data needed to drive SoilCalculator™ be housed on their own in-house servers. This necessitates data sharing agreements in most cases. Data stored on external in-house servers, however, will not be as readily updated as would be the case if the data were pulled directly from the Ontario servers where they are constantly being maintained and updated. It was first envisioned that web-based data would be used in the SoilCalculator™ to preclude the need for continuous updates being sent to Agren in the US. The current architecture of the SoilCalculator™ does not allow for web-based data acquisition and therefore, thought must be put toward whether or not the province feels that this aspect will limit the utility of the SoilCalculator™ if it were to be expanded province-wide.

Finally, although it did not limit its application as Agren Inc. indicated that the SoilCalculator™ tool is used for relative comparisons, the province should consider updating and improving the quality of the soils data layers needed as one of the inputs to Soil Calculator™.

Agren Inc. was asked for feedback on their experiences adapting SoilCalcultor™ to the Ontario context. The following letter on the next page summarizes their feedback.

1238 Heires Ave. • Carroll, IA 51401 • P: 712.792.6248 • w: www.agreninc.com

Report: Adapting SoilCalculator™ for Use in Ontario

Soils Database: Agren will need to create an import process to create Rusle2 soil files directly from the database. Dr. Daniel Yoder (University of Tennessee) and Dr. Seth Dabney (USDA Agricultural Research Service) continue to build the science for cell based RUSLE2 and Ephemeral Gully Erosion Estimator (EphGEE). As they continue to enhance the performance of these models, they are utilizing more existing parameters in the SSURGO database. It will be critical that we determine if the Ontario Soils Database contains this same level of information as the U.S. SSURGO database. Also, there is a lot of missing soils data that lacks a reliable K factor value (e.g. bottomland, water, urban or muck soils). This soils database would have to be cleaned up.

Management Systems: The selection of "managements" for Ontario needs to be cleaned up. For instance, when a user selects "soybeans" for the crop, managements with strawberries, raspberries, and dry edible beans are also pulled up in the pick list.

Climate files: Currently Ontario tiles their climate files to weather stations. In order to effectively utilize SoilCalculator, we will need to develop GIS polygons for these weather stations. Agren would then need to modify our code to use this GIS climate layer instead of relying on the county layer.

Topographic data: Two-foot contour lines need to be generated in order to effectively draw in contour buffers and terraces.

SoilCalculator Add-ons:

- **Ephemeral Gully Erosion Estimator (EphGEE):** There was a great need for a robust yet flexible ephemeral gully erosion model that could provide both field scale soil erosion estimates and also credit the conservation effects and targeted placement of conservation practices to control ephemeral gully erosion. By July, 2017, Agren should have the EphGEE fully incorporated within SoilCalculator.
- **RotationBuilder:** Currently, SoilCalculator is limited to accessing only single year managements. These single year managements can be added together to form multi-year managements. SoilCalculator currently does not allow the user to modify either the single or multi-year managements. In the next year, Agren will be developing a full RotationBuilder. A user will be able to modify any of these managements. Modifying these management systems will include adding or subtracting operations, vegetation, and changing residue amounts.

3 meter vs. 9 meter DEM: In talking with Dr. Seth Dabney (USDA's Agricultural Research Service), he does not expect any meaningful difference if SoilCalculator is run on 3-meter resolution vs. 9-meter resolution. However, if Ontario wants results from Agren's Ephemeral Gully Erosion Estimator (EphGEE), we will need a DEM that has a 3-meter resolution.

Future Costs: It is difficult to price SoilCalculator for Ontario's use. Variables that need to be considered are the geographic area of coverage, number of users, features required or desired, and use of Ephemeral Gully Erosion Estimator. Additionally, Agren would need to price out some of the items above to give a fair estimate of the cost.

Appendix 1: Phase I Report

SoilCalculator™ Data Requirements

Prepared By:

Jim Lyon, Chief Software Engineer, jim@agreninc.com, 865-466-4330

Lang Deng, GIS Data Manager, lang@agreninc.com, 515-669-9388

Version 1.2

Updated: 2016-02-16

1. Contents

2 PURPOSE

This document describes the data requirements for Agren SoilCalculator™, a tool for modeling soil erosion and related resource concerns on agricultural land using the RUSLE2 2-dimensional soil erosion model.

Data required for SoilCalculator includes GIS (spatial) data as well as tabular data.

3 DATA FORMAT REQUIREMENTS

3.1 GIS DATA

3.1.1 Vector GIS Data

The vector GIS data is generally stored in Esri (Environmental System Research Institute) File based Geodatabase (FGDB) format, unless otherwise noted.

3.1.1.1 Soil Data (Polygons with attributes)

The USDA-NRCS Gridded Soil Survey Geographic (gSSURGO) soils dataset is available from the USDA Geospatial Data Gateway (GDG, https://gdg.sc.egov.usda.gov/). This dataset includes both vector and raster representations.

See: https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/GSSURGO.html and the http://www.nrcs.usda.gov/wps/portal/nrcs/detail//?cid=nrcs142p2_053628.

The polygons represent soil "map units". This is the finest spatial resolution available for the SSURGO soils data. These polygons are used for both presentation and for calculation.

Soil characteristics affecting erosion vary strongly between polygons so they are important for display as well. Polygons are used in output reports since they help explain variations in erosion on a site that might not otherwise make sense.

Each soil polygon may contain multiple soil "components" with different soil properties, which are not mapped spatially inside the polygon. Each component is assigned a percent coverage of the polygon.

Agren selects a “dominant” soil component to represent the entire map unit and its data is used for all erosion calculations. In general this is the soil with the greatest percent coverage.

For some models (e.g. Nitrogen) it is possible to use composite values obtained by area-weighting the soil values of the components. This is never done for RUSLE2.

RUSLE2 requires a specific set of values to be able to do an erosion calculation. If those parameters are not all present in the soil for the map unit, this will be treated as a NODATA entry and no erosion will be calculated for this polygon. Examples are areas mapped as gravel pits, rock outcroppings, and sewage lagoons.

3.1.1.2 U.S. State Boundaries (Polygons)

State boundaries are taken from the NRCS dataset available from the USDA Geospatial Data Gateway (GDG, https://gdg.sc.egov.usda.gov/). These boundaries have been adjusted by NRCS to be consistent with the other data layers provided by the GDG and do not agree with boundaries provided by the U.S. Census Bureau, for example.

See: https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/NRCSTATE.html.

3.1.1.3 U.S. County Boundaries (Polygons)

State boundaries are taken from the NRCS dataset available from the USDA Geospatial Data Gateway (GDG, https://gdg.sc.egov.usda.gov/). These boundaries have been adjusted by NRCS to be consistent with the other data layers provided by the GDG and do not agree with boundaries provided by the U.S. Census Bureau, for example.

See: https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/NRCSCNTY.html.

This layer is used for search.

State and county information is used to validate licenses.

State and county information is currently used to select the climate used to run the RUSLE2 model. (This is only possible in the Eastern U.S. and will change in future versions.)

3.1.1.4 Contours (Polylines)

These are generated from the elevation data on a per state basis. There may be mismatches between contours at state boundaries but within a state they will be consistent.

This is a visual layer only used to guide the user and is not used in model calculations.

3.1.1.5 PLSS Townships (Polygons)

The Public Land Survey System (PLSS) Townships were obtained from the USDA GDG (https://gdg.sc.egov.usda.gov/).

See https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/PLSS.html.

This layer is used for search only.

3.1.1.6 PLSS Sections (Polygons)

The Public Land Survey System (PLSS) Sections were obtained from the USDA GDG (https://gdg.sc.egov.usda.gov/).

See https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/PLSS.html.

This layer is used for search only.

3.1.1.7 NRCS Crop Management Zones (Polygons)

The NRCS Crop Management Zones (CMZs) are large areas of similar agronomic conditions used to partition the set of NRCS management files. There are ~80,000 management files in the database maintained by the NRCS. This is generally too many to browse easily, so they have been subdivided by CMZs. The CMZs completely cover all areas in which the managements are used, and have no overlap. There is a nonstandard CMZ "00" used for generic managements. The same management description may be copied to other CMZs, but this commonly involves adjusting planting dates and operations typical in that CMZ. CMZs are generally unions of counties in the Eastern U.S., but in the west this doesn't hold.

This is a standard NRCS dataset associated with the RUSLE2 model.

See the NRCS/ARS Crop Management Zone Maps (images) and CMZ Shapefiles (shapefiles).

This layer is used for searching managements when selecting a management to use or modify. Managements are stored in a directory hierarchy in the RUSLE2 database and this is used to generate a mapping of the managements to the CMZ folders which contain them.

3.1.1.8 RUSLE2 Climate Regions (Polygons)

The NRCS RUSLE2 model uses a national map of climate polygons to RUSLE2 climate records. Each polygon has attributes which may be used to construct the RUSLE2 climate filename.

In practice this is a little complicated. For the Eastern US the filename is derived from the state and county names only, and the polygons coincide exactly with the county shapes. For the western US within each county there are subdivisions based on precipitation zones. In addition the names of climate files were generated manually using varying patterns, not programmatically. While it is not possible to generate the matching climate filenames from the shapes and attributes, it is possible to use queries to match the metadata scraped from the climate filenames back to their shapes. The climate files do not contain this metadata internally, just in their names.

See the NRCS/ARS Climate Data Download Site. This contains shapefiles for the Western US, but none for the eastern US, which are taken from the standard county and climate polygons and attributes.

3.1.2 Raster GIS Data

The raster GIS data can be either stored in FGDB or stored on a local drive by their native image format (TIFF, IMG, etc). The current practice is to not do any conversion of the original data and to let ArcGIS convert it on the fly as needed.

The gSSURGO soils data contains duplicate vector and raster data and is described above in the Vector Data section.

3.1.2.1 Aerial Photos
Image data in MrSID or JPEG format stored in Raster Mosaic format by state/province. They are from the USDA NAIP (National Agricultural Image Project) with 1 meter resolution. This data is obtained from the USDA GDG (https://gdg.sc.egov.usda.gov/).

See: https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/NAIPM.html (mosaic), andl https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/NAIPSL.html (seamlines).

3.1.2.2 Elevation Data
Terrain Digital Elevation Model (DEM) data with high resolution (3 m or better). The data is stored in the original source format, which may have multiple resolutions.

This is National Elevation Dataset (NED) data obtained from the USDA GDG (https://gdg.sc.egov.usda.gov/).

See: https://gdg.sc.egov.usda.gov/Catalog/ProductDescription/NED.html.

Note: The RUSLE2 model is currently run at 9 meter resolution. ArcGIS Server is used to generate this resolution from whatever resolution is available for the area of interest. This is the current limit of applicability of RUSLE2 – is should have a resolution of 9 meters or smaller.

3.1.3 Esri Basemaps
These layers are obtained from the ESRI ArcGIS Online map and image services.

- Street
- Imagery
- Topo

3.2 Tabular Data (Non-spatial)
Tabular data is stored in FGDB, SQLite GDB data format, MySQL database and Excel files.

3.2.1 SSURGO Soils Data
SSURGO contains soil data used to run the RUSLE2 model. This data is not used directly by the model, but instead RUSLE2-specific input files are generated by a one-time import process and stored separately.

The SSURGO map unit symbol ("musym") value is used to map from a geospatial location to the RUSLE2 input file to describe the soil. For historical reasons in the development of SoilCalculator, this is a multi-step process. The soil filenames assigned to RUSLE2 files on import are generated from SSURGO metadata. This is partially reversed to get to the string pair (path-name, file-name) used to retrieve the XML from the RUSLE2 database. Both of these strings may be generated from SSURGO using SQL queries and logic. Instead only the file-name part is generated. It is then used to find the full pair (path-name, file-name) in a SQL Server database by a SQL query. (This is a solution which will have to be changed eventually.)

3.2.2 RUSLE2 Model Database

The RUSLE2 model runs on its own model-specific files stored in a single SQLite 2.8 database. It contains all RUSLE2 input file types, including climates, soils, managements, vegetations, operations, and all supporting files.

Historically these SQLite databases are saved with file extension ".gdb", so they are referred to as GDB files. This is a RUSLE2-specific terminology.

Soil files are generated from SSURGO data by a one-time import process. The database stores all standard files required to support a RUSLE2 run. This database has a very simple relational model, and acts as a virtual filesystem mapping a string pair (path-name, file-name) to a single XML object containing all RUSLE2 parameters.

In practice there are too many soils to put in a single SQLite database and have it behave efficiently. The time required to load the database into memory alone becomes a problem. In this case other methods are used to fetch these files. The ability to fetch input files served over HTTP is built into RUSLE2 and this is used in the Amazon Web Services (AWS) implementation. Since the RUSLE2 Model Database is essentially just a key-value store with some additional metadata, this works well.

3.2.3 Managements Database

The RUSLE2 Model Database contains those files which are not user-editable inputs. Management descriptions are the main user-editable input to RUSLE2. The Managements Database is currently a SQL Server database which contains a duplicate set of all managements and supporting files used by RUSLE2. This is to support search and saving modified managements, something that the read-only Model Database doesn't allow.

The Managements Database has schema described separately to support search and enforced relationships between RUSLE2 files. However, the underlying data is ultimately just the XML files stored in the RUSLE2 Model Database and their metadata.

3.2.4 Economic Impact Data

Soil Calculator uses research conducted by Iowa State University, in addition to the market price for corn, and the cost of applied nitrogen, phosphate, and potash as a basis for demonstrating the economic value of a ton of lost topsoil.

The annual yield loss calculation is based on documentation provided by Dr. Rick Cruse of Iowa State University. Dr. Cruse's research quantifies soil erosion and topsoil depth lost across Iowa's HUC 12 watershed regions and determines how these values correspond to lost corn and soybean yield.

SoilCalculator uses a value of .02 bushels of corn lost for every 1 ton of soil lost to sheet and rill erosion. See http://www.leopold.iastate.edu/grants/e2014-17. For every 1-inch of top soil loss, this converts to a loss in productivity of 2.94 bu of corn per 1-inch of top soil.

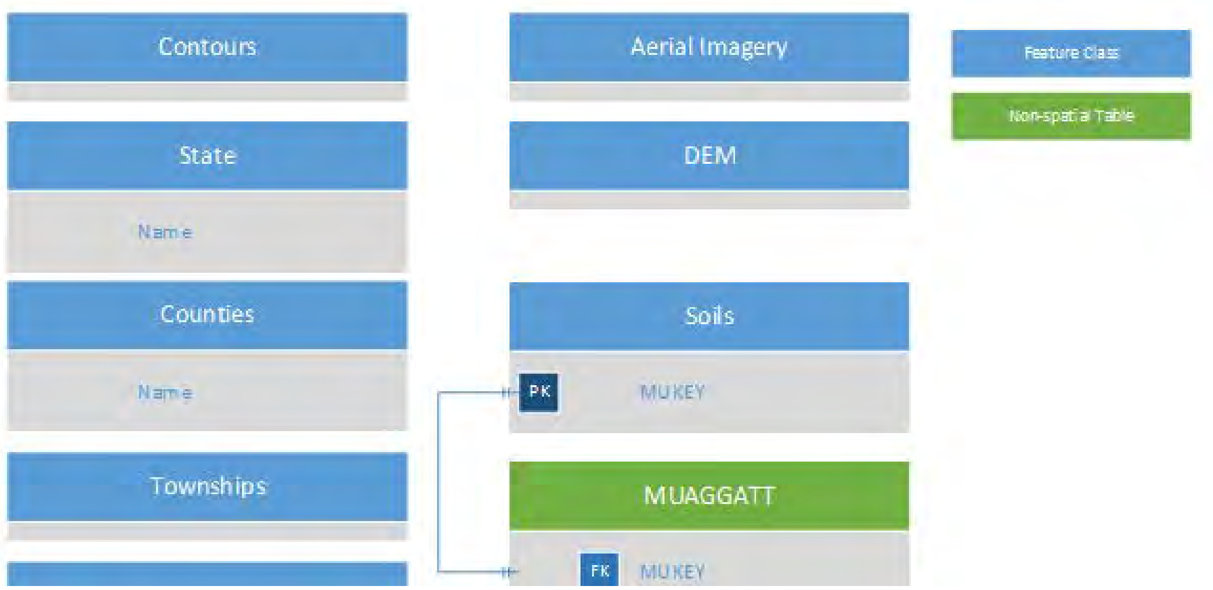
The value of lost nutrients in the top once-inch of soil are accumulated as follows:

- 5.3 lbs of nitrogen/ton of eroded topsoil
- 1.5 lbs of P_2O_5/ton of eroded topsoil
- 3.8 lbs of K_2O/ton of eroded topsoil

Economic values for the following are updated periodically and can be over-ridden by user-entered values. The economic figures are accumulated over a multi-year time frame to demonstrate the cumulative economic impact of lost top soil.

- Corn: $/bushel
- Nitrogen: $/lb (current default value= $.47/lb)
- Phsophate: $/lb (current default value= $.48/lb)
- Potash: $/lb (current default value= $.41/lb)

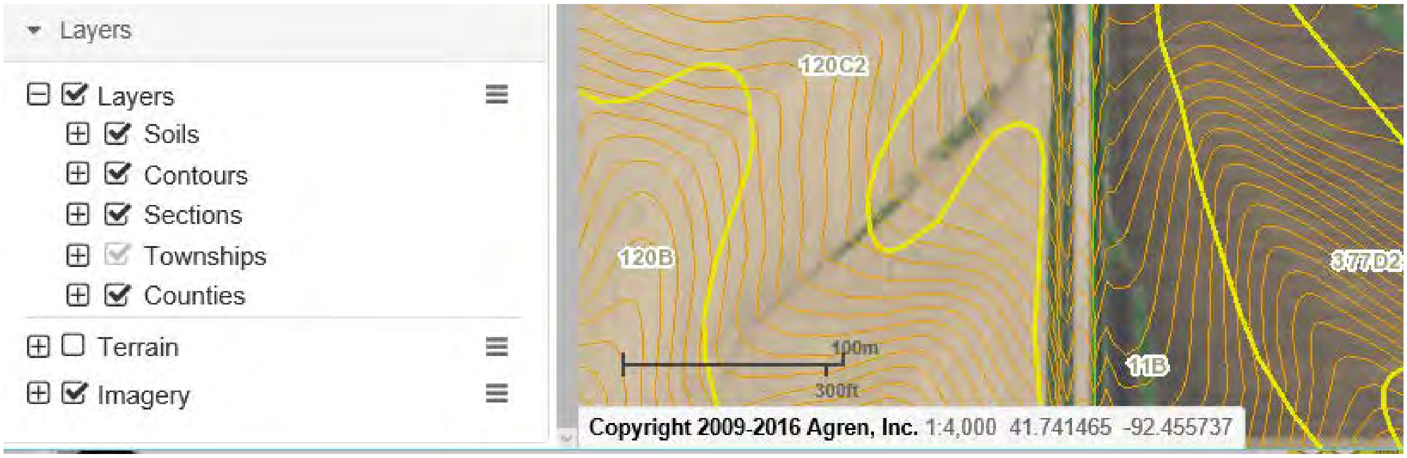
3.3 Data Model Diagram



3.3.1 GIS Data

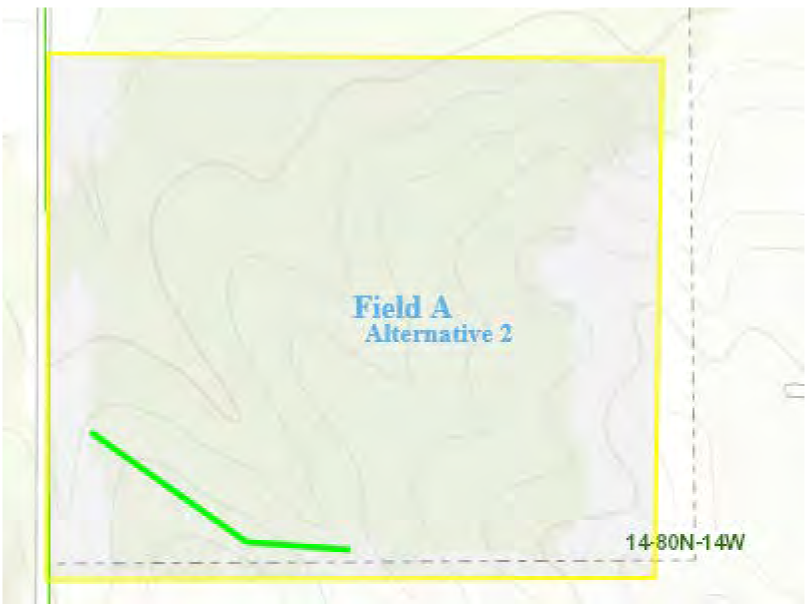
3.3.1.1 Layers Table

Layers (Table of Content) and layers display in Map as shown in SoilCalculator tool



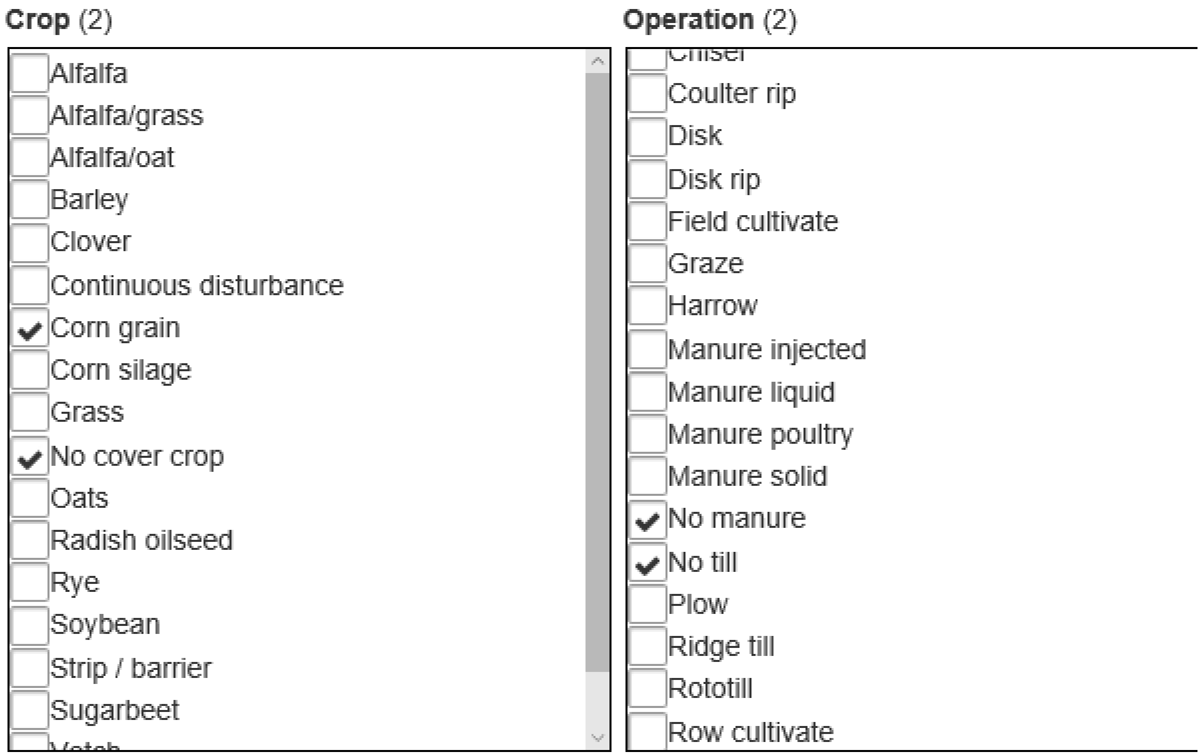
3.3.1.2 Spatial Data Created by SoilCalculator Tool:

The tool will create spatial data on the fly when doing the job. The following is the field boundary (a polygon feature) and a Terrace line (a line feature created by the tool for calculation). These tool created spatial data can be saved for future use.



3.3.2 Tabular Data (Non-Spatial)

3.3.2.1 Crop Rotation Management Selections Search Tool



3.3.2.2 Soil data for RUSLE2

SSURGO Column Label	RUSLE2 Parameter Name	SSURGO column name	Type	NA Ur
The following RUSLE2 parameters are created from SSURGO values.				
Area Symbol	NASIS_SASYM	areasymbol	String	-
Mapunit Symbol	NASIS_MUSYM	musym	String	-
Slope Length USLE – Representative Value	TYPICAL_LENGTH	slopelenusle_r	Float	mete
Slope Gradient - Representative Value	TYPICAL_STEEPNESS	slope_r	Float	%
T	SOIL_T_VALUE	tfact	Float	ton/a
Hydrologic Group	TILED_HYDROLOGIC_CLASS	hydgrp	String	-
Hydrologic Group	HYDROLOGIC_CLASS	hydgrp	String	-
Geomorphic Description	SOIL_DESCRIP	geomdesc	String	-
OM - Representative Value	NASIS_OM_REP_HOR_1	om_r	Float	%
OM - Representative Value	ORGANIC_MATTER	om_r	Float	%
pH H2O - Representative Value	NASIS_PH_1TO1_H20_REP_HOR_1	ph1to1h2o_r	Float	U_PI
Kf	ERODIBILITY	kffact	Float	U_EI
Kf	ERODIBILITY_HAND	kffact	Float	U_EI
Total Sand - Representative Value	SAND	sandtotal_r	Float	%
Total Silt - Representative Value	SILT	silttotal_r	Float	%
Total Clay - Representative Value	CLAY	claytotal_r	Float	%
CEC-7 - Representative Value	NASIS_CEC_7	cec7_r	Float	meq/
0.33 bar H2O - Representative Value	NASIS_WATER_CONTENT_THIRD_BAR	wthirdbar_r	Float	%
15 bar H2O - Representative Value	NASIS_WATER_CONTENT_15_BAR	wfifteenbar_r	Float	%

4 METADATA DESCRIPTION

4.1 SSURGO SOIL DATA

The SSURGO metadata is used to generate the filename string for the corresponding RUSLE2 soil. The full logic generates a string pair (path-name, file-name). We only describe the values used to generate the file-name part, since that is the current procedure.

Long-term this will be replaced with logic which uses the composite key (AREASYMBOL, MUSYM). The AREASYMBOL is a unique id associated with each county from its FIPS 2-letter state id and 3-digit county id. For example Adair County, Iowa has an AREASYMBOL value of “IA001”. The map unit symbol (MUSYM) is a unique id only within a county, which is why we have to use the pair as a composite key. Each soil map unit also has a database key MUKEY, which is an arbitrary integer which is not stable over time.

One reason this change is required is that there may actually be several RUSLE2 soils generated for each map unit, one for each component. We select a single representative soil to assign to this map unit by an external process.

The full SSURGO database schema is documented by the NRCS. See NRCS - SSURGO/STATSGO2 Structural Metadata and Documentation. SSURGO parameters used by RUSLE2 are document in section 5.2.1.

4.2 RUSLE2 Soil Data

The soil data used by the RUSLE2 model is described in detail by the RUSLE2 User Reference Guide and the RUSLE2 Science Documentation, available from the ARS RUSLE2 Documentation page.

Here we document RUSLE2 parameters and how they derive from the values in SSURGO. There are additional SSURGO parameters used which are not stored as parameters, documented in the next section. This list also omits some parameters not used by the RUSLE2 model in calculations.

There are also a few parameters imported for informational purposes only but not used by the RUSLE2 model. Examples are NASIS_SASYM (areasymbol), NASIS_MUSYM (musym), TYPICAL_LENGTH (slopelenusle_r), TYPICAL_STEEPNESS (slope_r), where the RUSLE2 parameter is listed first.

In the tables of parameters below:

- The "Type" column represents the type in RUSLE2, not necessarily the type in SSURGO. In particular, representative values in SSURGO tend to be integers, but in RUSLE2 they are floats.
- All defaults for missing values are given in SSURGO units.

4.2.1 Imported SSURGO Parameters

SSURGO Column Label	RUSLE2 Parameter Name	SSURGO column	Type	SSURGO Units	Value If Missing
T	SOIL_T_VALUE	tfact	Float	ton/ac-yr	3
Hydrologic Group	TILED_HYDROLOGIC_CLASS	hydgrp	String	-	(mod-high)
Hydrologic Group	HYDROLOGIC_CLASS	hydgrp	String	-	(mod-high)
Geomorphic Description	SOIL_DESCRIP	geomdesc	String	-	
OM - Representative Value	ORGANIC_MATTER	om_r	Float	%	2.5
pH H2O - Representative Value	NASIS_PH_1TO1_H20_REP_HOR_1	ph1to1h2o_r	Float	pH	NaN
Kf	ERODIBILITY	kffact	Float	-	3.5
Total Sand - Representative Value	SAND	sandtotal_r	Float	%	41 (loam)
Total Silt - Representative Value	SILT	silttotal_r	Float	%	41 (loam)
Total Clay - Representative Value	CLAY	claytotal_r	Float	%	18 (loam)

The following parameters were added on 2010-04-17.

SSURGO Column Label	RUSLE2 Parameter Name	SSURGO column	Type	SSURGO Units	Value If Missing
CEC-7 - Representative Value	NASIS_CEC_7	cec7_r	Float	meq/100g	NaN
0.33 bar H2O - Representative Value	NASIS_WATER_CONTENT_THIRD_BAR	wthirdbar_r	Float	%	NaN
15 bar H2O - Representative Value	NASIS_WATER_CONTENT_15_BAR	wfifteenbar_r	Float	%	NaN
Db 0.33 bar H2O – Representative Value	NASIS_BULK_DENSITY_THIRD_BAR	dbthirdbar_r	Float	g/cm3	1.35

4.2.2 Parameters Used to Generate RUSLE2 Soil Names

There are a large number of SSURGO values which are used in the query to build and import the RUSLE2 soil file, which do not end up as RUSLE2 parameters in that file.

SSURGO Column Label	SSURGO name	Type	SSURGO Units	Required in SSURGO	If Missing	Notes
Area Name	Areaname	String	-	YES		Used for folder name
Chorizon Key	Chkey	String	-	YES		Used only in queries
Chorizon Texture Group Key	Chtgkey	String	-	YES		Used only in queries
Component Key	Cokey	String	-	YES		Used only in queries
Kind	Compkind	Choice	-			Used to exclude "Miscellaneous area" records.
Component Name	Compname	String	-	YES		Used for file name
Comp % - Representative Value	comppct_r	Float	%	(See Notes)	(skip record)	Used for file name. Either majcompflag or comppct_r must be populated
Top Depth - Representative Value	hzdept_r	Integer	cm	YES		Used to order horizons. RUSLE2 takes only the top horizon that meets its criteria.
In Lieu	Lieutex	Choice	-			Used to identify organic soils
Local Phase	Localphase	String	-	YES		Used for file name

Major Component	Majcompflag	Boolean	-	(See Notes)		Either majcompflag or comppct_r must be populated
Mapunit Key	Mukey	Integer	-	YES		Used only in queries
Mapunit Name	Muname	String	-	YES		Used for folder name
Mapunit Symbol	Musym	String	-	YES		Used for folder name
Order	Taxorder	Choice	-			Used to identify histosols. Value "Histosols" is a histosol.
Subgroup	Taxsubgrp	Choice	-			Used to identify histosols. Value "Histic" is a histosol.
Texture Description	Texdesc	String	-	YES		Used for file name

RUSLE2 soil filenames are currently algorithmically generated as follows. All names in brackets are SSURGO column names listed above.

rusle2_fullname = "soils\\" + <areaname> + "\\" + mu_folder_name + "\\" + full_component_name;

mu_folder_name = <musym> + " " + <muname>;

full_component_name = <compname> + " " + <texdesc> + " " + <localphase> + " " + <comppct_r> + "%";

This filename mapping is somewhat arbitrary. This is just how it has been done historically for the SSURGO data. The real requirement is that we be able to create a unique string key for each soil record in the database which can be expressed as a path.

4.3 RUSLE2 Climate Data

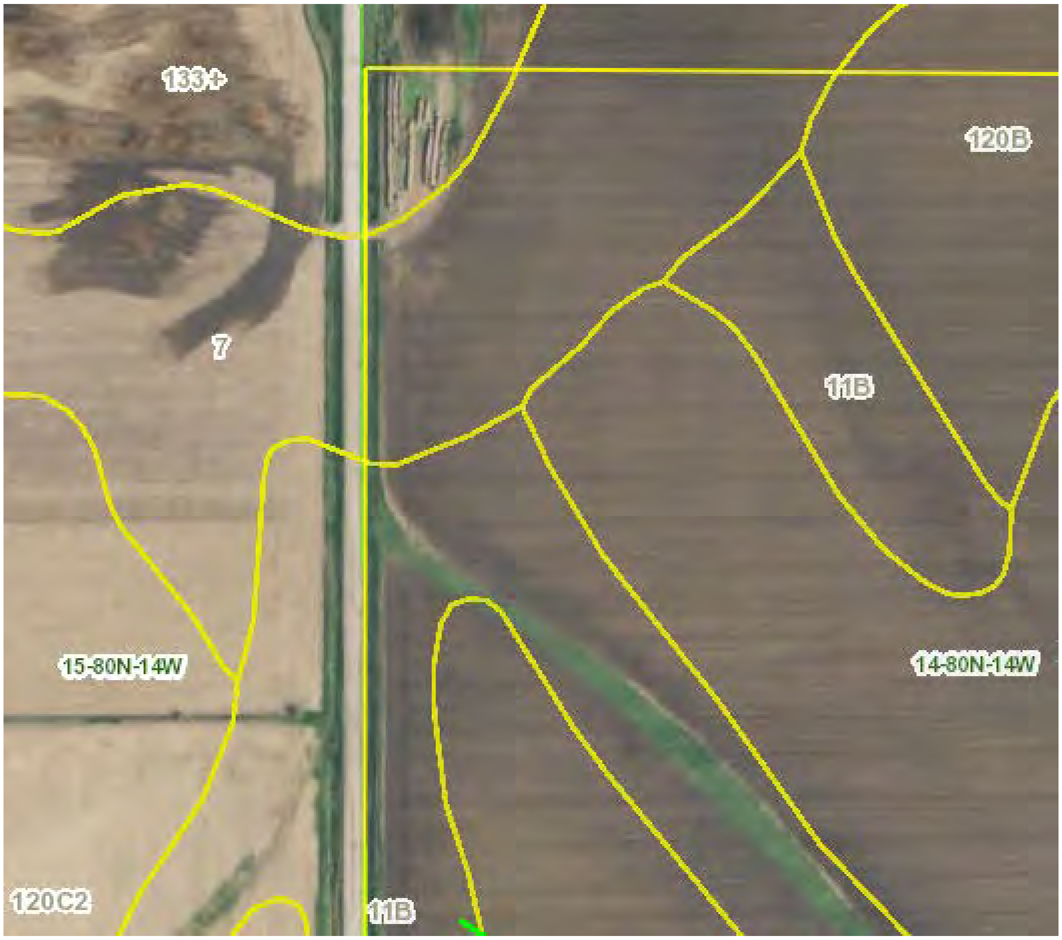
The climate data used by the RUSLE2 model is described in detail by the RUSLE2 User Reference Guide and the RUSLE2 Science Documentation, available from the ARS RUSLE2 Documentation page.

RUSLE2 climate data generally represents average values from 30-40 years of historical data. Preparing some values requires understanding the RUSLE2 model. There are values such as EI (Erosivity Intensity) which must be entered correctly for the RUSLE2 model to work as expected.

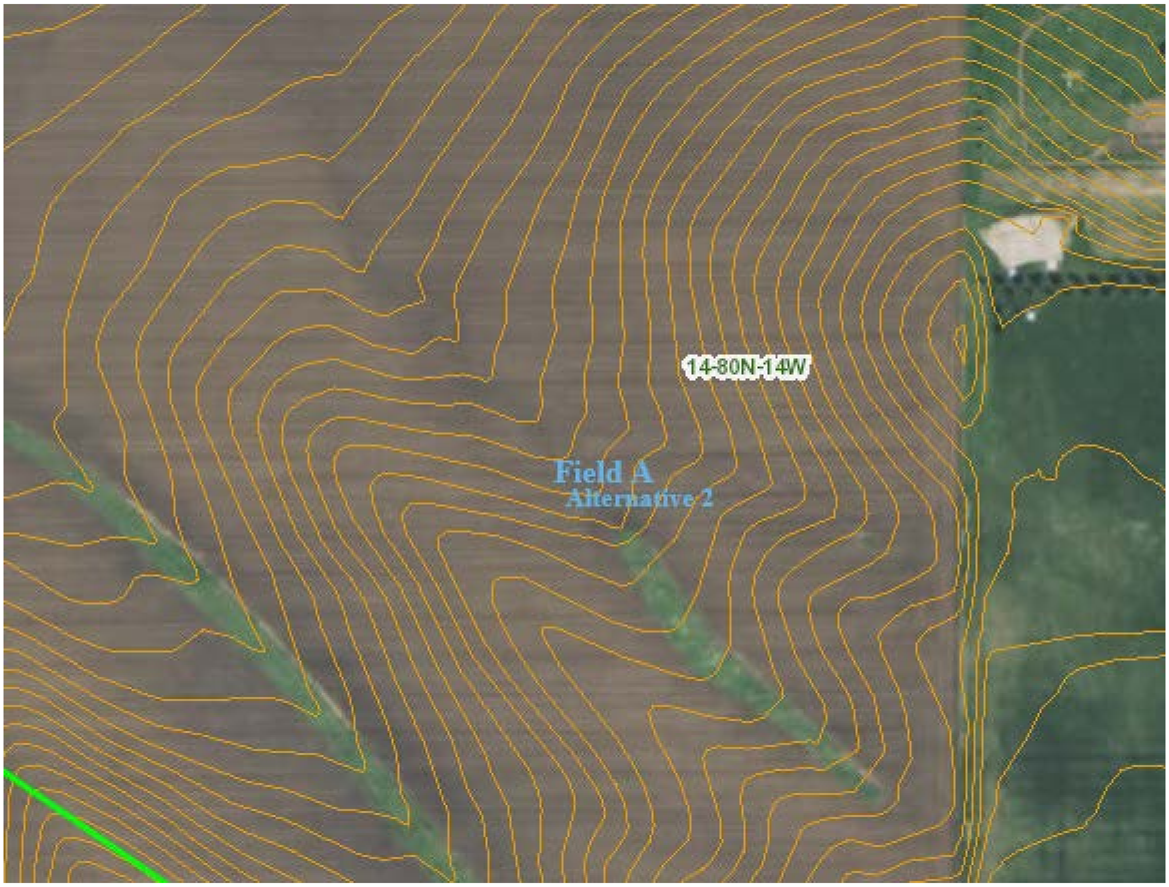
5 Examples

5.1 GIS Data

5.1.1 Soil Polygon



5.1.2 Contours

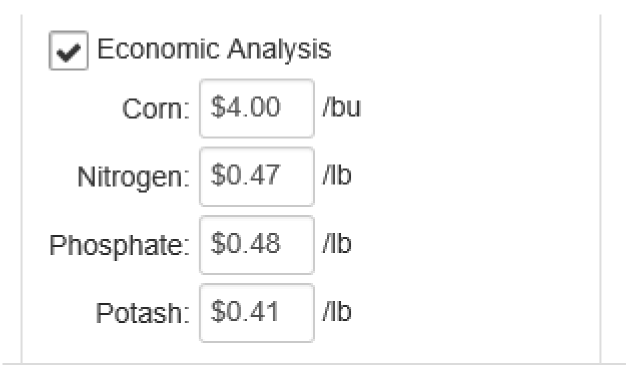


5.1.3 DEM (Terrain)

5.1.4 Aerial Imagery

5.2 TABULAR DATA

5.2.1 Economic Data



Economic result by the tool based on the above data and crop rotation management input.

Alternative 1

Year	Cumulative Yield Loss/Acre	+	Cumulative Nutrient Loss/Acre	=	Total Yield & Nutrient Loss/Acre	x acres	My Total Cumulative Erosion Cost
1	$0.30		$20.03		$20.34		$1,283.50
3	$1.83		$60.10		$61.92		$3,908.08
5	$4.56		$100.17		$104.73		$6,609.45
10	$16.73		$200.33		$217.06		$13,698.81
20	$63.88		$400.67		$464.54		$29,317.22

0.26" of top soil will be lost every ten years under Alternative 1 totaling approximately $13,699 in lost yield and nutrients.

Alternative 2

Year	Cumulative Yield Loss/Acre	+	Cumulative Nutrient Loss/Acre	=	Total Yield & Nutrient Loss/Acre	x acres	My Total Cumulative Erosion Cost
1	$0.28		$18.33		$18.61		$1,174.29
3	$1.67		$54.99		$56.66		$3,575.56
5	$4.17		$91.64		$95.82		$6,047.08
10	$15.31		$183.29		$198.59		$12,533.22
20	$58.44		$366.57		$425.02		$26,822.72

0.24" of top soil will be lost every ten years under Alternative 2 totaling approximately $12,533 in lost yield and nutrients.

Appendix 2: Examples of Soil Savings Reports

SoilCalculator®

SOIL SAVINGS PLAN

Client:
Farm:
Location: Waterloo County, ON

Field		Hectares
Field A	--	17.24

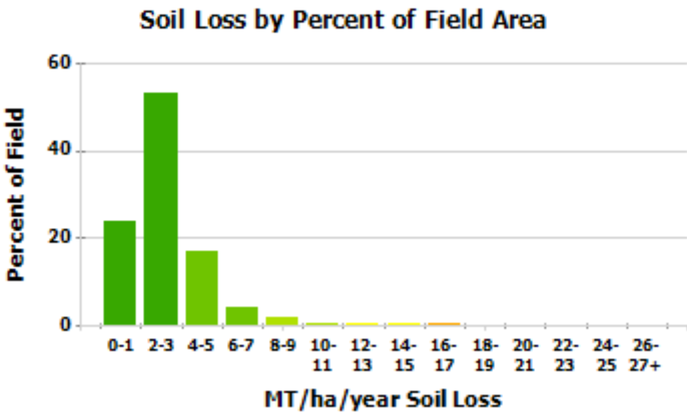
Soil Savings Summary

	Alternative 1	Alternative 2	Alternative 3
Crop rotation and operations	Continuous Soybeans	Conventional CBWw	NotillCBWw
Supporting practices	none	none	none
1 year soil loss (metric tonnes/ha)			
Field average	2.4 metric ton	1.5 metric ton	0.1 metric ton
Top 20% most erodible average	5.4 metric ton	3.3 metric ton	0.2 metric ton
10 year soil loss (cm)			
Field average	0.46 cm	0.29 cm	0.02 cm
Top 20% most erodible average	1.02 cm	0.62 cm	0.04 cm

Calculated Soil Loss

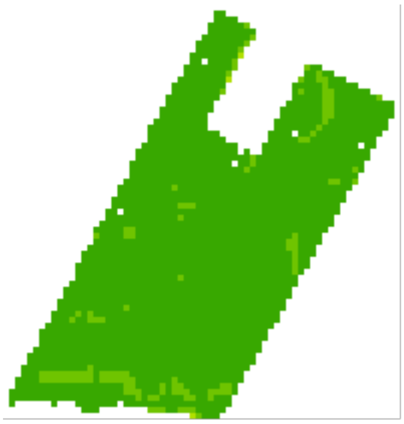
Alternative 1

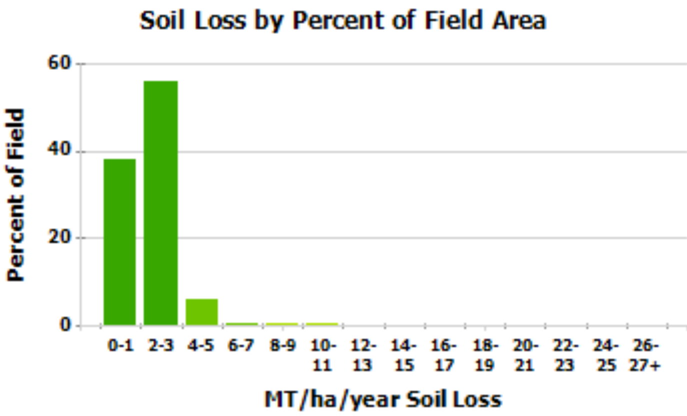
40.0 metric ton/yr annual soil loss



Alternative 2

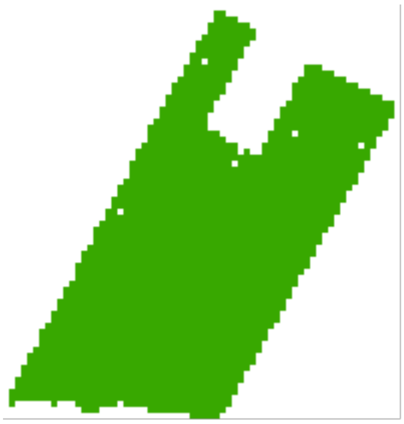
24.9 metric ton/yr annual soil loss

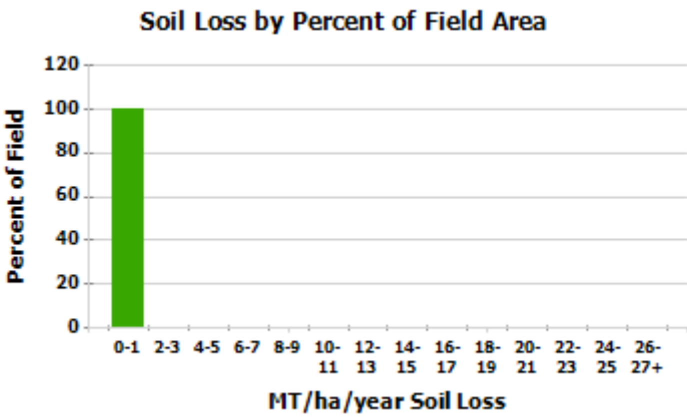




Alternative 3

1.9 metric ton/yr annual soil loss





Economic Impact

(Reported in USD)

Inputs: Corn: $4.00/bu
Nitrogen: $0.47/lb
Phosphate: $0.48/lb
Potash: $0.41/lb

Alternative 1

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.19		$12.71		$12.90		$222.44
3	$1.16		$38.13		$39.29		$677.32
5	$2.89		$63.55		$66.44		$1,145.49
10	$10.61		$127.10		$137.71		$2,374.16
20	$40.52		$254.20		$294.72		$5,081.01

0.46 cm of top soil will be lost every ten years under Alternative 1 totaling approximately $2,374 in lost yield and nutrients.

Alternative 2

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.12		$7.90		$8.02		$138.22
3	$0.72		$23.69		$24.41		$420.85
5	$1.80		$39.49		$41.29		$711.76
10	$6.59		$78.97		$85.57		$1,475.20
20	$25.18		$157.95		$183.13		$3,157.11

0.29 cm of top soil will be lost every ten years under Alternative 2 totaling approximately $1,475 in lost yield and nutrients.

Alternative 3

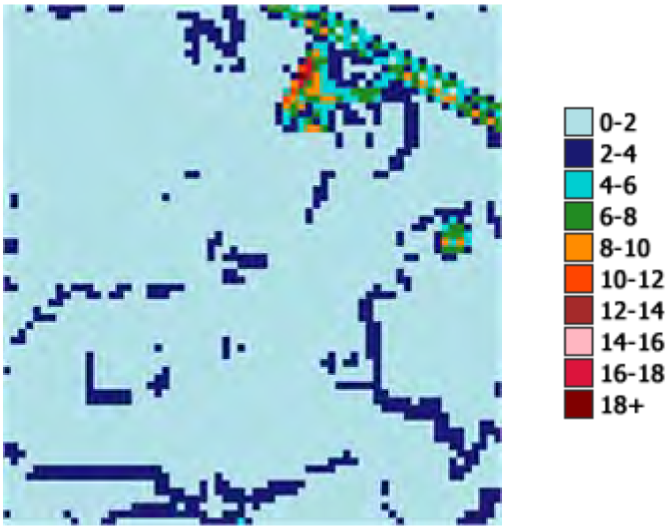
Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.01		$0.60		$0.61		$10.57
3	$0.06		$1.81		$1.87		$32.19
5	$0.14		$3.02		$3.16		$54.44
10	$0.50		$6.04		$6.54		$112.83
20	$1.93		$12.08		$14.01		$241.46

0.02 cm of top soil will be lost every ten years under Alternative 3 totaling approximately $113 in lost yield and nutrients.

Slope & Soils Summary

Slope Steepness

% Slope



Soils

Soil Map Unit (SMU)	Map Unit Name	Hectares	Area	Slope Steepness
ca08-onond347t	TAVISTOCK LOAM	2.03	12 %	1.35 %
ca08-onond347p	PERTH LOAM	14.63	88 %	0.8 %
		17.24	**100%**	

Disclaimer

Id: 9689074637764d6c82918aba82d9f413
Application: 28
Service: 1.0.6192.26995
Rome: 2.5.2.20
R2Dp: 3.12.1.0

Field A - Alternative 1

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Plow, moldboard			
5/5/2	disk, tandem light finishing			
5/15/2	Cultivator, field 6-12 in sweeps			
5/15/2	Sprayer, pre-emergence			
5/15/2	planter, double disk opnr	Soybean, mw 30 in rows	40	
6/28/2	Sprayer, post emergence			0
8/1/2	Sprayer, insecticide post emergence			
10/10/2	Harvest, killing crop 20pct standing stubble			866

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 2

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
11/3/1	Plow, moldboard			
4/28/2	Cultivator, field 6-12 in sweeps			
5/1/2	Planter, double disk opnr	Corn, grain	170	
5/3/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136
11/1/2	Plow, moldboard			
5/5/3	disk, tandem light finishing			
5/15/3	Cultivator, field 6-12 in sweeps			
5/15/3	Sprayer, pre-emergence			
5/15/3	planter, double disk opnr	Soybean, mw 30 in rows	40	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			866
10/11/3	Fert applic. surface broadcast			
10/11/3	Disk, tandem heavy primary op.			
10/12/3	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	80	
4/16/4	Fert applic. surface broadcast			
7/26/4	Harvest, killing crop 50pct standing stubble			2040
7/31/4	Bale straw or residue			

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 3

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
5/1/2	Planter, double disk opnr w/fluted coulter	Corn, grain	170	
5/1/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136
5/15/3	Sprayer, pre-emergence			
5/15/3	Planter, double disk opnr w/fluted coulter	Soybean, mw 30 in rows	40	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			866
10/11/3	Fert applic. surface broadcast			
10/11/3	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	80	
4/15/4	Fert applic. surface broadcast			
7/25/4	Harvest, killing crop 50pct standing stubble			2040

Supporting Conservation Practices

Practice	Area	Other Notes
None		

SoilCalculator®

SOIL SAVINGS PLAN

Client:
Farm:
Location: Wellington County, ON

Field		Hectares
Field A	--	37.5

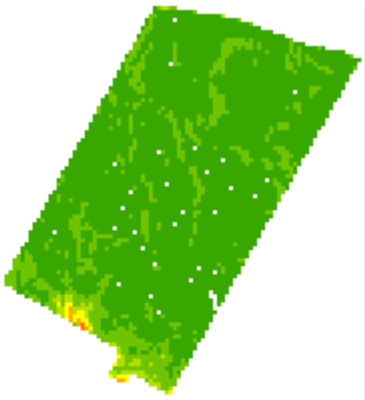
Soil Savings Summary

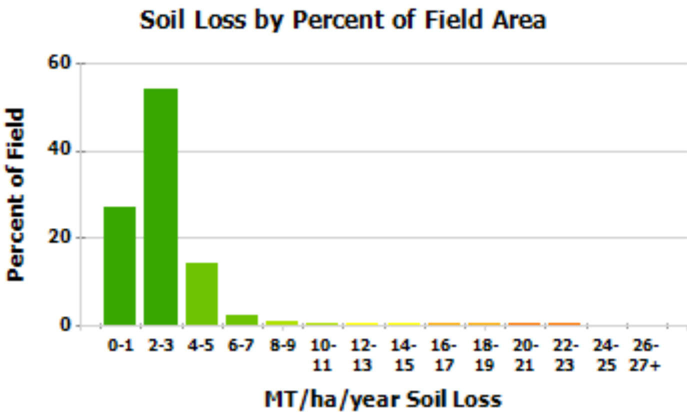
	Alternative 1	Alternative 2	Alternative 3
Crop rotation and operations	Conventional CBWw	CCBuAlfAlfAlf	NotillCBWw
Supporting practices	none	none	none
1 year soil loss (metric tonnes/ha)			
Field average	2.3 metric ton	1.4 metric ton	0.1 metric ton
Top 20% most erodible average	5.2 metric ton	3.1 metric ton	0.2 metric ton
10 year soil loss (cm)			
Field average	0.43 cm	0.26 cm	0.02 cm
Top 20% most erodible average	0.99 cm	0.59 cm	0.04 cm

Calculated Soil Loss

Alternative 1

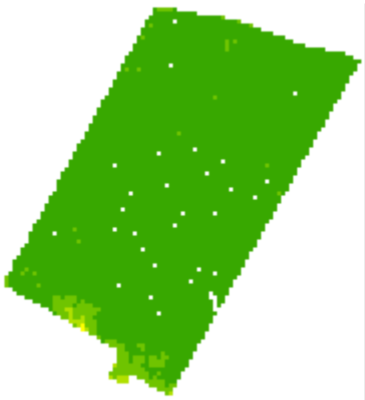
81.4 metric ton/yr annual soil loss

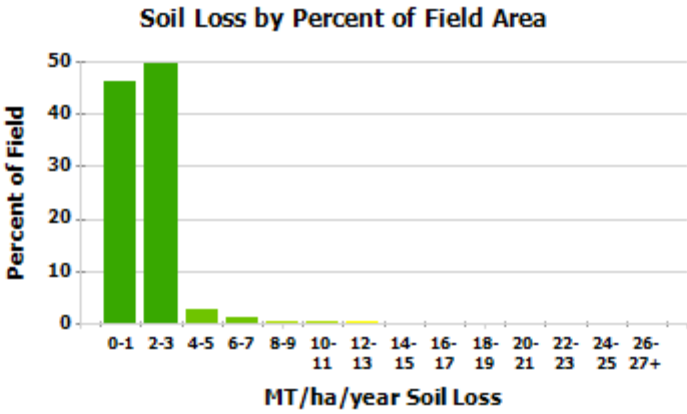




Alternative 2

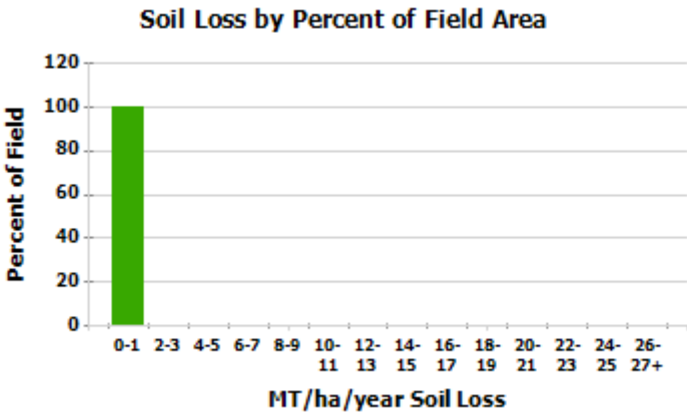
49.0 metric ton/yr annual soil loss





Alternative 3

4.2 metric ton/yr annual soil loss



Economic Impact

(Reported in USD)

Inputs: Corn: $4.00/bu
Nitrogen: $0.47/lb
Phosphate: $0.48/lb
Potash: $0.41/lb

Alternative 1

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.18		$11.87		$12.06		$452.07
3	$1.08		$35.62		$36.71		$1,376.49
5	$2.70		$59.37		$62.08		$2,327.96
10	$9.92		$118.75		$128.67		$4,824.94
20	$37.86		$237.50		$275.36		$10,326.00

0.43 cm of top soil will be lost every ten years under Alternative 1 totaling approximately $4,825 in lost yield and nutrients.

Alternative 2

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.11		$7.15		$7.26		$272.28
3	$0.65		$21.46		$22.11		$829.07
5	$1.63		$35.76		$37.39		$1,402.15
10	$5.97		$71.52		$77.50		$2,906.10
20	$22.80		$143.05		$165.85		$6,219.43

0.26 cm of top soil will be lost every ten years under Alternative 2 totaling approximately $2,906 in lost yield and nutrients.

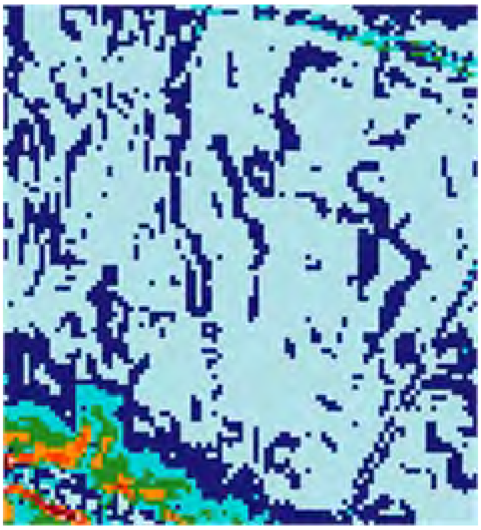
Alternative 3

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.01		$0.62		$0.63		$23.44
3	$0.06		$1.85		$1.90		$71.37
5	$0.14		$3.08		$3.22		$120.70
10	$0.51		$6.16		$6.67		$250.16
20	$1.96		$12.31		$14.28		$535.37

0.02 cm of top soil will be lost every ten years under Alternative 3 totaling approximately $250 in lost yield and nutrients.

Slope & Soils Summary

Slope Steepness



% Slope

- 0-2
- 2-4
- 4-6
- 6-8
- 8-10
- 10-12
- 12-14
- 14-16
- 16-18
- 18+

Soils

Soil Map Unit (SMU)	Map Unit Name	Hectares	Area	Slope Steepness
ca08-onond002p	PERTH LOAM	35.72	98 %	1.23 %
ca08-onond002h	HURON LOAM	0.66	2 %	1.31 %
		37.5	**100%**	

Disclaimer

Id: 70610c6926aa46f78dfe5d63fe13fc50
Application: 28
Service: 1.0.6192.26995
Rome: 2.5.2.20
R2Dp: 3.12.1.0

Field A - Alternative 1

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
11/3/1	Plow, moldboard			
4/28/2	Cultivator, field 6-12 in sweeps			
5/1/2	Planter, double disk opnr	Corn, grain	170	
5/3/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136
11/1/2	Plow, moldboard			
5/5/3	disk, tandem light finishing			
5/15/3	Cultivator, field 6-12 in sweeps			
5/15/3	Sprayer, pre-emergence			
5/15/3	planter, double disk opnr	Soybean, mw 30 in rows	40	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			866
10/11/3	Fert applic. surface broadcast			
10/11/3	Disk, tandem heavy primary op.			
10/12/3	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	80	
4/16/4	Fert applic. surface broadcast			
7/26/4	Harvest, killing crop 50pct standing stubble			2040
7/31/4	Bale straw or residue			

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 2

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
11/3/1	Plow, moldboard			
4/27/2	Fert applic. surface broadcast			
4/28/2	Cultivator, field 6-12 in sweeps			
5/1/2	Planter, double disk opnr	Corn, grain	180	
5/3/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
10/20/2	Harvest, killing crop 50pct standing stubble			3136
11/1/2	Fert applic. surface broadcast			
11/3/2	Plow, moldboard			
4/27/3	Fert applic. surface broadcast			
4/28/3	Cultivator, field 6-12 in sweeps			
5/1/3	Planter, double disk opnr	Corn, grain	180	
5/3/3	Sprayer, pre-emergence			
6/7/3	Sprayer, post emergence and fert. tank mix			250
10/20/3	Harvest, killing crop 50pct standing stubble			3136
10/23/4	Plow, moldboard			
5/3/5	Fert applic. surface broadcast			
5/3/5	Cultivator, field 6-12 in sweeps			
5/8/5	Drill or air seeder single disk openers, fert. opnrs 7-10 in spac.	Barley, spring	75	
5/14/5	Fert applic. surface broadcast			
6/2/5	Sprayer, post emergence			250
8/2/5	Harvest, killing crop 50pct standing stubble			1980
8/7/5	Bale straw or residue			
6/25/6	Harvest, hay, legume	Alfalfa, yr2 regrowth after cutting	1.5	608
8/12/6	Harvest, hay, legume	Alfalfa, yr2 senes to yr3 regrowth	2.25	405
6/25/7	Harvest, hay, legume	Alfalfa, yr3 regrowth after cutting	1.7	675
8/12/7	Harvest, hay, legume	Alfalfa, yr3 senes to yr4 regrowth	2.5	459
6/25/8	Harvest, hay, legume	Alfalfa, yr4 regrowth after cutting	1.75	540
8/12/8	Harvest, hay, legume	Alfalfa, yr4 senes to yr5 regrowth	2	472

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 3

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
5/1/2	Planter, double disk opnr w/fluted coulter	Corn, grain	170	
5/1/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136
5/15/3	Sprayer, pre-emergence			
5/15/3	Planter, double disk opnr w/fluted coulter	Soybean, mw 30 in rows	40	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			866
10/11/3	Fert applic. surface broadcast			
10/11/3	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	80	
4/15/4	Fert applic. surface broadcast			
7/25/4	Harvest, killing crop 50pct standing stubble			2040

Supporting Conservation Practices

Practice	Area	Other Notes
None		

SoilCalculator®

SOIL SAVINGS PLAN

Client:
Farm:
Location: Waterloo County, ON

Field		Hectares
Field A	--	14.9

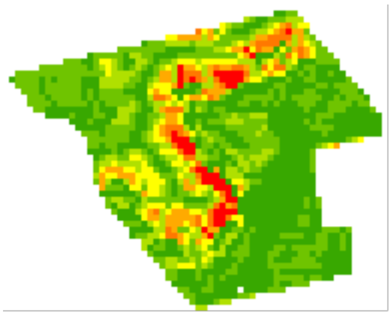
Soil Savings Summary

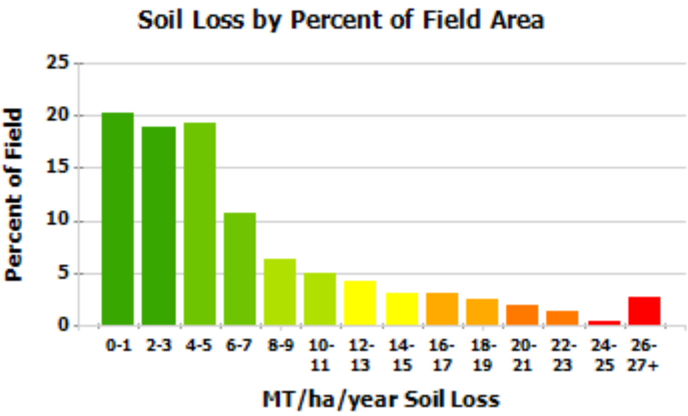
	Alternative 1	Alternative 2	Alternative 3
Crop rotation and operations	conv gr corn	NT grain corn	CBW plow corn
Supporting practices	none	none	none
1 year soil loss (metric tonnes/ha)			
Field average	7.0 metric ton	0.1 metric ton	6.2 metric ton
Top 20% most erodible average	19.6 metric ton	0.3 metric ton	17.4 metric ton
10 year soil loss (cm)			
Field average	1.34 cm	0.03 cm	1.17 cm
Top 20% most erodible average	3.74 cm	0.05 cm	3.31 cm

Calculated Soil Loss

Alternative 1

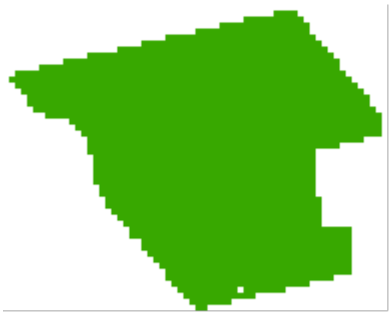
102.6 metric ton/yr annual soil loss

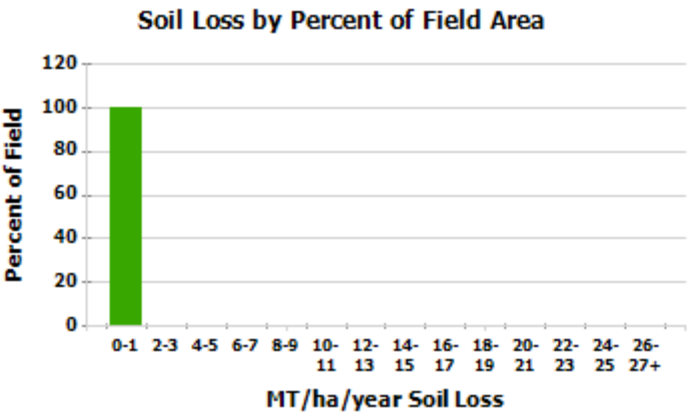




Alternative 2

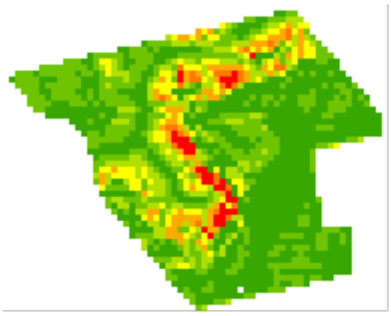
1.9 metric ton/yr annual soil loss

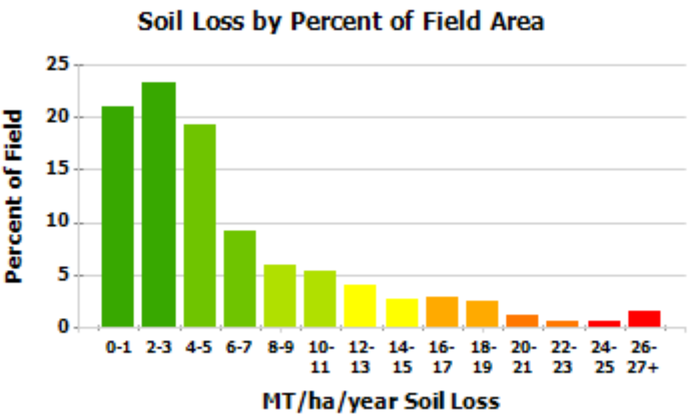




Alternative 3

90.1 metric ton/yr annual soil loss





Economic Impact

(Reported in USD)

Inputs: Corn: $4.00/bu
Nitrogen: $0.47/lb
Phosphate: $0.48/lb
Potash: $0.41/lb

Alternative 1

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.56		$37.05		$37.61		$560.39
3	$3.37		$111.14		$114.52		$1,706.31
5	$8.44		$185.24		$193.67		$2,885.75
10	$30.94		$370.47		$401.41		$5,981.03
20	$118.12		$740.95		$859.07		$12,800.17

1.34 cm of top soil will be lost every ten years under Alternative 1 totaling approximately $5,981 in lost yield and nutrients.

Alternative 2

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.01		$0.70		$0.71		$10.55
3	$0.06		$2.09		$2.16		$32.13
5	$0.16		$3.49		$3.65		$54.35
10	$0.58		$6.98		$7.56		$112.64
20	$2.22		$13.95		$16.18		$241.06

0.03 cm of top soil will be lost every ten years under Alternative 2 totaling approximately $113 in lost yield and nutrients.

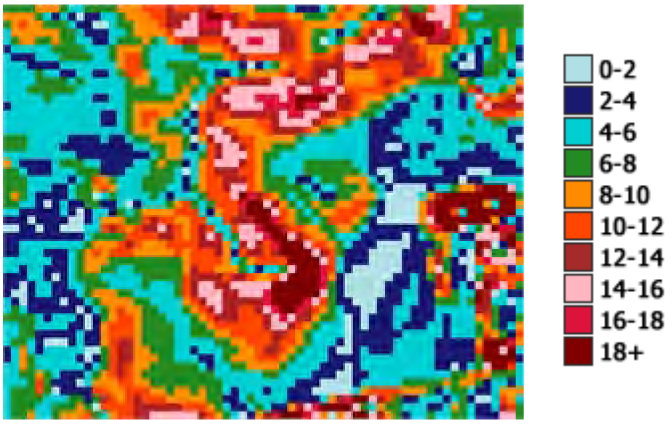
Alternative 3

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.49		$32.55		$33.05		$492.42
3	$2.97		$97.66		$100.63		$1,499.37
5	$7.41		$162.77		$170.19		$2,535.77
10	$27.19		$325.54		$352.73		$5,255.66
20	$103.80		$651.09		$754.89		$11,247.79

1.17 cm of top soil will be lost every ten years under Alternative 3 totaling approximately $5,256 in lost yield and nutrients.

Slope & Soils Summary

Slope Steepness



Soils

Soil Map Unit (SMU)	Map Unit Name	Hectares	Area	Slope Steepness
ca08-onond347f	FOX SANDY LOAM	0.06	0 %	5.25 %
ca08-onond347f	FOX SANDY LOAM	1.28	9 %	3.71 %
ca08-onond347h	HEIDELBERG FINE SANDY LOAM	4.2	29 %	5.21 %
ca08-onond347f	FOX SANDY LOAM	9.06	62 %	8.87 %
		14.9	**100%**	

Disclaimer

Id: ef232892c11a41df8ef156daec462461
Application: 28
Service: 1.0.6192.26995
Rome: 2.5.2.20
R2Dp: 3.12.1.0

The content and products associated with Agren® SoilCalculator® are provided to you on an “as-is” and “as available” basis. Agren, Inc. makes no representations or warranties of any kind, express or implied, as to the operation of Agren SoilCalculator or the information, estimates, content, materials, products or services included on or associated with Agren SoilCalculator. You expressly agree that your use of Agren SoilCalculator and all products and services included on or associated with Agren SoilCalculator are at your sole risk.

Agren, Inc. does not make any representations, warranties or guarantees express or implied, regarding the accuracy, correctness, or completeness of the content of Agren SoilCalculator, nor the safety, reliability, title, timeliness, completeness, merchantability, conformity, or fitness for a particular purpose of the content of Agren SoilCalculator. It is your sole responsibility to independently evaluate the accuracy, correctness, or completeness of the content of Agren SoilCalculator and estimates produced with Agren SoilCalculator software.
Agren, Inc. makes no representation, warranty, or guarantee that the content is free of infection from any viruses, worms, or other code or computer programming routines that are intended to damage or detrimentally interfere with any system data.

Field A - Alternative 1

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/2	Fert applic. surface broadcast			
11/3/2	Plow, moldboard			
4/28/3	Cultivator, field 6-12 in sweeps			
5/1/3	Planter, double disk opnr	Corn, grain	180	
5/3/3	Sprayer, pre-emergence			
6/7/3	Sprayer, post emergence and fert. tank mix			250
6/10/3	Fert applic. side-dress, liquid			
10/20/3	Harvest, killing crop 50pct standing stubble			3136

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 2

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
5/1/2	Planter, double disk opnr w/fluted coulter	Corn, grain	180	
5/1/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 3

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
11/3/1	Plow, moldboard			
4/27/2	Fert applic. surface broadcast			
4/28/2	Cultivator, field 6-12 in sweeps			
5/1/2	Planter, double disk opnr	Corn, grain	180	
5/3/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
10/20/2	Harvest, killing crop 50pct standing stubble			3136
5/15/3	Sprayer, pre-emergence			
5/15/3	Drill or airseeder, double disk, w/ fluted coulters	Soybean, mw 7in rows	40	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			577
10/12/3	Fert applic. surface broadcast			
10/12/3	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	70	
4/16/4	Fert applic. surface broadcast			
7/26/4	Harvest, killing crop 50pct standing stubble			2040

Supporting Conservation Practices

Practice	Area	Other Notes
None		

SOIL SAVINGS PLAN

Client:
Farm:
Location: Waterloo County, ON

Field		Hectares
Field A	--	14.9

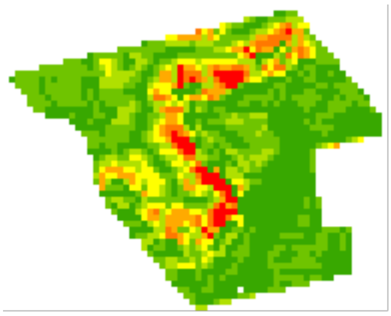
Soil Savings Summary

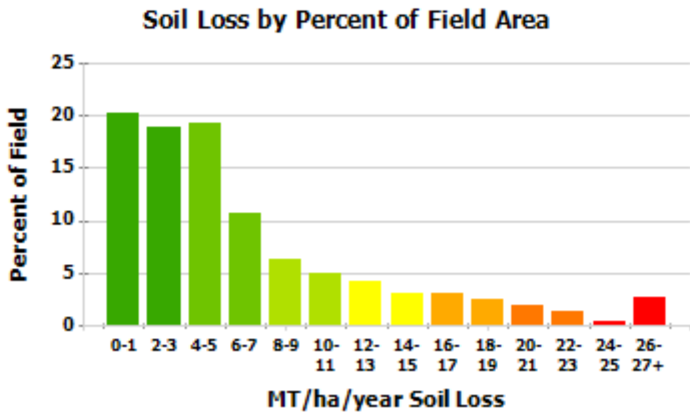
	Alternative 1	Alternative 2	Alternative 3
Crop rotation and operations	conv gr corn	NT grain corn	CBW plow corn
Supporting practices	none	none	none
1 year soil loss (metric tonnes/ha)			
Field average	7.0 metric ton	0.1 metric ton	6.2 metric ton
Top 20% most erodible average	19.6 metric ton	0.3 metric ton	17.4 metric ton
10 year soil loss (cm)			
Field average	1.34 cm	0.03 cm	1.17 cm
Top 20% most erodible average	3.74 cm	0.05 cm	3.31 cm

Calculated Soil Loss

Alternative 1

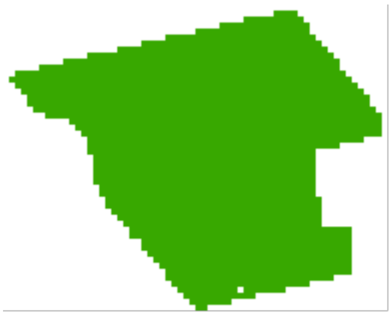
102.6 metric ton/yr annual soil loss

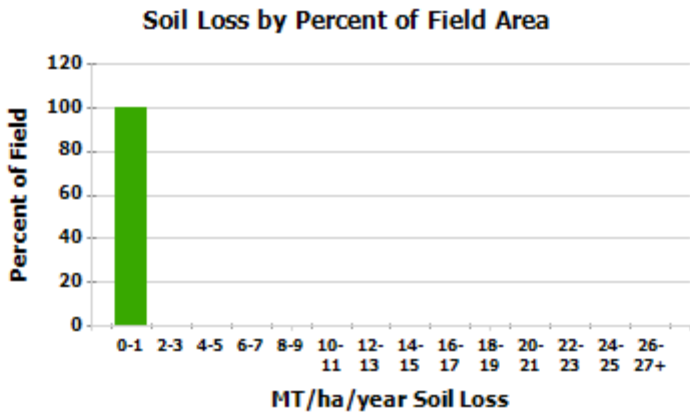




Alternative 2

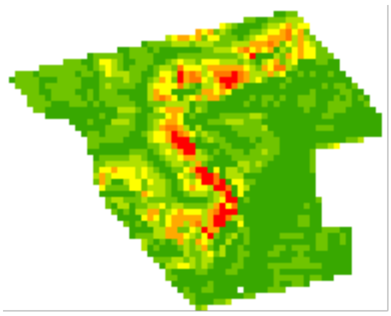
1.9 metric ton/yr annual soil loss

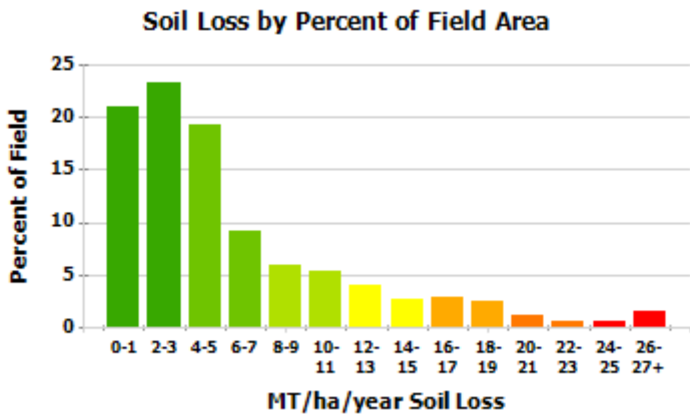




Alternative 3

90.1 metric ton/yr annual soil loss





Economic Impact

(Reported in USD)

Inputs: Corn: $4.00/bu
Nitrogen: $0.47/lb
Phosphate: $0.48/lb
Potash: $0.41/lb

Alternative 1

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.56		$37.05		$37.61		$560.39
3	$3.37		$111.14		$114.52		$1,706.31
5	$8.44		$185.24		$193.67		$2,885.75
10	$30.94		$370.47		$401.41		$5,981.03
20	$118.12		$740.95		$859.07		$12,800.17

1.34 cm of top soil will be lost every ten years under Alternative 1 totaling approximately $5,981 in lost yield and nutrients.

Alternative 2

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.01		$0.70		$0.71		$10.55
3	$0.06		$2.09		$2.16		$32.13
5	$0.16		$3.49		$3.65		$54.35
10	$0.58		$6.98		$7.56		$112.64
20	$2.22		$13.95		$16.18		$241.06

0.03 cm of top soil will be lost every ten years under Alternative 2 totaling approximately $113 in lost yield and nutrients.

Alternative 3

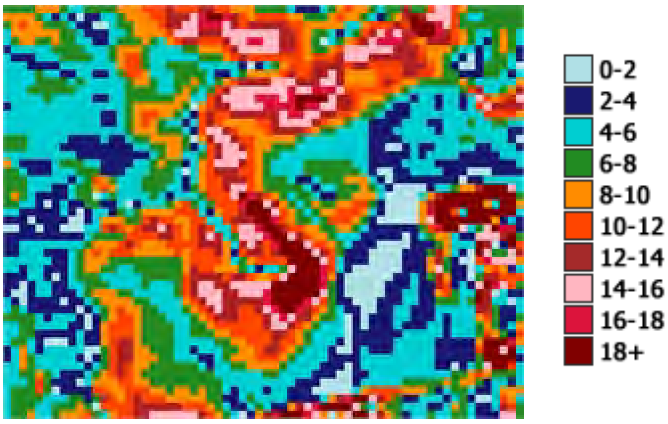
Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.49		$32.55		$33.05		$492.42
3	$2.97		$97.66		$100.63		$1,499.37
5	$7.41		$162.77		$170.19		$2,535.77
10	$27.19		$325.54		$352.73		$5,255.66
20	$103.80		$651.09		$754.89		$11,247.79

1.17 cm of top soil will be lost every ten years under Alternative 3 totaling approximately $5,256 in lost yield and nutrients.

Slope & Soils Summary

Slope Steepness

% Slope



Soils

Soil Map Unit (SMU)	Map Unit Name	Hectares	Area	Slope Steepness
ca08-onond347f	FOX SANDY LOAM	0.06	0 %	5.25 %
ca08-onond347f	FOX SANDY LOAM	1.28	9 %	3.71 %
ca08-onond347h	HEIDELBERG FINE SANDY LOAM	4.2	29 %	5.21 %
ca08-onond347f	FOX SANDY LOAM	9.06	62 %	8.87 %
		14.9	**100%**	

Disclaimer

Id: ef232892c11a41df8ef156daec462461
Application: 28
Service: 1.0.6192.26995
Rome: 2.5.2.20
R2Dp: 3.12.1.0

Field A - Alternative 1

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/2	Fert applic. surface broadcast			
11/3/2	Plow, moldboard			
4/28/3	Cultivator, field 6-12 in sweeps			
5/1/3	Planter, double disk opnr	Corn, grain	180	
5/3/3	Sprayer, pre-emergence			
6/7/3	Sprayer, post emergence and fert. tank mix			250
6/10/3	Fert applic. side-dress, liquid			
10/20/3	Harvest, killing crop 50pct standing stubble			3136

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 2

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
5/1/2	Planter, double disk opnr w/fluted coulter	Corn, grain	180	
5/1/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 3

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
11/3/1	Plow, moldboard			
4/27/2	Fert applic. surface broadcast			
4/28/2	Cultivator, field 6-12 in sweeps			
5/1/2	Planter, double disk opnr	Corn, grain	180	
5/3/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
10/20/2	Harvest, killing crop 50pct standing stubble			3136
5/15/3	Sprayer, pre-emergence			
5/15/3	Drill or airseeder, double disk, w/ fluted coulters	Soybean, mw 7in rows	40	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			577
10/12/3	Fert applic. surface broadcast			
10/12/3	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	70	
4/16/4	Fert applic. surface broadcast			
7/26/4	Harvest, killing crop 50pct standing stubble			2040

Supporting Conservation Practices

Practice	Area	Other Notes
None		

SoilCalculator

SOIL SAVINGS PLAN

Client:
Farm:
Location: Perth County, ON

Field		Hectares
Field A	--	31.5

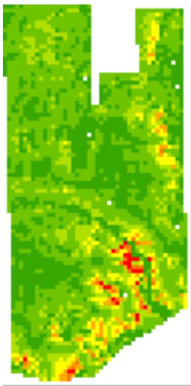
Soil Savings Summary

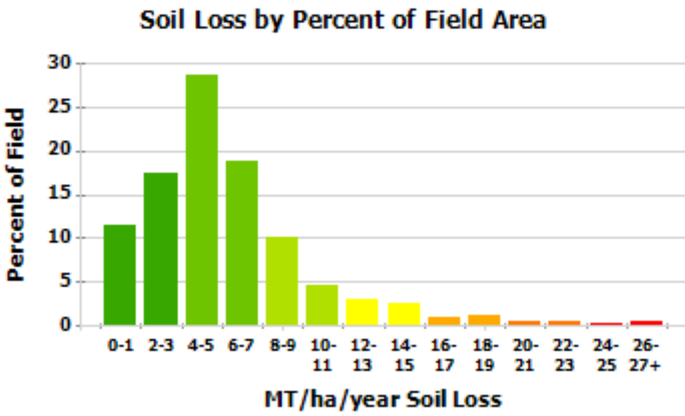
	Alternative 1	Alternative 2	Alternative 3
Crop rotation and operations	Conventional Corn Soy WWheat	NT Corn Soy WWheat	Conv-Corn-Soy
Supporting practices	none	none	none
1 year soil loss (metric tonnes/ha)			
Field average	5.94 metric ton	0.54 metric ton	9.55 metric ton
Top 20% most erodible average	13.43 metric ton	0.95 metric ton	21.97 metric ton
10 year soil loss (cm)			
Field average	1.13 cm	0.103 cm	1.817 cm
Top 20% most erodible average	2.554 cm	0.18 cm	4.179 cm

Calculated Soil Loss

Alternative 1

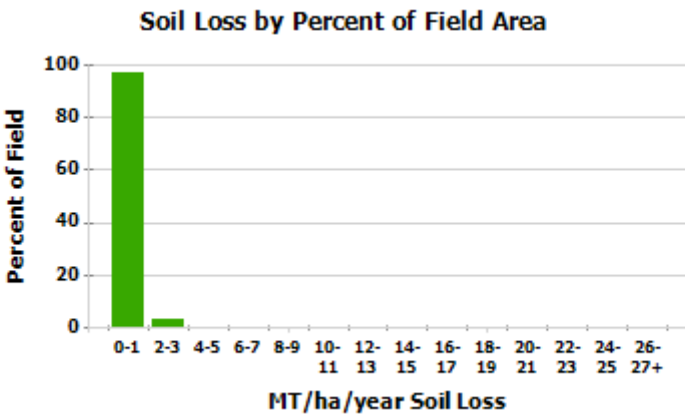
176.17 metric ton/yr annual soil loss





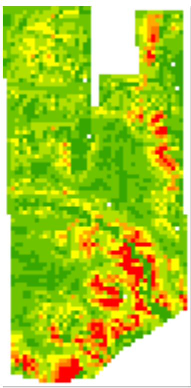
Alternative 2

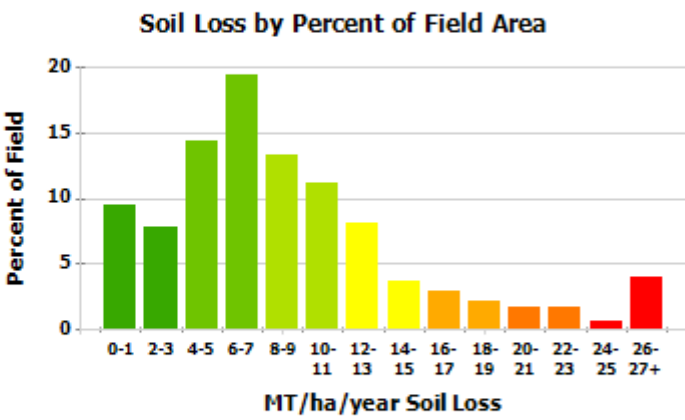
16.04 metric ton/yr annual soil loss



Alternative 3

283.14 metric ton/yr annual soil loss





Economic Impact

(Reported in USD)

Inputs: Corn: $4.00/bu
Nitrogen: $0.47/lb
Phosphate: $0.48/lb
Potash: $0.41/lb

Alternative 1

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.48		$31.32		$31.79		$1,001.44
3	$2.85		$93.95		$96.80		$3,049.26
5	$7.13		$156.58		$163.71		$5,156.99
10	$26.15		$313.16		$339.32		$10,688.42
20	$99.85		$626.33		$726.18		$22,874.61

1.1303 cm of top soil will be lost every ten years under Alternative 1 totaling approximately $10,688 in lost yield and nutrients.

Alternative 2

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.04		$2.85		$2.89		$91.18
3	$0.26		$8.55		$8.81		$277.64
5	$0.65		$14.26		$14.91		$469.55
10	$2.38		$28.51		$30.90		$973.20
20	$9.09		$57.03		$66.12		$2,082.78

0.1029 cm of top soil will be lost every ten years under Alternative 2 totaling approximately $973 in lost yield and nutrients.

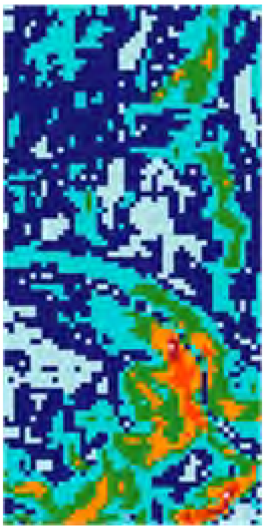
Alternative 3

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectares	My Total Cumulative Erosion Cost
1	$0.76		$50.33		$51.10		$1,609.57
3	$4.59		$151.00		$155.58		$4,900.93
5	$11.46		$251.67		$263.13		$8,288.57
10	$42.03		$503.33		$545.36		$17,178.97
20	$160.49		$1,006.66		$1,167.15		$36,765.22

1.8166 cm of top soil will be lost every ten years under Alternative 3 totaling approximately $17,179 in lost yield and nutrients.

Slope & Soils Summary

Slope Steepness



% Slope

- 0-2
- 2-4
- 4-6
- 6-8
- 8-10
- 10-12
- 12-14
- 14-16
- 16-18
- 18+

Soils

Soil Map Unit (SMU)	Map Unit Name	Hectares	Area	Slope Steepness
ca08-onond120g	GUELPH LOAM	29.7	100 %	3.67 %
		31.5	**100%**	

Disclaimer

Id: cab41c5e51c24e1b838f4687853929df
Application: 18
Service: 1.0.6152.29473
Rome: 2.5.2.20
R2Dp: 3.12.1.0

The content and products associated with "SoilCalculator" are provided to you on an "as is" basis. Agren, Inc. makes no representation, warranty or guarantee of any kind, express or implied, as to the operation of "SoilCalculator". Your use of all products and services included on or associated with "SoilCalculator" are at your own risk.

Agren, Inc. does not make any representation, warrany or guarantee of any kind, express or implied, regarding the accuracy, correctness, or completeness of the content of "SoilCalculator", nor the safety, reliability, title, timeliness, completeness, merchantability, conformity, or fitness for a particular purpose of the content of "SoilCalculator". It is your responsibility to independently evaluate the accuracy, correctness, or completeness of the content of "SoilCalculator".

Field A - Alternative 1

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
11/3/1	Plow, moldboard			
4/28/2	Cultivator, field 6-12 in sweeps			
5/1/2	Planter, double disk opnr	Corn, grain	170	
5/3/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136
11/1/2	disk, tandem light finishing			
5/15/3	Cultivator, field 6-12 in sweeps			
5/15/3	Sprayer, pre-emergence			
5/15/3	planter, double disk opnr	Soybean, mw 30 in rows	45	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			866
10/11/3	Fert applic. surface broadcast			
10/11/3	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	80	
4/15/4	Fert applic. surface broadcast			
7/25/4	Harvest, killing crop 50pct standing stubble			2040
7/30/4	Bale straw or residue			

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 2

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
5/1/2	Planter, double disk opnr w/fluted coulter	Corn, grain	170	
5/1/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136
5/15/3	Sprayer, pre-emergence			
5/15/3	Planter, double disk opnr w/fluted coulter	Soybean, mw 30 in rows	45	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			866
10/5/4	Fert applic. surface broadcast			
10/5/4	Drill or air seeder single disk openers 7-10 in spac.	Wheat, winter 7in rows, Ontario	80	
4/10/5	Fert applic. surface broadcast			
7/20/5	Harvest, killing crop 50pct standing stubble			2040
7/25/5	Bale straw or residue			

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Field A - Alternative 3

Crop Rotations and Operations

Date	Rotation and Subtype	Crop and Subtype	Avg. Yield (# harvest units)	Residue (lb/ac)
11/1/1	Fert applic. surface broadcast			
11/3/1	Plow, moldboard			
4/28/2	Cultivator, field 6-12 in sweeps			
5/1/2	Planter, double disk opnr	Corn, grain	170	
5/3/2	Sprayer, pre-emergence			
6/7/2	Sprayer, post emergence and fert. tank mix			250
6/10/2	Fert applic. side-dress, liquid			
10/20/2	Harvest, killing crop 50pct standing stubble			3136
11/1/2	Plow, moldboard			
5/5/3	disk, tandem light finishing			
5/15/3	Cultivator, field 6-12 in sweeps			
5/15/3	Sprayer, pre-emergence			
5/15/3	planter, double disk opnr	Soybean, mw 30 in rows	45	
6/28/3	Sprayer, post emergence			0
8/1/3	Sprayer, insecticide post emergence			
10/10/3	Harvest, killing crop 20pct standing stubble			866

Supporting Conservation Practices

Practice	Area	Other Notes
None		

Appendix 3: Workshop Materials

Piloting a New Soil Erosion Prediction Tool in Ontario

Draft Agenda

400 Clyde Road, P.O. Box 729, Cambridge, ON N1R 5W6

Wednesday February 7, 2017

10:00 am – 3:00pm

Auditorium

Workshop Objective: Soil erosion is a key contributor to soil degradation and declining soil health. Controlling it can preserve crop productivity and soil health and is a strategy for reducing phosphorus loads to watercourses. This workshop will introduce participants to existing and new tools that can estimate erosion rates and compare the relative erosion control benefits of different cropping and tillage management options.

****Bring your laptop to access the internet and the SoilCalculator tool; please download "RUSLE2 for Ontario" on your laptop (see link below). Refer to the link's "Module 1" video tutorial for detailed instructions in installing RUSLE2. If you encounter installation difficulties, assistance will be provided at the workshop.**

9:45	**Coffee & Networking**	
10:00	Welcome, Introductions and Objectives of the Workshop	S. Cooke
10:05	Why Estimate Rates of Soil Erosion?	G. Ferguson
10:30	Tools/Techniques Available to Estimate Soil Erosion Rates in Ontario 1. Universal Soil Loss Equation (USLE) – Factsheet; NMAN 2. Revised Universal Soil Loss Equation (RUSLE2) for Ontario	K. McKague
10:50	GRCA's GIS-based tool to characterize gully erosion potential	GRCA
11:10	Introduction to Agren's SoilCalculator Tool – Why SoilCalculator was developed and how it is being used in USA – via Adobe Connect	T. Buman (Agren) (Adobe Connect)
11:45	**Questions and Discussion of the Tool**	
12:15	**Lunch with access to internet to explore SoilCalculator Tool and other materials**	
1:00	Overview of SoilCalculator Pilot Project. - Ontario Datasets used "behind the scenes" in SoilCalculator - What to Expect with this Pilot Version	K. McKague
1:15	Hands-on Exercises (using example exercises and independent exploration of the tools by participants) 1. RUSLE2 [download to your laptop prior to workshop] 2. SoilCalculator (web-based tool)	ALL
2:30	Open Roundtable Discussion	ALL
2:55	Participants to fill out survey	S. Cooke
3:00	Adjourn	

Resources and Links

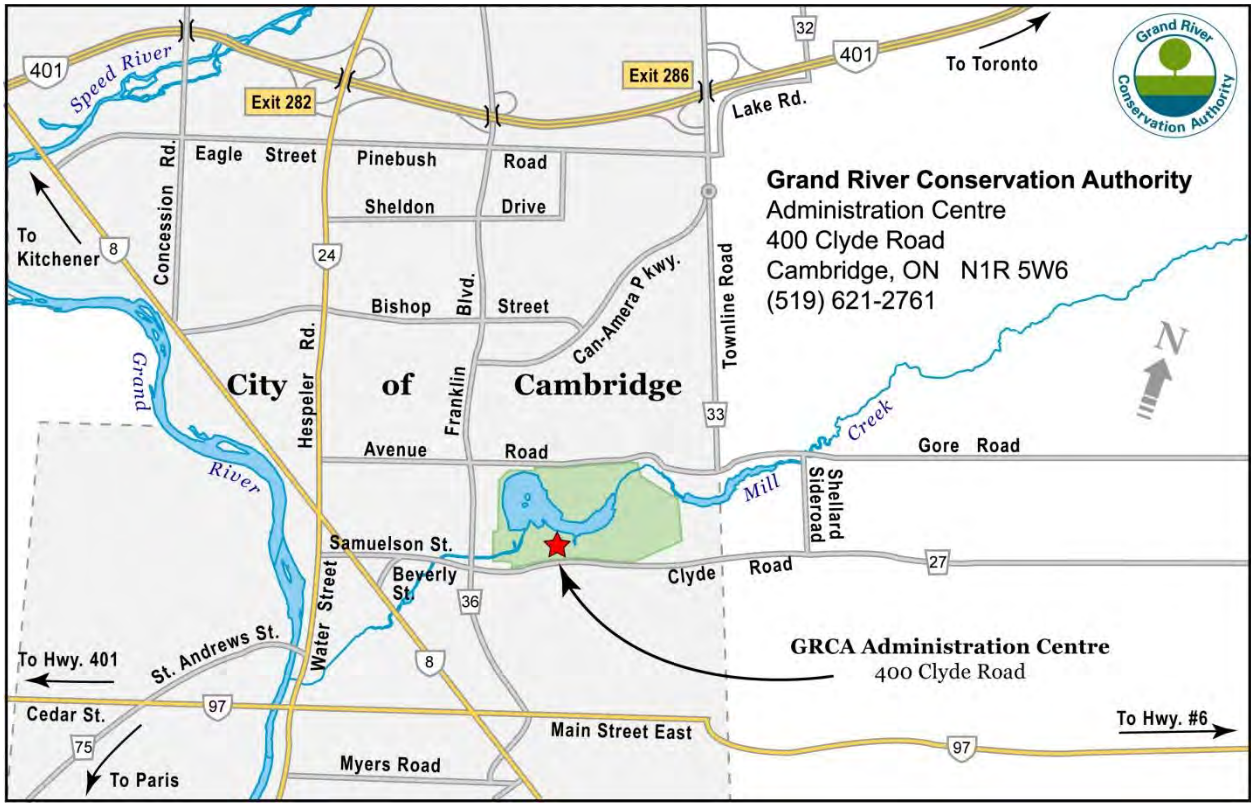
Agren SoilCalculator: http://www.agrentools.com/government-entity/our-tools/soilcalculator/

RUSLE (Ontario) [download: http://www.omafra.gov.on.ca/english/engineer/rusle2/

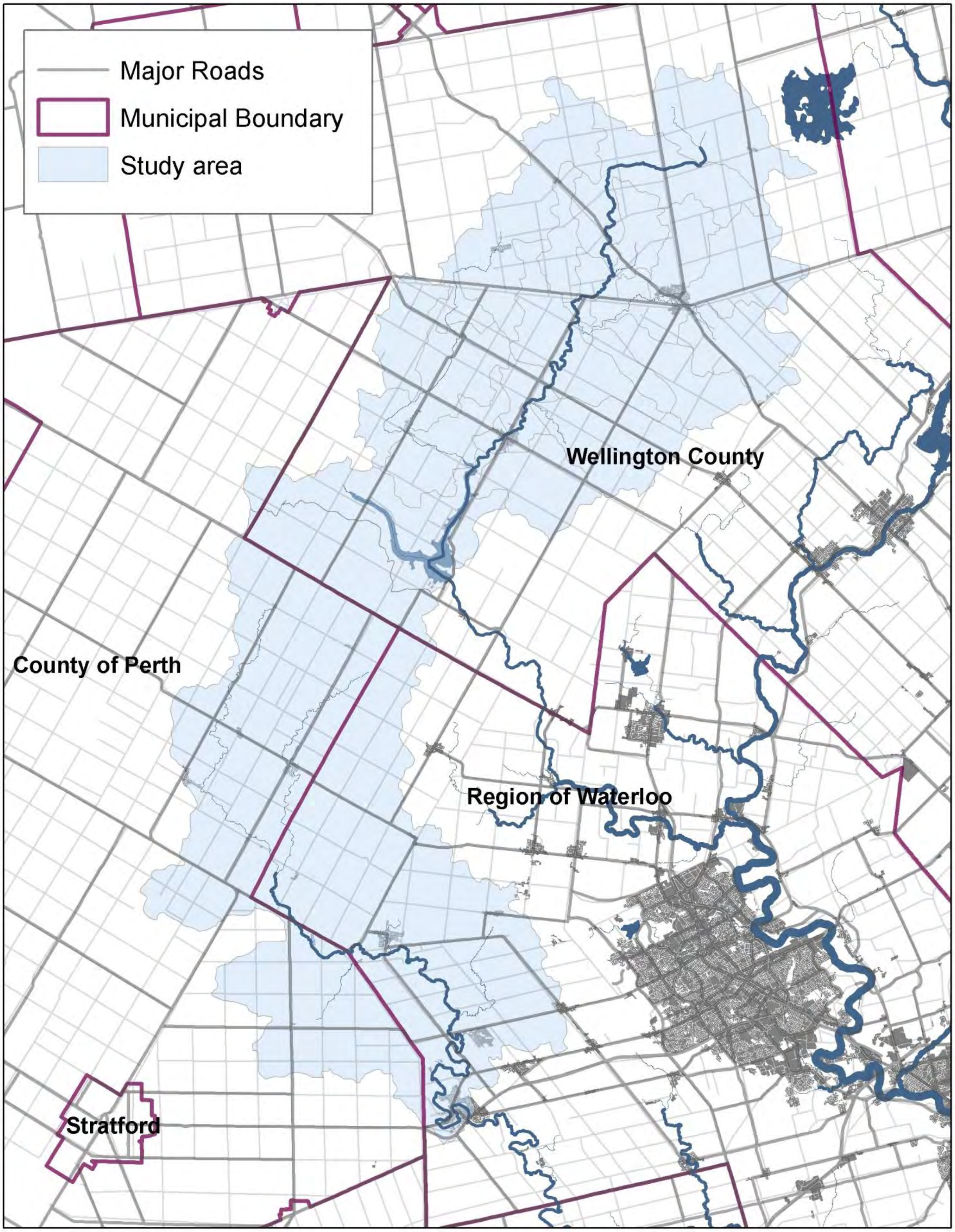
GRCA's Soil Erosion characterization pilot project -

https://www.youtube.com/watch?v=Axm08cs7xgE&feature=youtu.be

Directions to GRCA, Head Office, Cambridge, Ontario



Pilot/Study Area – Where SoilCalculator is being Tested



Why Estimate Soil Erosion Rates?

in Ontario

Prepared by:
Gabe Ferguson, OMAFRA

Presented at:
Soil Erosion Prediction Tools Workshop
Cambridge, ON

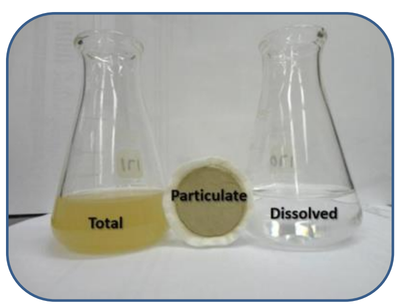
February 7, 2017

How Does NPS P Leave Farmland?

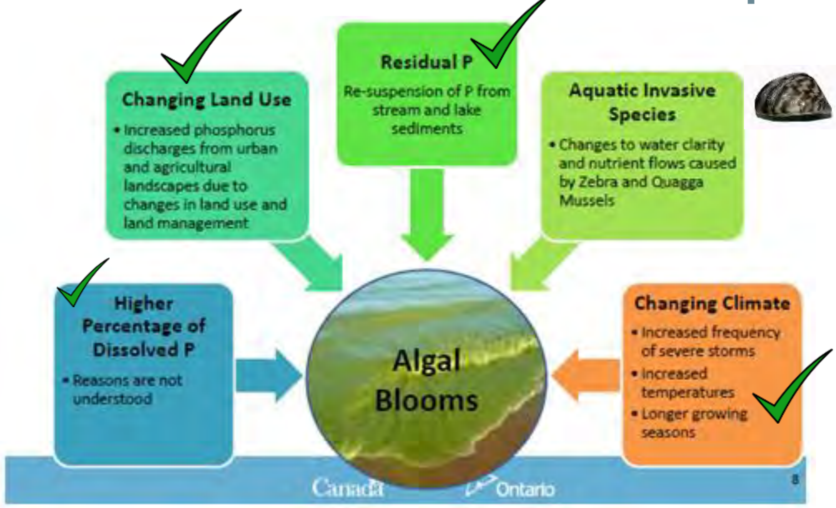
It Leaves with the Water!

- **In Particulate form**
  (i.e. attached to eroded soil)
- **In Dissolved form**
  (i.e. dissolved fertilizer/manure P in runoff and drainage waters)

Wherever and whenever water is running and erosion is occurring, phosphorus in some form and amount will likely be with it.



Non-Point Source P Loads - Complex

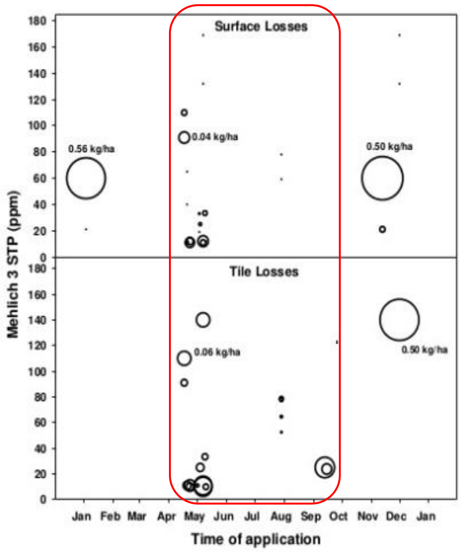


Where can Erosion Control Help?

Erosion Control

& Dissolved P

Source King, K. 2015 (Edge of Field Monitoring Conference – Memphis, TN)



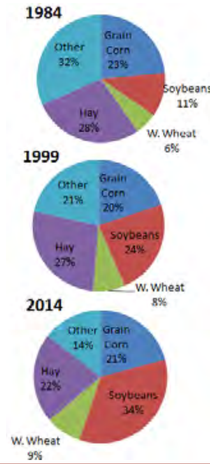
To reduce dissolved P losses, timing and placement of fertilizers and manure are critical considerations <u>in addition to</u> erosion control

Erosion Control

& Changing Land Use

Less Crop Diversity

Fields only growing corn or soybeans, 2011 – 2013
(southwestern Ontario example)

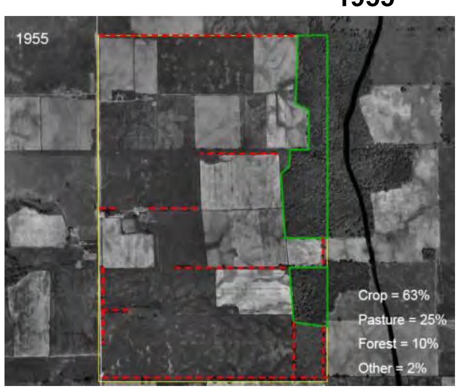


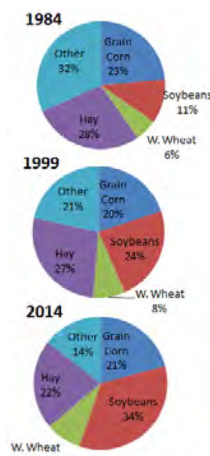
Erosion Control

& Changing Land Use

Bigger Fields

1955



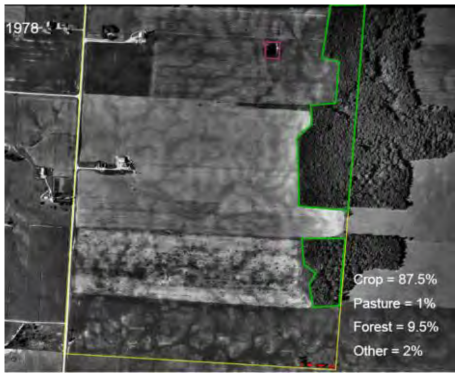


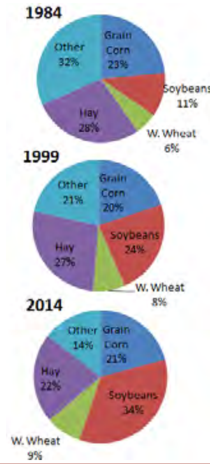
Erosion Control

& Changing Land Use

Bigger Fields

1978



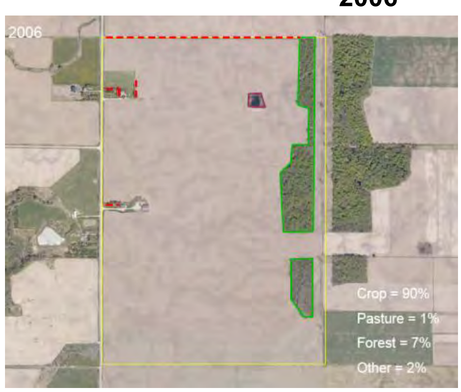


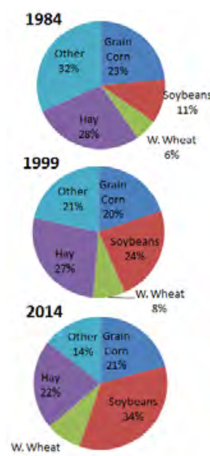
Erosion Control

& Changing Land Use

Bigger Fields

2006





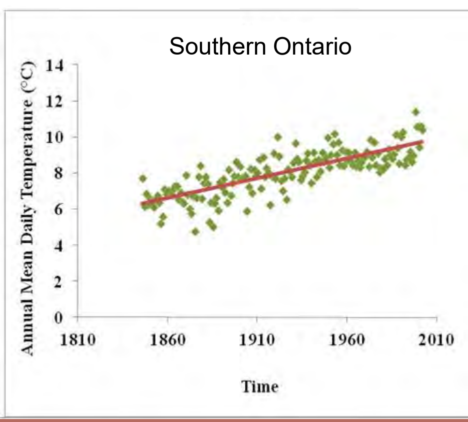
Erosion Control

& Residual P in Sediments

Erosion Control

In Response to Climate Change

Winter air temperatures steadily increasing



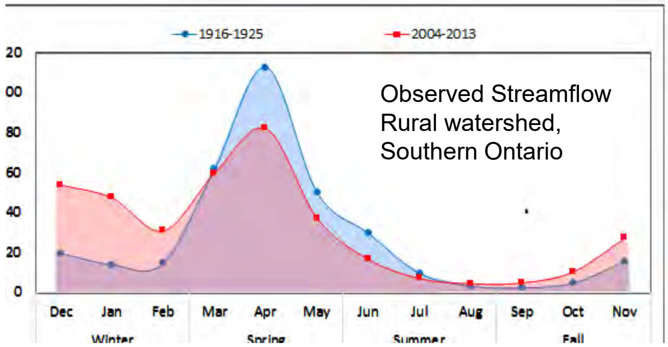
Change in °C/100 years	
Extreme Daily Min.:	+ 3.5 to 4
Mean Daily Min.:	+2
Mean Daily:	+1
Mean Daily Max.:	+0.5
Extreme Daily Max.:	0 to +0.5

Winter temperatures rising at greatest rate

Erosion Control

In Response to Climate Change

Result – Rural NPS runoff is increasing in non-growing period

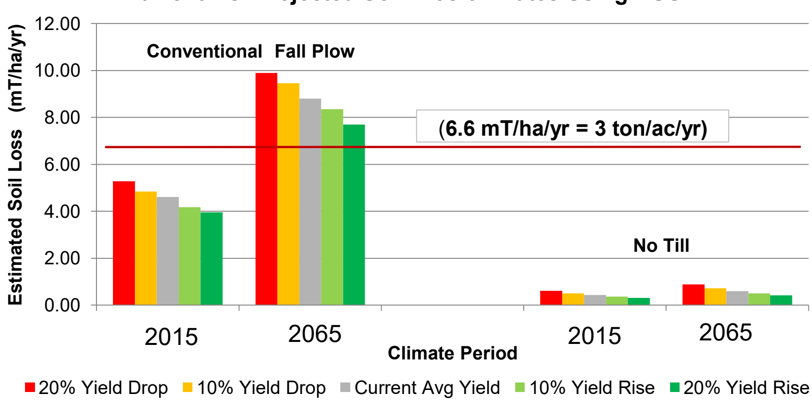


How susceptible are our fields to erosion in the non-growing season?

Change in Erosion Potential under Changing Climate

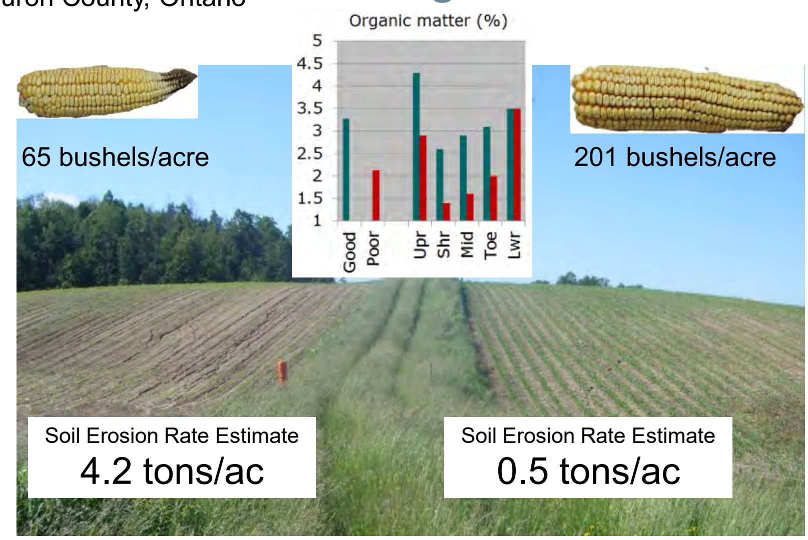
Example: Corn-soybean-winter wheat rotation on Bryanston silt loam and 3% hillslope

Current vs Projected Soil Erosion Rates Using RUSLE2



Controlling Erosion has Long-Term Yield Benefits

Huron County, Ontario



Estimating Soil Erosion Rates in Ontario

Prepared by:
Kevin McKague, OMAFRA

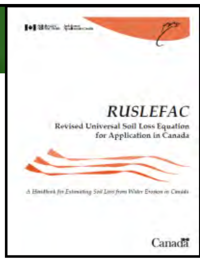
Presented at:
Soil Erosion Prediction Tools Workshop
Cambridge, ON

February 7, 2017

Tools Available to Quantify Erosion
under Ontario Conditions

We have 2 (potentially 3) options:

1. Original USLE (**U**niversal **S**oil **L**oss **E**quation)
   (adapted to Ontario in the early 1980's) Related to this is "RUSLEfac" (Ag Canada publication in 2000's)
2. RUSLE2 (**R**evised **U**niversal **S**oil **L**oss **E**quation v**2**)
   (built datasets to adapt to Ontario setting in 2013-14 Still a "work in progress")
3. Potentially "SoilCalculator"


RUSLEFAC
Revised Universal Soil Loss Equation for Application in Canada

Methodology for using is described in:

Option 1: USLE


FACTSHEET
Ontario
UNIVERSAL SOIL LOSS EQUATION (USLE)

Also in Ag Canada's RUSLEfac document
(more detailed methodolgy than described in factsheet)

and automatically calculated in:

NMAN (AgriSuite) software

USLE

A rather simple equation that numerates the key factors influencing sheet and rill erosion. It looks like the following:

$$A = R \times K \times L \times S \times C \times P$$ where

A - computed soil loss per unit area (T/ha/yr)

R - rainfall and runoff factor (MJ-mm/ha-hr-yr)

K - soil erodibility factor

LS - slope length (L) and slope steepness (S) factors

C - cover and management factor (e.g. tillage, crops grown)

P - support practice factor (e.g. terracing, strip cropping)

Soil Erosion

Types….

Water **Tillage** **Wind**

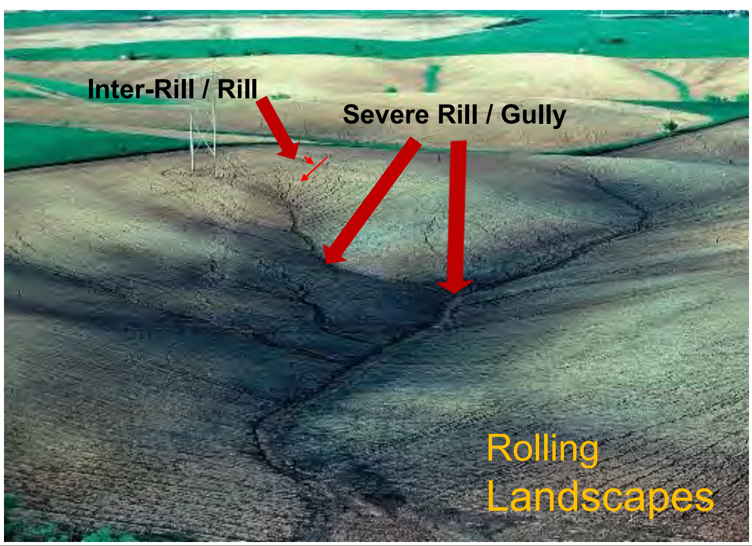


USLE/RUSLE2:

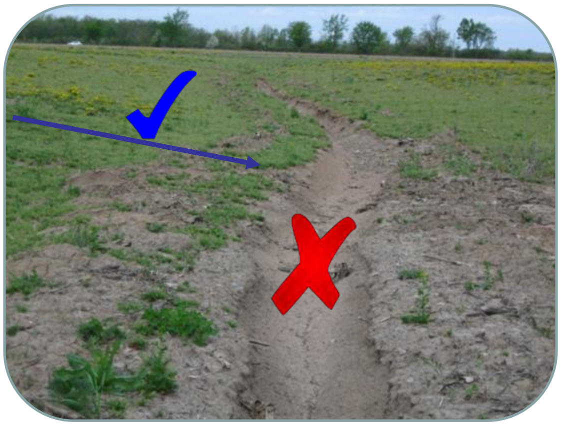
- Deals with water erosion
- Tillage erosion algorithms - embedded but not "turned on"

5

Water Erosion Types



USLE and RUSLE2 DO NOT Estimate Rates of Soil Loss due to Gully Erosion



"EpheGEE" model developed to define gully erosion

The Science behind USLE/RUSLE2

10,000 plot years of field data and 2000 plot years of rainfall simulation data are behind the mathematical equations and professional judgement embedded in USLE/RUSLE2

USLE plots

* Assumes soil density is 1.5 g/cm^3

AgriSuite

The USLE in NMAN

Soil Test Values: Add Soil Test

Soil Test	Value	Units
Phosphorus (Sodium Bicarbona	18	ppm
Potassium (Ammonium Acetate	186	ppm
pH	7.4	
Organic Matter K_1	3.1	%

Location | Properties | Soil Test | Field Inputs

☐ Field is within 150 m (492 ft) of surface water

Tillable Area: 50 ac

Area for Material: 48 ac

Maximum Slope: **S** 9 %

Slope Length: **L** 295 ft

Soil Series: Brant

Soil Texture: K_2 Loam

Hydrologic Soil Group: B

Runoff Potential: High

Farm Location

R Regional Municipality of Waterloo, Township of Wilmot

Geotownship: WILMOT

Cropping Information

Crop: C_1 Soybeans / soybeans

Yield: 40 bu/ac (@ 13.0% moisture)

(Geotownship Average: 41 bu/ac)

Cropping Year: Fall 2016 - Fall 2017

Approximate Planting Date (if applicable): May 15, 2017

Approximate Harvest Date (or dormancy): October 1, 2017

Tillage Method: C_2 Plough

☑ Tillage occurs in fall

Cropping/Tillage Practice: Up & Down Slope **P**

Estimated Soil Erosion: 32.3 ton/ac **A**

$$A = R \times K \times L \times S \times C \times P$$

AgriSuite

USLE Applied in NMAN

USLE erosion estimate gets used in current P-Index calculation also embedded in NMAN

Phosphorus Index [Fall 2016 - Fall 2017]

P-Index Factor	Value	Weight	Rating
1. Soil Erosion 32.34 ton/ac	8	2	**16**
2. Water Runoff Class B, 9% slope	8	1	**8**
3. Phosphorus Soil Test 18 mg/L	2	2	**4**
4. Fertilizer Application Rate 0 lb/ac	0	0.5	**0**
5. Fertilizer Application Method	0	1.5	**0**
6. Manure Application Rate 0 lb/ac	0	0.5	**0**
7. Manure Application Method	0	1.5	**0**
			28

Option 2: RUSLE2

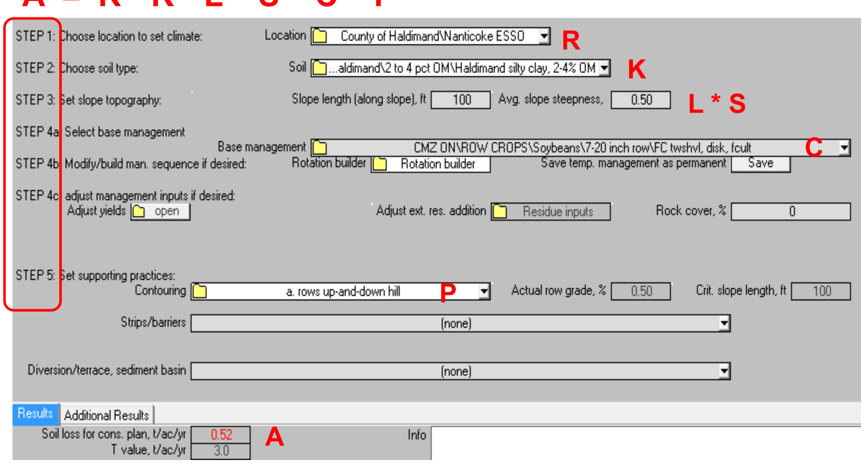
2) **RUSLE2** = **R**evised **U**niversal **S**oil **L**oss **E**quation v**2**

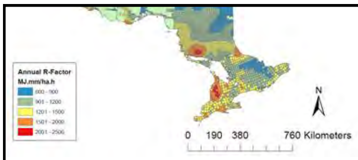
- Adopted by USDA-NRCS for use in Soil Conservation Planning in 2004.
- Adapted for potential use in Ontario in 2014
- Still takes form **A = RKLSCP**, BUT computerized and:
  - enables seasonal and daily long-term average estimates of soil erosion by water (as well as annual).
  - Uses "Management Practice" factor instead of "C" factor
  - incorporates a "Rotation Builder"
  - Allows representation of complex slopes, grass strips, etc.
  - Incorporates a Soil Conditioning Index (SCI) (soil health indicator)

RUSLE2 Basic Screen

Hillslope "Profile" View

A = R x K x L x S x C x P

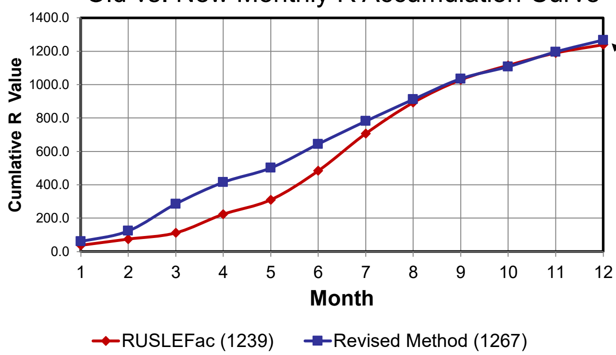




USLE vs. RUSLE2

Analyzed 300+ climate stations to develop new MONTHLY R values (rain + snowmelt)

Old vs. New Monthly R Accumulation Curve



USLE "R" (annual)

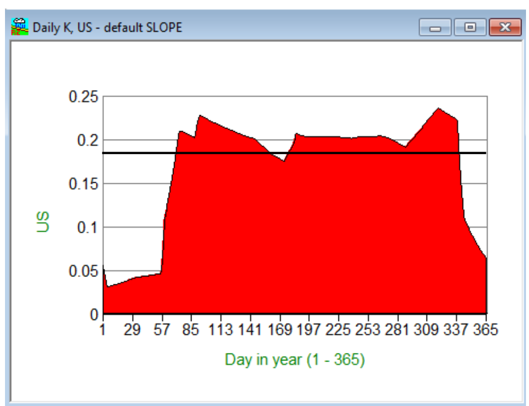
USLE vs. RUSLE2

Seasonal Variation of K

Fox SL - Base K value = 0.18

This option has been activated in current version
(i.e. can turn off)

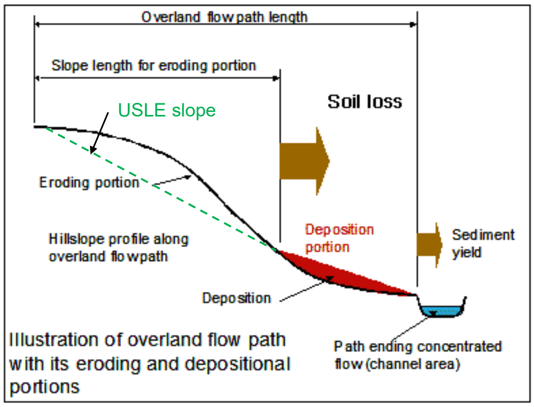
Frozen soil covered, but melting soil not
(3 - 5 times higher K)



USLE vs. RUSLE2

complex vs. simple slopes

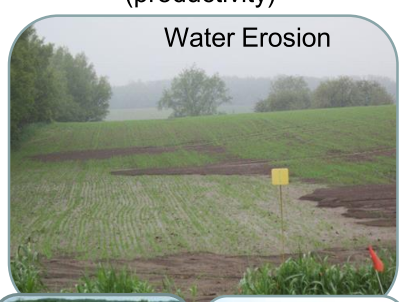
With additional input, RUSLE2 can estimate sediment yield as well as erosion:



Soil Movement vs. Soil Loss

Soil Movement within Field

(productivity)



Production Costs!

Soil Loss (Sedimentation)

(environment and productivity)

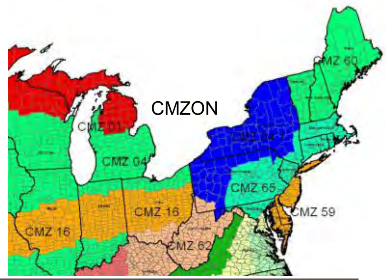
Environmental AND Production Costs!

USLE vs. RUSLE2

Management Practice Factor vs. old “C” Factor

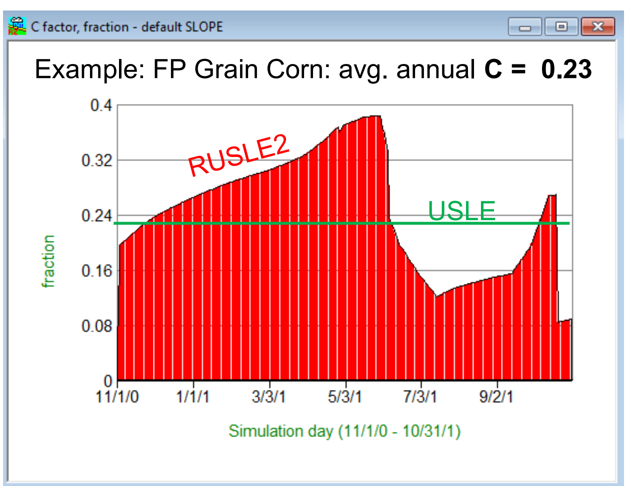
- RUSLE2 divides USA into Crop Management Zones (CMZs)
- Created a unique Ontario CMZ (CMZON) for all crops in NMAN, plus a few more.
- Asked for Input from Crop Specialists
- Use RUSLE2 “Rotation Builder” to build personal rotations and store in “My Managements”

USA CMZs 04, 01 and 16 are similar to regions in Ontario



USLE vs. RUSLE2

Management Practice (C) Factor Changes in Time



RUSLE2/USLE Output Examples

Provides a relative comparison of management practice options for a site

Location	Soil Type	Slope		Crop and Tillage	RUSLE2 Erosion Rate (t/ac/yr)	USLE NMAN (t/ac/yr)	Soil Conditioning Index (soil health indicator)
		Grade (%)	Length (ft)				
Haldimand	silty clay	0.5	100	soybeans fall tilled	0.52	1.4	-0.09
Brant	silt loam	7	140	soybeans fall tilled	9.3	16.3	-0.8
Haldimand	silty clay	0.5	100	soybean w. wheat rotation	0.31	--- (1.2)	0.3
Brant	silt loam	7	140	soybean w. wheat rotation	4.8	--- (13.9)	-0.2
Haldimand	silty clay	0.5	100	NT soys into rolled rye cc	0.14	---	0.5

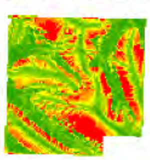
Agren's SoilCalculator

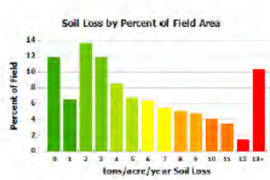
A Potential 3rd Option to Estimate Manage Practice Effects on Soil Loss in Ontario?

Field	Sec/Twp/Rng	Acres
Field A	002-082N-036W	149.52

Alternative 2

813.15 tons/yr annual soil loss

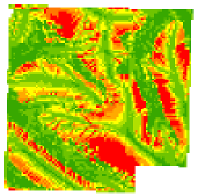




	Alternative 1	Alternative 2	Alternative 3
Crop rotation and operations	Corn-Soybean Fall Till SB Res_Fall Till Corn Res	Corn-Soybean No-till in SB Res_FD SFC Corn Res	Corn-Soybean Strip-till Corn_Strip-till Soybeans
Supporting practices	none	none	none
1 year soil loss (tons/acre)			
Field average	7.05 tons	5.45 tons	2.59 tons

Key Components:

- GIS–based (2-dimensional)
- Web-based
- Visual input and output
- Faster and easier to use than RUSLE2, without compromising on using the best information available.



Key Datasets Used by SoilCalculator

- Ortho-Imagery
- A Digital Elevation Model (DEM)
  (i.e. detailed topographic information layer)
- A contour map layer
- A soils map layer
- RUSLE2 datasets (built and maintained)
  - Monthly R values
  - K values for each soil map unit
  - Dataset of the common cropping and management practices used for crops grown in Ontario
  - Can build rotations (saved as favourites)

The SoilCalculator Pilot Project

Presented by:
Kevin McKague, OMAFRA

Presented at:
Soil Erosion Prediction Tools Workshop
Cambridge, ON

February 7, 2017

Project Objectives

Phase 1

- Assemble and determine if the publically-available datasets needed to “drive” the Soil Calculator Tool even exist for Ontario.
- If they do, determine if they are in the format that can be readily used in the Agren product

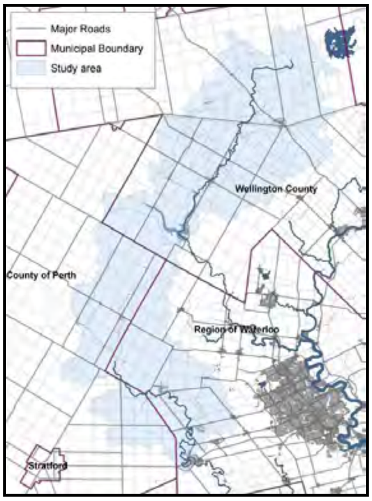
If Phase 1 findings are positive, move to Phase 2 or STOP

Phase 2

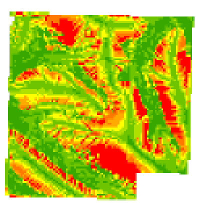
- Build SoilCalculator for a Pilot Region of Ontario (Proof of Concept)
- Assess the Pilot tool for ease of use, applicability, value etc. (Today is a part of this – potential end-user feedback)

Phase 3???

Why Pilot in the Upper Nith, Upper Conestogo?



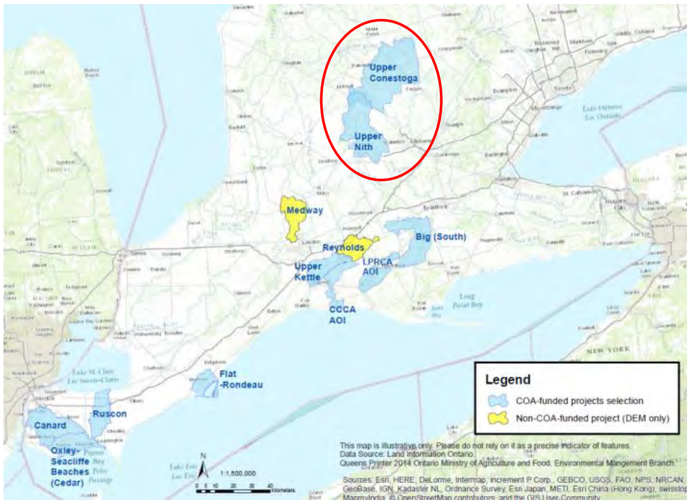
- Identified in the GRCA Watershed Management Plan as being high priority for addressing rural non-point phosphorus loading
- 2 years ago - one of the few places in Ontario that had the necessary detailed DEM datasets (GRCA-developed, NOT LiDAR, but an ortho-image derived product)
- Take advantage of GRCA rural extension experience and mesh with their targeting tool
- Build on earlier work with GRCA on developing some of the RUSLE2 datasets (i.e. monthly R factors). This a continuation.



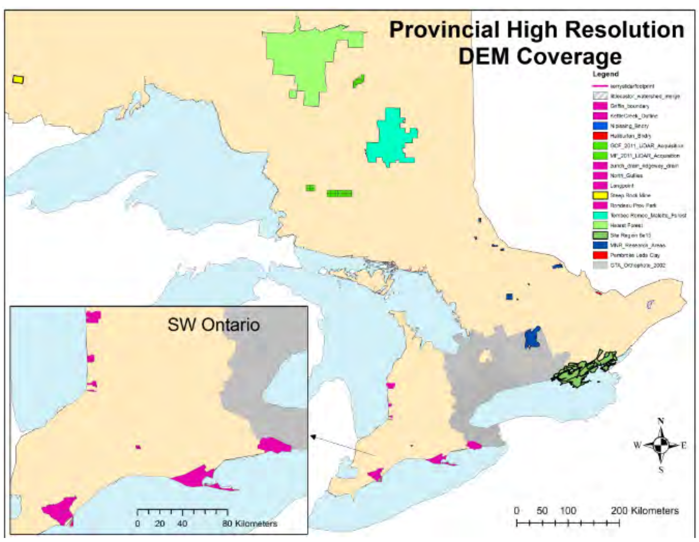
Key Datasets Needed to "Drive" SoilCalculator

- Ortho-Imagery
- A Digital Elevation Model (DEM)
  (i.e. detailed topographic information layer)
- A contour map layer
- A soils map layer
- RUSLE2 datasets
  - Monthly R values
  - K values for each soil map unit
  - Dataset of the common cropping and management practices used for crops grown in Ontario
  - Can build rotations (saved as favourites)

Current PAC-DEM Coverage for Ontario



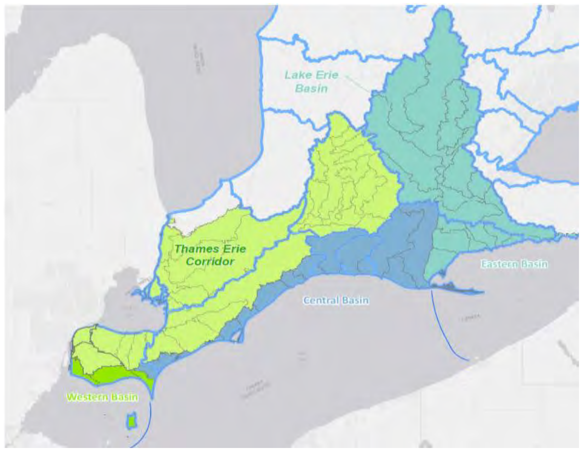
Current LiDAR DEM Coverage for Ontario



COMING SOON!

Publically-Available LiDAR DEM

covering the entire Lake Erie Basin



What to Expect with Pilot Version

Not Perfection!

It is PROOF OF CONCEPT

- Give you a feel for the approach/technology
- Do you see value, applications?
- Could you advise on how to make it more useful?
- Should OMAFRA invest in it more?
- Would you invest in it?

Demonstration of RUSLE2 and SoilCalculator

Source: GRCA on-line mapping (1 m contour intervals)

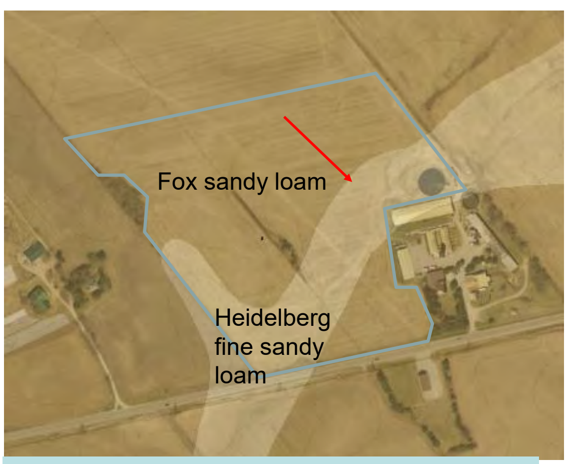
Example Site Description:

- Region of Waterloo (Upper Nith)
- Rolling landscape
- Continuous no-till corn, but sometimes soybeans

General RUSLE2 operating instructions in worksheet packet

Site Soils Information

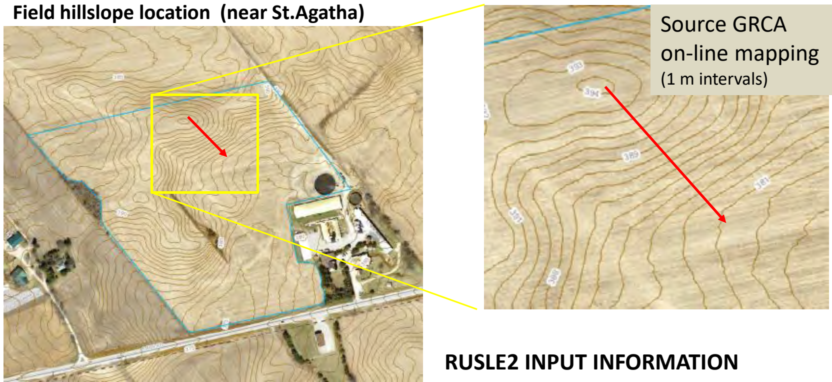
Demo Field



Source: OMAFRA on-line Ag Information Atlas (AgMaps)

RUSLE2 Input

Field hillslope location (near St.Agatha)



Legend

- Hillslope location for RUSLE2 calculation
- Topographic contours (1 m intervals)

RUSLE2 INPUT INFORMATION

Nearest Climate Station: Waterloo-Wellington

Soil type: Fox Sandy Loam, 2 – 4% OM

Hillslope: 12.7m drop in 105m (340’) (12%)

Alt 1: Grain Corn (try various tillage options)

Alt 2: Corn, Soybean (try various tillage options)

Alt 3: Corn, Soybean, Winter wheat rotation (try various tillage options)

RUSLE2 DEMO

Soil Loss Summaries for Demo Field

Using RUSLE2

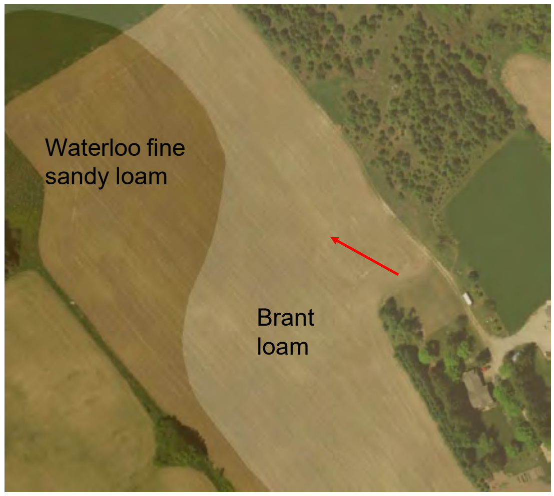
Upper Nith Hillslope: 12% slope (12.7 m in 105 m), Fox sandy loam, 2-4% OM

Crop/Rotation	Tillage Methods	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
Grain Corn	Fall plow, spring cultivate	10	-0.5
Grain Corn	No till	0.18	+0.8
1 Corn, 1 Soybean	No till (all)	2.3	+0.3
Corn, Soybean, Winter Wheat (straw baled)	Conventional tillage (all)	10	-0.6
Corn, Soybean, Winter Wheat (straw left)	No till (all)	1.8	+0.4

RUSLE2
Practice Exercises

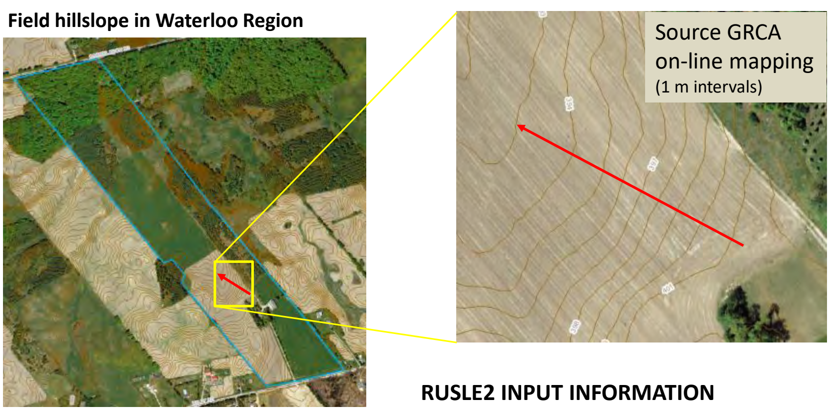
Site Soils Information, Exercise 1

Source: AgMaps



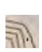
RUSLE2 Example Exercise #1

Field hillslope in Waterloo Region



Legend

Hillslope location for RUSLE2 calculation



Topographic contours (1 m intervals)

RUSLE2 INPUT INFORMATION

Nearest Climate Station: Waterloo-Wellington
Soil type: Brant Loam, 2 – 4% OM
Hillslope: 8.1m drop in 90m (295’) = 9% slope
Crop1: Soybeans (try various tillage options)
Crop2: 2 Soybeans, 3 year Alfalfa
(try various tillage options)

Soil Loss Summaries for Exercise 1

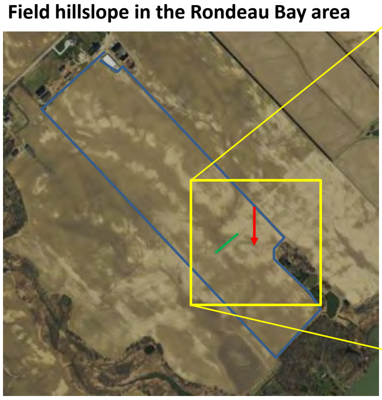
Using RUSLE2

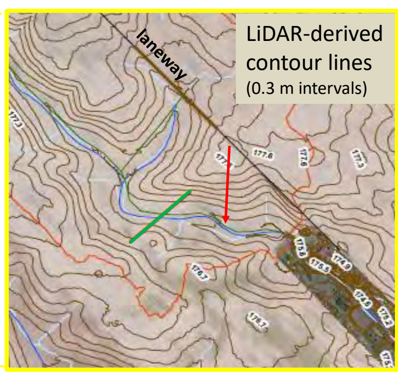
Waterloo Region Hillslope: 9% slope (8.1 m in 90 m), Brant loam, 2-4% OM

Crop/Rotation	Tillage Methods	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
Soybeans	Fall disk, spr. cultivate	18	-1
Soybeans (nr)	No till (single disk openers)	3.8	+0.02
Soybeans (nr), oat cover crop	No till (all)	0.9	+0.7
2 year Soybeans, 3 years Alfalfa	No till soybeans, Direct seed Alfalfa	0.26	+0.6

RUSLE2 Example Exercise #2

Field hillslope in the Rondeau Bay area





Legend

- Hillslope location for RUSLE2 calculation
- Berm crest
- Topographic contours (0.3 m (1') intervals)

RUSLE2 INPUT INFORMATION

Nearest Climate Station: Ridgetown

Soil type: Beverly – silt loam, <2% OM

Hillslope: 7.2' drop in 360' length = 2% slope

Crop1: Grain Corn (try various tillage options)

Crop2: Grain Corn, Soybeans, winter wheat+straw (try various tillage options)

Crop3: Burley tobacco

Soil Loss Summaries for Exercise 2

Using RUSLE2

Rondeau Bay Hillslope: 2% slope (2 m in 100m), Beverly silt loam, <2% OM

Crop/Rotation	Tillage Methods	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
Grain Corn	Fall plow, spr. disk/cult	2.6	+0.2
Grain Corn	No till	0.1	+0.8
Corn-Soybean-winter wheat (remove straw)	Fall plow, spr. disk/cult all crops	2.8	+0.04
Corn-Soybean-winter wheat (keep straw)	No till all crops	0.48	+0.5
Corn-Soybean-winter wheat (bale straw), oat cover crop after wheat	Strip-till corn. No till soys, w. wheat and oat cover crop	1.2 (0.95)	+0.4 (+0.5)
Burley tobacco	Fall plow	5.5	-0.6

Hands-On Demonstration of SoilCalculator

Prepared by:
Kevin McKague, OMAFRA

Presented at:
Soil Erosion Prediction Tools Workshop
Cambridge, ON

February 7, 2017

General Instructions

for Estimating Soil Erosion Rates Using Agren's SoilCalculator

OMAFRA/GRCA Pilot Project

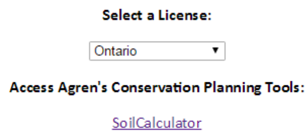
Upper Nith, Upper Conestogo

For more instruction, refer also to on-line video tutorials found on the Agren website

Prepared by:
Kevin McKague, OMAFRA
February 7, 2017

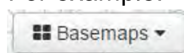
SoilCalculator: Start/Locate Site

1. GOOGLE: "Agren Soil Calculator"
2. Select: *Soil Calculator* | *Agren Tools*
3. On Agren's main screen, find "Login" (top right corner)
4. Type in your Username and Password (provided by Agren).

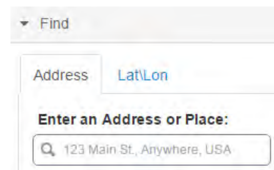


5. Select a Licence: select "Ontario"
6. Click on "SoilCalculator"

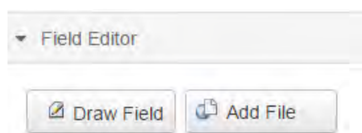
1. Locate the field of interest by navigating on screen. For example:
   - Zoom-in, zoom out with mouse
   - Locate using roads and map labels
   - Turn on "imagery" base map and visually identify field.



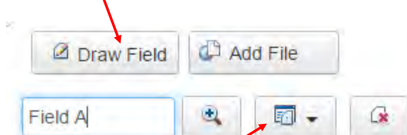
   - type in nearest town name (Address)
   - Type in GPS coordinates (Lat\Lon) of field



SoilCalculator: Define Field

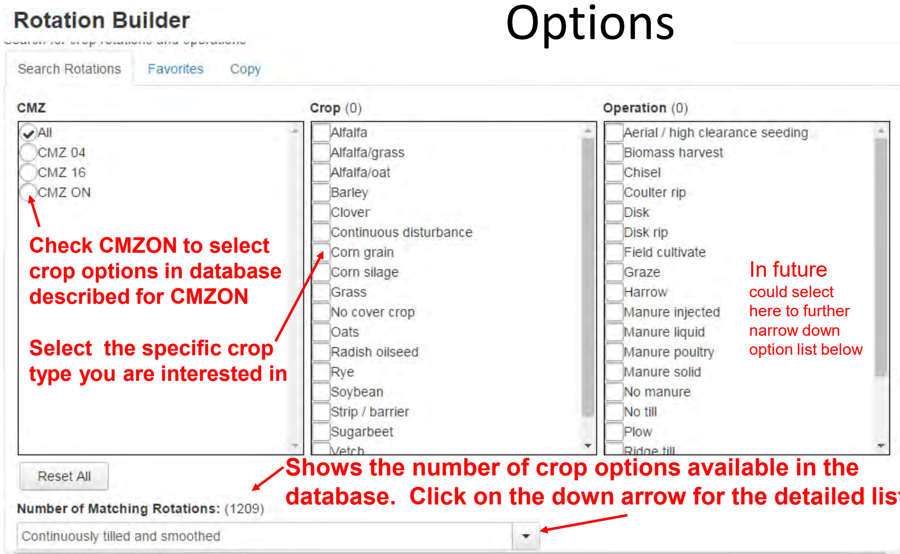


7. Click on "Draw Field" then click on map to start drawing field boundary.



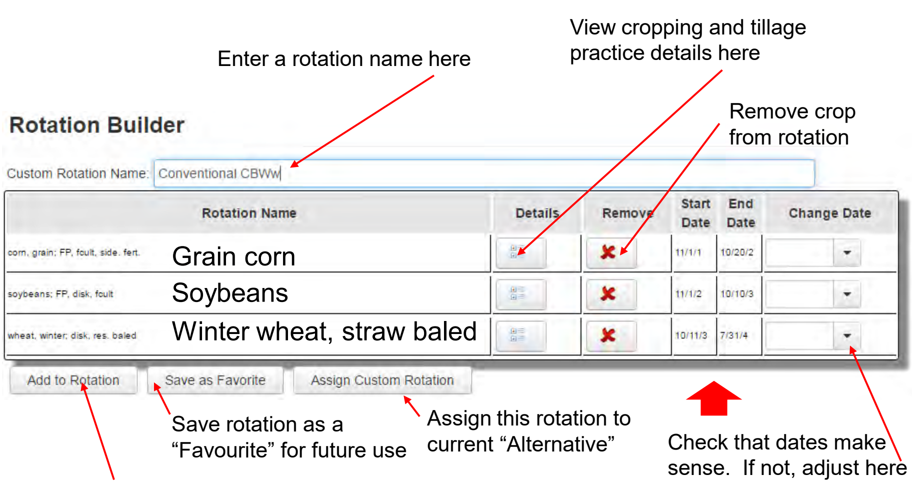
8. Click here to define different crop management alternatives for the field you have identified (up to 10 fields per session and a maximum of 3 alternatives per field)

Selecting Management Options



Refer to List of Tillage and Management Codes used by RUSLE2 for Ontario provided in Workshop packet

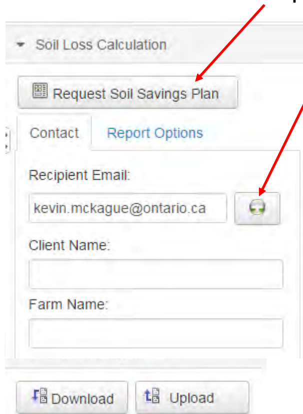
Building Rotations



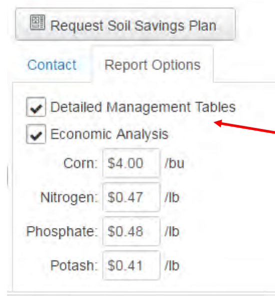
Click here to add another crop year to the rotation. Note a crop year begins just after previous crop harvest and ends at current crop's harvest.

Soil Loss Calculation

Request Soil Savings Plan - This sends input to the Agren server where calculations are completed and results returned to you by e-mail (~1hr)



Add more email addresses here if want report sent to others



<u>Before</u> you send report, check the report options you want included and adjust default values

Session management area lets you save (download) your session for later reloading (upload)

Check E-Mail for Report

Soil Savings Plan.pdf

Attached to the report is a summary document called *Soil Savings Plan.pdf*.

Other documents are also sent, consisting of shape files and raw data files that can be used in standard GIS software (e.g. ArcMaps) to prepare custom reports and maps.

Preparing a Soil Savings Plan for the Demonstration Field

Address: St. Agatha, Ontario
(Field is just west of village)

Alt 1: (e.g. current cropping)
continuous corn – fall plow
Corn, grain; FP, fcult, sidefert

Alt 2: continuous corn - notill
Corn, grain; notill, sidefert

Alt3: Build a corn-soybean-winter wheat rotation. Fall plow wheat stubble, no till 7"row soys, no till wheat.
Corn, grain; FP, fcult, sidefert
7-20 in row soybeans , NT single disk opener
7" row winter wheat, NT, residue baled

Agren
SoilCalculator DEMO

https://www.agrentools.com/government-entity/our-tools/soilcalculator/

Soil Erosion Estimates – Demo Farm

Soil Savings Summary

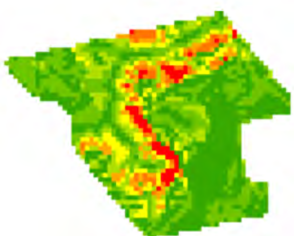
Also, refer to copy of Soil Savings Plan for demo farm in workshop packet

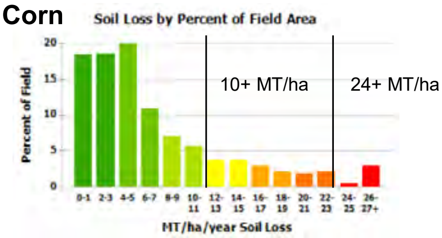
	Alternative 1	Alternative 2	Alternative 3
Crop rotation and operations	conv gr corn	NT grain corn	CBW plow corn
Supporting practices	none	none	none
1 year soil loss (metric tonnes/ha)			
Field average	7.0 metric ton	0.1 metric ton	6.2 metric ton
Top 20% most erodible average	19.6 metric ton	0.3 metric ton	17.4 metric ton
10 year soil loss (cm)			
Field average	1.34 cm	0.03 cm	1.17 cm
Top 20% most erodible average	3.74 cm	0.05 cm	3.31 cm

SoilCalculator Output

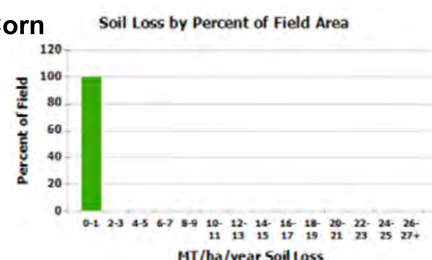
See Worksheet Packet for “Soil Savings Plan”

Fall Plow Corn

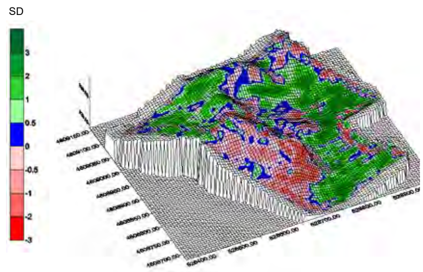




No-Till Corn

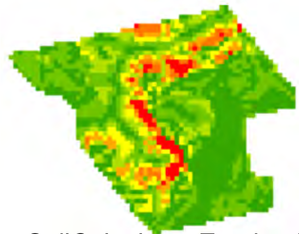


Yield Map vs. Erosion Map

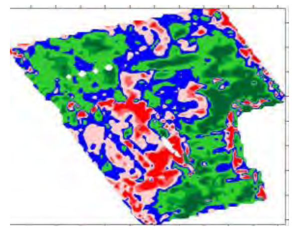


Normalized Yield Map

(based on 4 years of corn and soybean yield data (1999-2002))



SoilCalculator Erosion Map



1999 Soybean Yield Map

SoilCalculator Cost of Soil Erosion

Economic Impact

(Reported in USD)

Inputs: Corn: $4.00/bu
Nitrogen: $0.47/lb
Phosphate: $0.48/lb
Potash: $0.41/lb

Continuous fall plow corn

Alternative 1

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectare	My Total Cumulative Erosion Cost
1	$0.56		$37.05		$37.61		$560.39
3	$3.37		$111.14		$114.52		$1,706.31
5	$8.44		$185.24		$193.67		$2,885.75
10	$30.94		$370.47		$401.41		$5,981.03
20	$118.12		$740.95		$859.07		$12,800.17

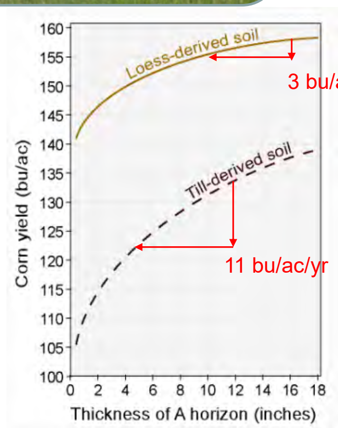
1.34 cm of top soil will be lost every ten years under Alternative 1 totaling approximately $5,981 in lost yield and nutrients.

Continuous no till corn

Alternative 2

Year	Cumulative Yield Loss/Hectare	+	Cumulative Nutrient Loss/Hectare	=	Total Yield & Nutrient Loss/Hectare	x Hectare	My Total Cumulative Erosion Cost
1	$0.01		$0.70		$0.71		$10.55
3	$0.06		$2.09		$2.16		$32.13
5	$0.16		$3.49		$3.65		$54.35
10	$0.58		$6.98		$7.56		$112.64
20	$2.22		$13.95		$16.18		$241.06

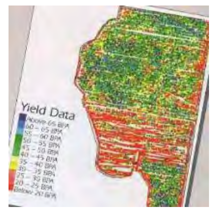
Method Behind the Cost Analysis



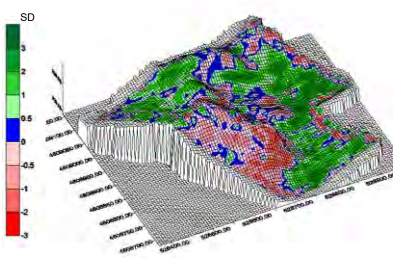
(Kasemi et al, 1990)

Iowa Data (Rick Cruse, Iowa State U)

- Estimated **6.8 inches** of topsoil lost in Iowa over last 150 years
- Assume:
  - 20 million acres corn in Iowa
  - 5 bu/ac yield loss from erosion
  - $3.00/bu
- Cost = 20,000,000 X 5 X 3 = $300M/yr ($15/ac/yr + $2.10 in N and P loss) (USD)



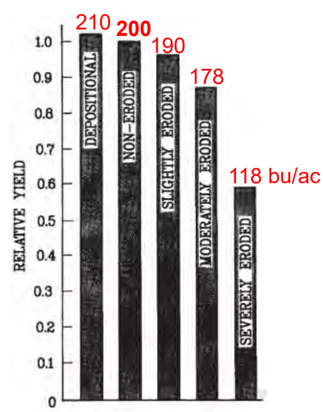
Ontario cost data



1999 Normalized Yield Map

(Waterloo County Field)

Ontario Data



(Battiston et al, 1987)

16

Iowa Example

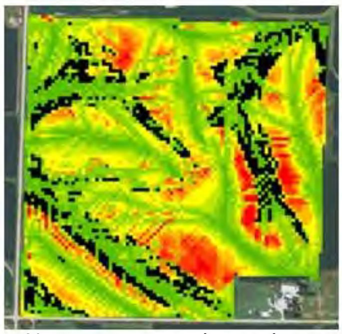
Uses for other output files

Effect of Grass Strips and Buffers on Sediment

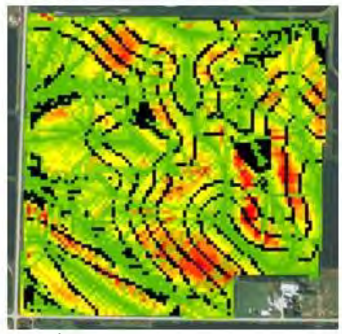
(Source: Agren Inc. Blog- Dec 2015)

With Strips:

- 17% reduction in soil erosion
- Eroded soil closer to where originated



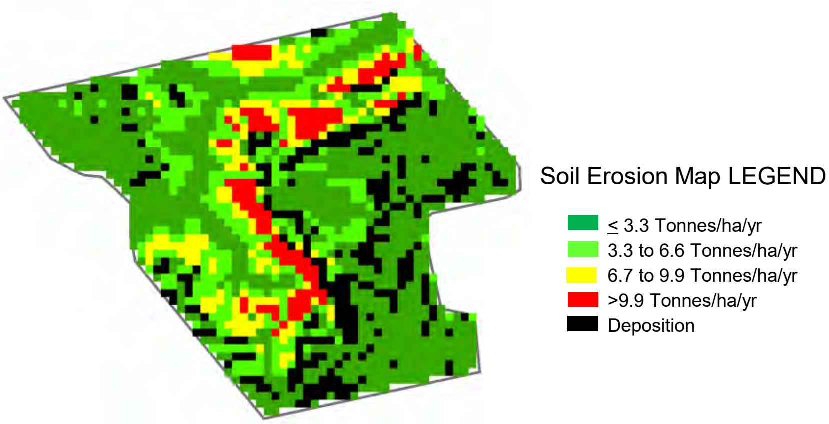
No grass vegetation strips



With grass vegetation strips

Uses for other output files

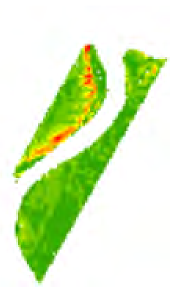
Map of Deposition Areas on Demonstration Field



SoilCalculator Practice Exercises

or use fields you are familiar with

Note: Some bottomland soils are missing K factor data and so will not return mapped results as shown here as an example



SoilCalculator Practice Exercise 1 Crosshill Area Field

Lat\Long: 43.548301, -80.794303

Alt 1: Continuous Soybeans
Fall plow, plant 30" rows

Alt 2: Corn-Soy-Winter Wheat rotation
Fall plow all crops except disk in advance of planting winter wheat.

Alt3: Corn-Soy-Winter Wheat rotation
No-till all crops (double disk openers, fluted coulters)

See worksheet packet for example "Soil Savings Plan.pdf" output

SoilCalculator Practice Exercise 2
Drayton Area Field

Lat\Long: 43.741436, -80.661765

Alt 1: Corn-Soy-Winter Wheat rotation
Fall plow all crops except disk in advance of planting winter wheat.

Alt 2: 2 years Corn-1 Year spring Barley (underseeded)-3 years Alfalfa /Hay
Fall plow corn and barley

Alt3: Corn-Soy-Winter Wheat rotation
No-till all crops (double disk openers, fluted coulters)

See worksheet packet for example “Soil Savings Plan.pdf” output

SoilCalculator Practice Exercise 3
Wellesley Area Field

Lat\Long: 43.457964, -80.801399

Alt 1: Corn-Soy-Winter Wheat rotation
Fall plow all crops except disk in advance of planting winter wheat.

Alt 2: Corn-Soy-Winter Wheat rotation
No-till all crops (double disk openers, fluted coulters)

Alt3: Corn-Soybean rotation
Fall plow

See worksheet packet for example “Soil Savings Plan.pdf” output

General Instructions

for Estimating Soil Erosion Rates Using RUSLE2 for Ontario's

OMAFRA Basic Screen

Hillslope Profile View

For more instruction, refer also to on-line video tutorials found at:
http://www.omafra.gov.on.ca/english/engineer/rusle2/

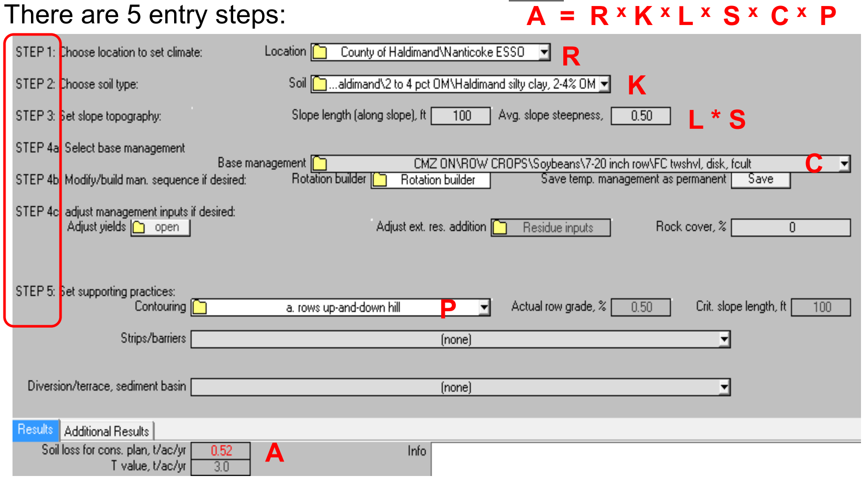
Prepared by:
Kevin McKague, OMAFRA
February 7, 2017

RUSLE2 Basic Screen

Hillslope "Profile" View

There are 5 entry steps:

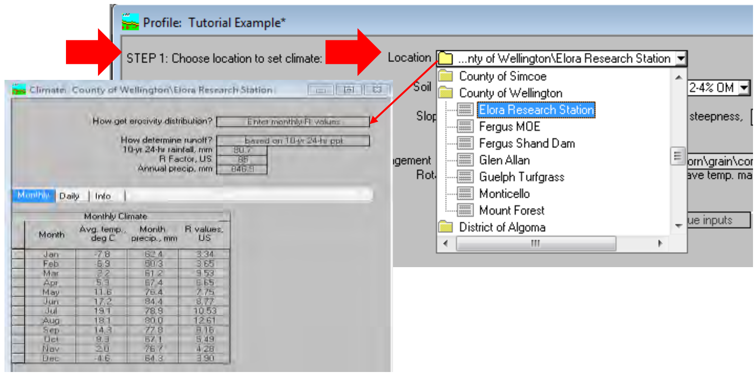
A = R x K x L x S x C x P



Climate (R)

Data for 350+ Ontario climate stations are stored in the RUSLE2 database. Use the station closest to your site.

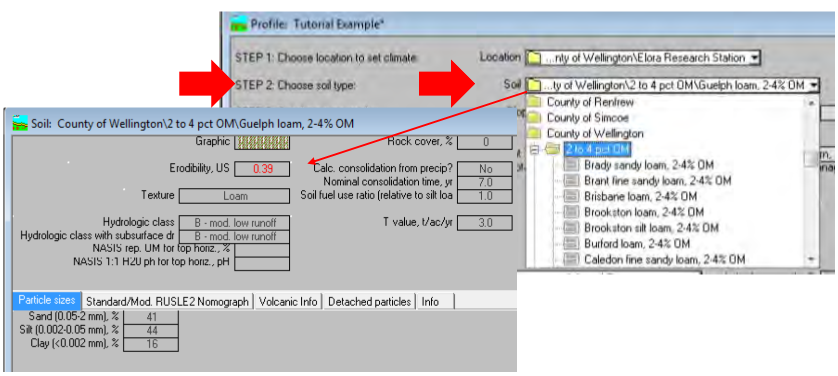
Step 1: Choose location to set climate (the old USLE “R” factor)



Soil Erodibility (K)

Soils data for each mapped soil unit in the province has been assembled and stored in the RUSLE2 database. Information is organized by County/Region. Choose the soil series mapped for your site of interest.

Step 2: Choose soil type



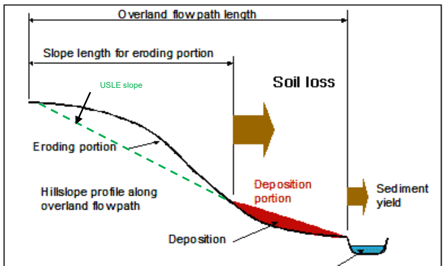


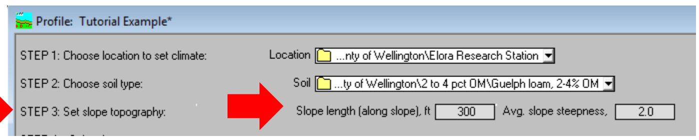
Illustration of overland flow path with its eroding and depositional portions

Topography (LS)

Option 1: OMAFRA Basic Screen

Users measure the representative slope of interest in the field. RUSLE2's basic screen asks for a description of the "USLE" slope (average slope length and gradient of eroded portion – see sketch)

Step 3: Enter representative slope's length and steepness (%)



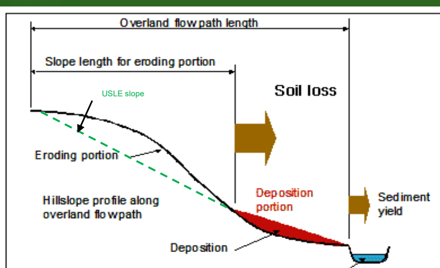


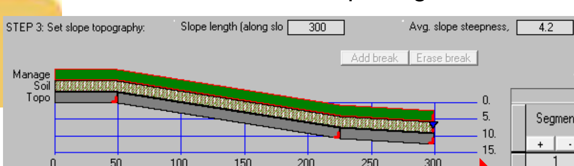
Illustration of overland flow path with its eroding and depositional portions

Topography (LS)

Option 2: Input Screen "OMAFRA Segmented slope"

Change your input screen in lower right corner of window by loading the "OMAFRA Segmented slope" screen and enter slope segment details (see below). This option estimates sediment yield at the bottom of a hill's flowpath (see sketch)

Step 3: Enter representative slope's length and steepness (%) for each slope segment.



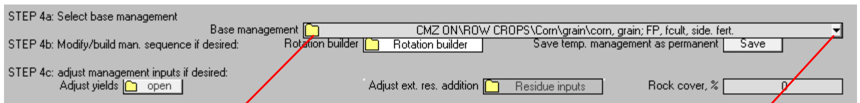
Seg length (horiz)						
Segment	Seg length (horiz), ft	Seg length (along slope), ft	Steepness, %	Cons. plan. soil loss to here,	Soil loss, t/ac/yr	Sediment delivery, t/ac/yr
1	50	50	1.0	0.65	0.65	0.65
2	170	180	6.0	3.9	4.9	3.9
3	75	75	2.0	2.8	-5.1	1.7

Crops and Tillage (C)

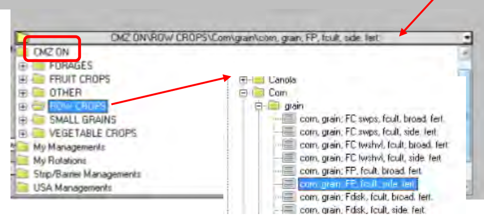
Step 4a: Select base management from available database

Step 4b: Modify/Build crop management sequence if desired (i.e. select tillage operations within a crop year. Save in “My Managements”)

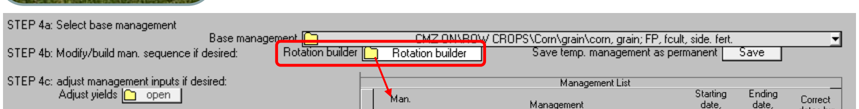
Step 4c: Adjust Management Inputs (e.g. yields if desired)



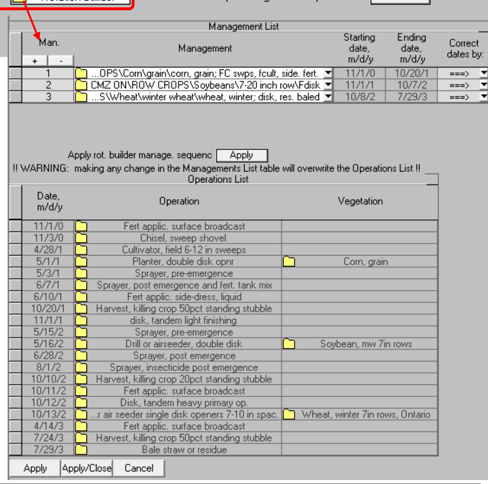
Ontario crops database (called CMZON) contains what are thought to be the more common cultivation practices in Ontario for single year crops. The option exists to build and save your own custom practices



Rotation Building

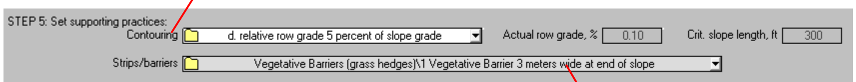


- Build rotations by combining single crop years WITHIN Rotation Builder tool
- IMPORTANT: Ensure dates of field activities line up between years.
- Save completed rotations in your “My Rotations” database for future use.

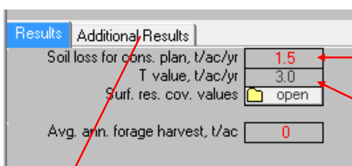


RUSLE2 Basic Screen

Step 5: Select supporting practices
(if any)

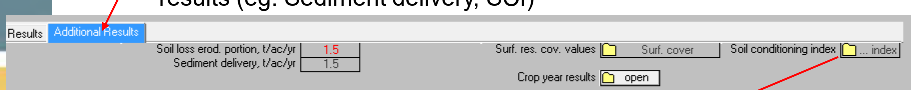


RUSLE2 Output

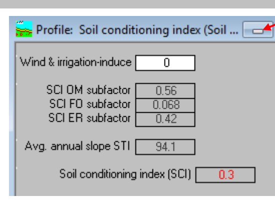


Estimated average annual soil loss (units shown).
T value is a predefined "tolerable" soil loss.

Clicking on "Additional Results" tab displays more results (eg. Sediment delivery, SCI)



SCI value < 0 suggests soil is being degraded by selected practices



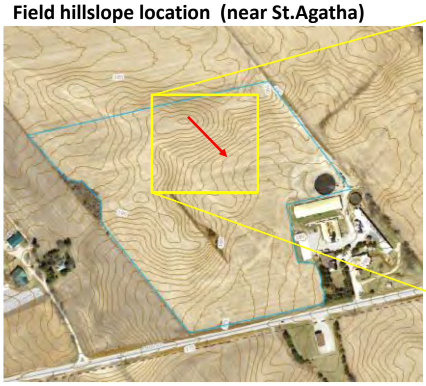
Example Summary of RUSLE2 Output

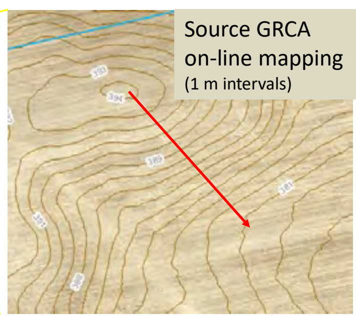
Provides a relative comparison of management practice options for a site

Location	Soil Type	Slope		Crop and Tillage	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
		Grade (%)	Length (ft)			
Haldimand	silty clay	0.5	100	soybeans fall tilled	0.52	-0.09
Brant	silt loam	7	140	soybeans fall tilled	9.3	-0.8
Haldimand	silty clay	0.5	100	soybean w. wheat rotation	0.31	0.3
Brant	silt loam	7	140	soybean w. wheat rotation	4.8	-0.2
Haldimand	silty clay	0.5	100	NT soys into rolled rye cc	0.14	0.5

RUSLE2 Input (Demo Field)

Field hillslope location (near St.Agatha)





Legend

- Hillslope location for RUSLE2 calculation
- Topographic contours (1 m intervals)

RUSLE2 INPUT INFORMATION

Nearest Climate Station: Waterloo-Wellington

Soil type: Fox Sandy Loam, 2 – 4% OM

Hillslope: 12.7m drop in 105m (340') (12%)

Alt 1: Grain Corn (try various tillage options)

Alt 2: Corn, Soybean (try various tillage options)

Alt 3: Corn, Soybean, W.wheat rotation (try various tillage options)

Soil Loss Summaries for Demo Field

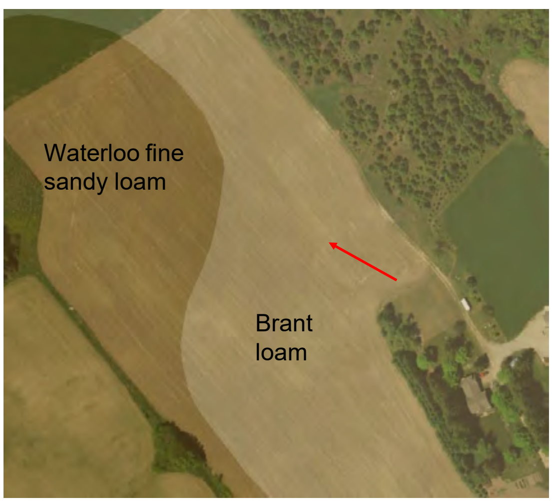
Using RUSLE2

Upper Nith Hillslope: 12% slope (12.7 m in 105 m), Fox sandy loam, 2-4% OM

Crop/Rotation	Tillage Methods	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
Grain Corn	Fall plow, spring cultivate	10	-0.5
Grain Corn	No till	0.18	+0.8
1 Corn, 1 Soybean	No till (all)	2.3	+0.3
Corn, Soybean, Winter Wheat (straw baled)	Conventional tillage (all)	10	-0.6
Corn, Soybean, Winter Wheat (straw left)	No till (all)	1.8	+0.4

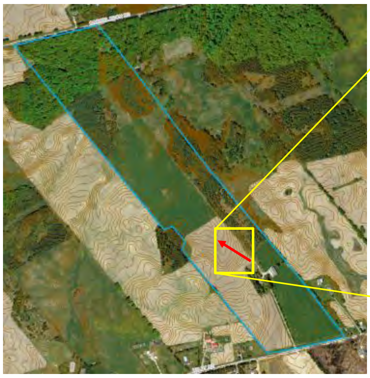
RUSLE2
Practice Exercises

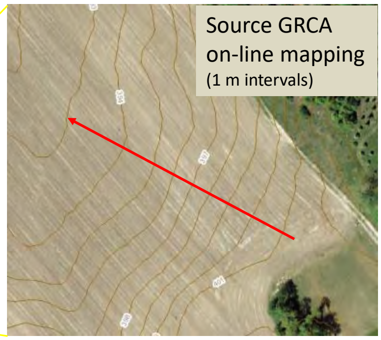
Site Soils Information, Exercise 1
Source: AgMaps



RUSLE2 Example Exercise #1

Field hillslope in Waterloo Region





Legend

- Hillslope location for RUSLE2 calculation
- Topographic contours (1 m intervals)

RUSLE2 INPUT INFORMATION

Nearest Climate Station: Waterloo-Wellington

Soil type: Brant Loam, 2 – 4% OM

Hillslope: 8.1m drop in 90m (295') = 9% slope

Crop1: Soybeans (try various tillage options)

Crop2: 2 Soybeans, 3 year Alfalfa
(try various tillage options)

Soil Loss Summaries for Exercise 1

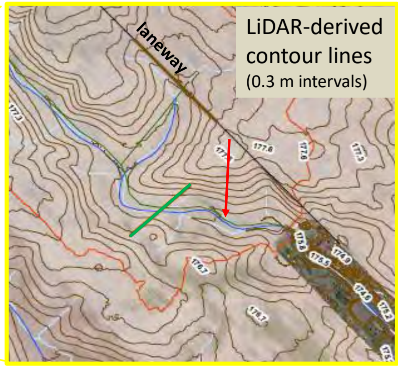
Using RUSLE2

Waterloo Region Hillslope: 9% slope (8.1 m in 90 m), Brant loam, 2-4% OM

Crop/Rotation	Tillage Methods	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
Soybeans	Fall disk, spr. cultivate	18	-1
Soybeans (nr)	No till (single disk openers)	3.8	+0.02
Soybeans (nr), oat cover crop	No till (all)	0.9	+0.7
2 year Soybeans, 3 years Alfalfa	No till soybeans, Direct seed Alfalfa	0.26	+0.6

RUSLE2 Example Exercise #2

Field hillslope in the Rondeau Bay area



Legend

- Hillslope location for RUSLE2 calculation
- Berm crest
- Topographic contours (0.3 m (1') intervals)

RUSLE2 INPUT INFORMATION

Nearest Climate Station: Ridgetown

Soil type: Beverly – silt loam, <2% OM

Hillslope: 7.2' drop in 360' length = 2% slope

Crop1: Grain Corn (try various tillage options)

Crop2: Grain Corn, Soybeans, winter wheat+straw (try various tillage options)

Crop3: Burley tobacco

Soil Loss Summaries for Exercise 2

Using RUSLE2

Rondeau Bay Hillslope: 2% slope (2 m in 100m), Beverly silt loam, <2% OM

Crop/Rotation	Tillage Methods	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
Grain Corn	Fall plow, spr. disk/cult	2.6	+0.2
Grain Corn	No till	0.1	+0.8
Corn-Soybean-winter wheat (remove straw)	Fall plow, spr. disk/cult all crops	2.8	+0.04
Corn-Soybean-winter wheat (keep straw)	No till all crops	0.48	+0.5
Corn-Soybean-winter wheat (bale straw), oat cover crop after wheat	Strip-till corn. No till soys, w. wheat and oat cover crop	1.2 (0.95)	+0.4 (+0.5)
Burley tobacco	Fall plow	5.5	-0.6

Identifying Gully Erosion Potential In The Grand River Watershed

Presentation by: Jill Marshall & Anne Loeffler
February 7th 2017

Presentation Overview

1) Using GIS technologies to identify potential gully erosion locations

2) Describe how the identified gully locations have been used to engage the local agricultural community

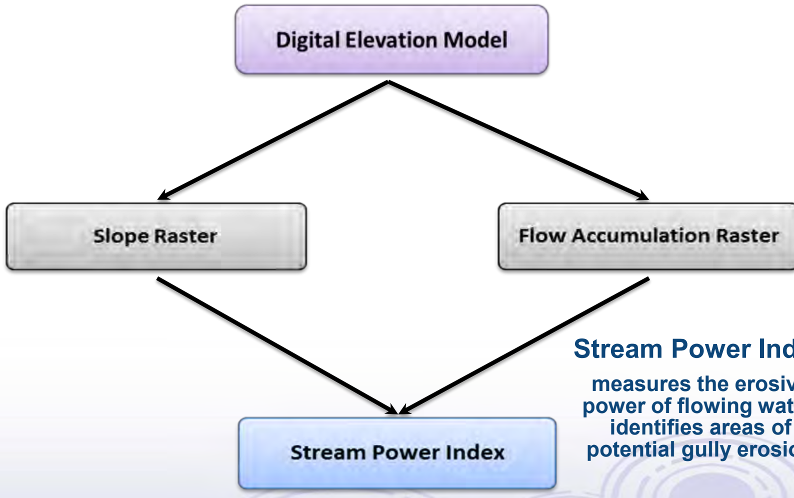
Identify Gully Locations

3

Identify Gully Locations

4

Terrain Analysis



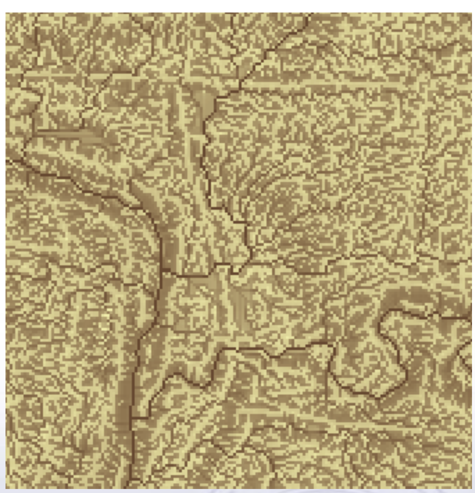
Stream Power Index

measures the erosive power of flowing water, identifies areas of potential gully erosion

▪Approach adapted from: Galzki et al. 2007 Minnesota Department of Agriculture and Galzki 2009 University of Minnesota

5

Stream Power Index (SPI)



- **High SPI values represent the likely overland flow paths during a storm event**

– the potential gullies

SPI - Log Scale

High : 16.2355

Low : -13.8155

6

Stream Power Index (SPI)

SPI Signatures

- A path of high SPI values that flow into observed surface hydrology

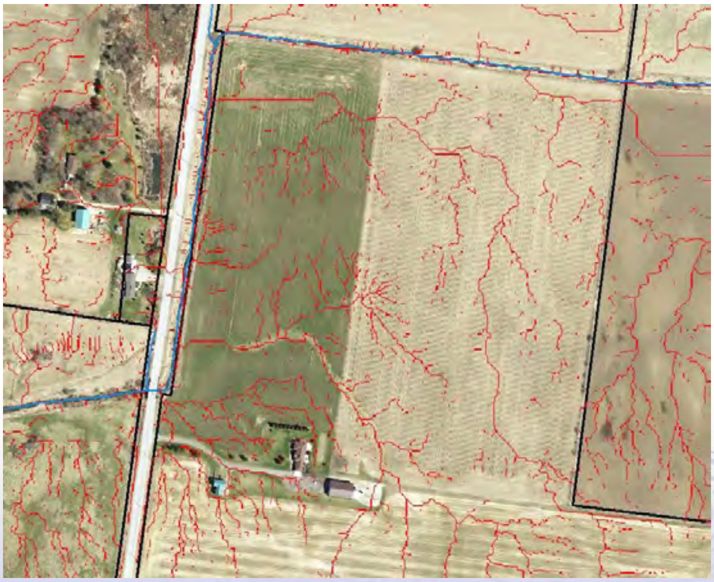
SPI Value	Percentile
-0.540	75.00%
-0.079	80.00%
0.460	85.00%
1.135	90.00%
2.214	95.00%

Stream Power Index (SPI)

Field Verification

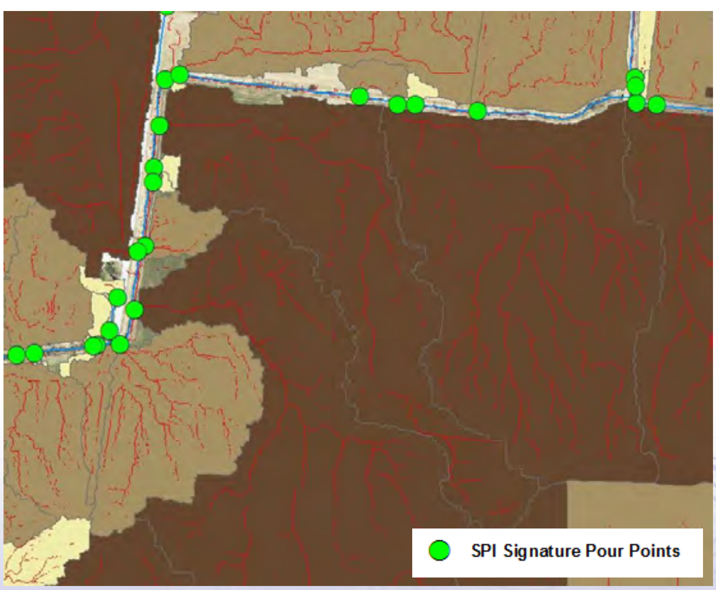
SPI Signatures - 95th Percentile			
Correctly Identified	Incorrect Identification		
	False Positive	Thick Vegetation	Other
9/10 (90%)	0/10 (0%)	1/10 (10%)	0/10 (0%)

Potential Gully Locations



9

Gully Catchment Areas



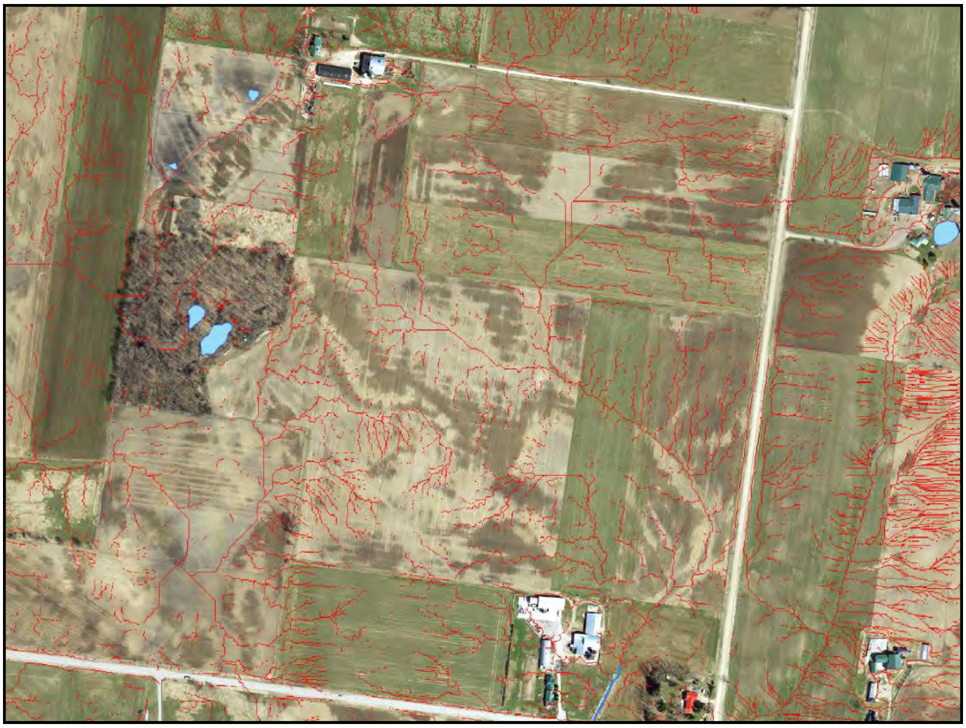
10

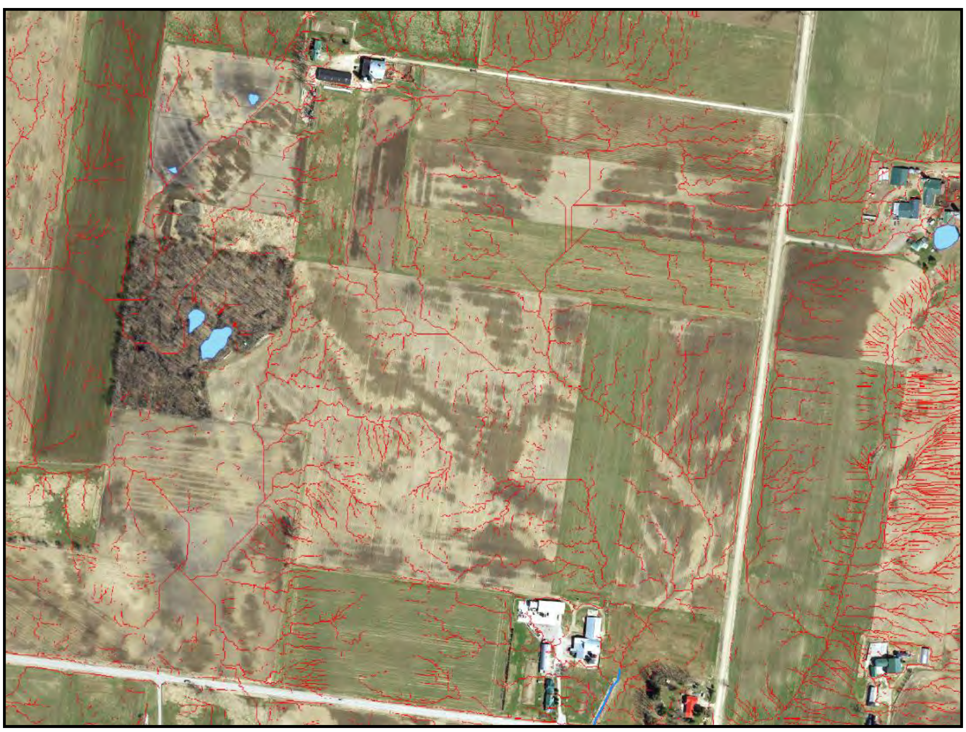
Wellesley Pond

11

Using SPI maps

12





Two years later: three WASCOBs on two farms, and both farmers have started using cover crops for the first time.

Key points

- Mapping allows the grower to see the field(s) from a watershed perspective
- Works as a communication tool
- Leads to discussion about potential placement of erosion control structures
- Helpful in WASCOB design (delineating subwatershed)
- Encourages discussion about managing effects of severe weather events

19

Contact info:

Jill Marshall

jmarshall@grandriver.ca

Anne Loeffler

aloeffler@grandriver.ca

519-621-2761

See the Youtube video at:
https://www.youtube.com/watch?v=Axm08cs7xgE&feature=youtu.be

https://www.grandriver.ca/en/our-watershed/Studies-and-reports.aspx

20

General Instructions

for Estimating Soil Erosion Rates Using Agren's SoilCalculator

OMAFRA/GRCA Pilot Project

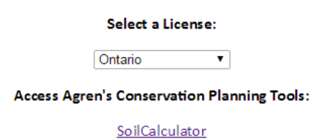
Upper Nith, Upper Conestogo

For more instruction, refer also to on-line video tutorials found on the Agren website

Prepared by:
Kevin McKague, OMAFRA
February 7, 2017

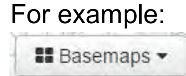
SoilCalculator: Start/Locate Site

1. GOOGLE: "Agren Soil Calculator"
2. Select: *Soil Calculator* | *Agren Tools*
3. On Agren's main screen, find "Login" (top right corner)
4. Type in your Username and Password (provided by Agren).

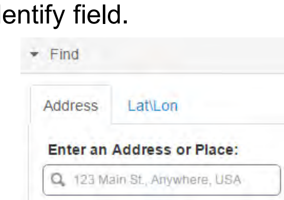


5. Select a Licence: select "Ontario"
6. Click on "SoilCalculator"

1. Locate the field of interest by navigating on screen. For example:
   - Zoom-in, zoom out with mouse
   - Locate using roads and map labels
   - Turn on "imagery" base map and visually identify field.

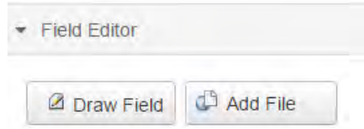


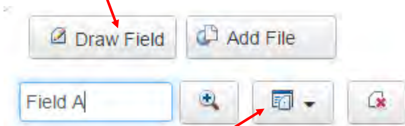
   - type in nearest town name (Address)
   - Type in GPS coordinates (Lat\Lon) of field



SoilCalculator: Define Field

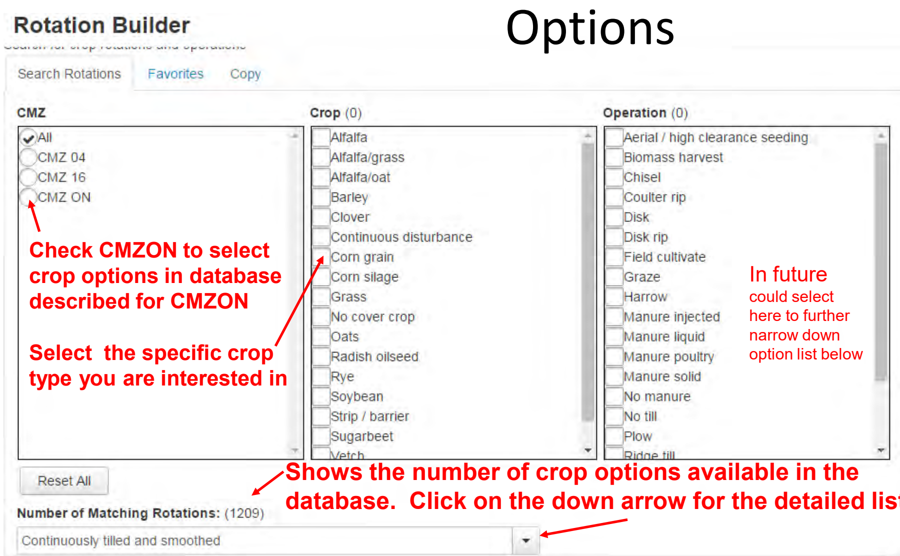
7. Click on “Draw Field” then click on map to start drawing field boundary.





8. Click here to define different crop management alternatives for the field you have identified (up to 10 fields per session and a maximum of 3 alternatives per field)

Selecting Management Options



Check CMZON to select crop options in database described for CMZON

Select the specific crop type you are interested in

In future could select here to further narrow down option list below

Shows the number of crop options available in the database. Click on the down arrow for the detailed list

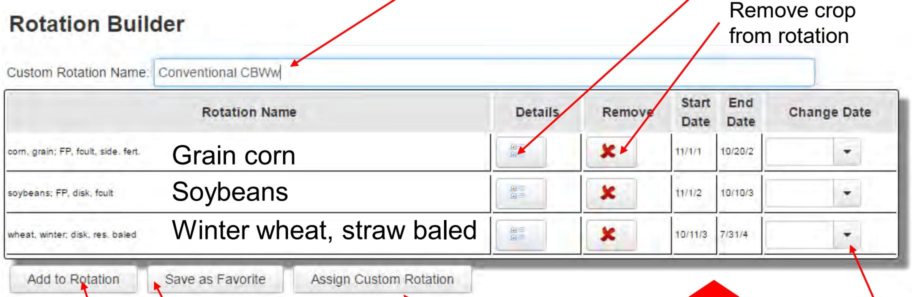
Refer to List of Tillage and Management Codes used by RUSLE2 for Ontario provided in Workshop packet

Building Rotations

Enter a rotation name here

View cropping and tillage practice details here

Remove crop from rotation



Save rotation as a "Favourite" for future use

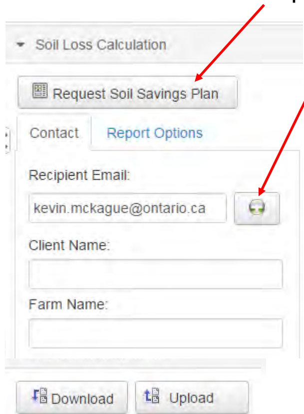
Assign this rotation to current "Alternative"

Check that dates make sense. If not, adjust here

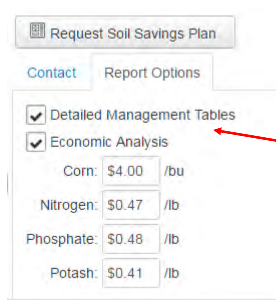
Click here to add another crop year to the rotation. Note a crop year begins just after previous crop harvest and ends at current crop's harvest.

Soil Loss Calculation

Request Soil Savings Plan - This sends input to the Agren server where calculations are completed and results returned to you by e-mail (~1hr)



Add more email addresses here if want report sent to others



Before you send report, check the report options you want included and adjust default values

Session management area lets you save (download) your session for later reloading (upload)

Check E-Mail for Report

Field		Hectares
St Agatha -E	--	30.1
St Agatha - W	--	15.84

Soil Savings Plan.pdf

Attached to the report is a summary document called *Soil Savings Plan.pdf*.

Other documents are also sent, consisting of shape files and raw data files that can be used in standard GIS software (e.g. ArcMaps) to prepare custom reports and maps.

SoilCalculator Practice Exercises

or use fields you are familiar with

Note: Some bottomland soils are missing K factor data and so will not return mapped results as shown here as an example

SoilCalculator Practice Exercise 1 Crosshill Area Field

Lat\Long: 43.548301, -80.794303

Alt 1: Continuous Soybeans
Fall plow, plant 30” rows

Alt 2: Corn-Soy-Winter Wheat rotation
Fall plow all crops except disk in advance of planting winter wheat.

Alt3: Corn-Soy-Winter Wheat rotation
No-till all crops (double disk openers, fluted coulters)

See worksheet packet for example “Soil Savings Plan.pdf” output

SoilCalculator Practice Exercise 2
Drayton Area Field

Lat\Long: 43.741436, -80.661765

Alt 1: Corn-Soy-Winter Wheat rotation
Fall plow all crops except disk in advance of planting winter wheat.

Alt 2: 2 years Corn-1 Year spring Barley (underseeded)-3 years Alfalfa /Hay
Fall plow corn and barley

Alt3: Corn-Soy-Winter Wheat rotation
No-till all crops (double disk openers, fluted coulters)

See worksheet packet for example “Soil Savings Plan.pdf” output

SoilCalculator Practice Exercise 3
Wellesley Area Field

Lat\Long: 43.457964, -80.801399

Alt 1: Corn-Soy-Winter Wheat rotation
Fall plow all crops except disk in advance of planting winter wheat.

Alt 2: Corn-Soy-Winter Wheat rotation
No-till all crops (double disk openers, fluted coulters)

Alt3: Corn-Soybean rotation
Fall plow

See worksheet packet for example “Soil Savings Plan.pdf” output

Appendix 4: Summary of Survey

Soil Erosion Tools Workshop- Feb 7, 2017
Feedback Survey Summary

1. Area of Expertise:

CCAs: 8 **Extension**: 4 **Technical**: 4 **Other**: 6 (community organization, GIS Analyst, Water Quality specialist with CA)

2. Are farmers asking you for assistance with addressing erosion issues in their fields?

No: 8 **Yes**: 10 (Those that answered yes were: extension staff (4), CCA (4), Community org, govt, Env specialist, water quality specialist)

If yes, what kind of assistance are they requesting and do you know why they are requesting it?

- grant system to retire land/take out of production. People on ground to run Agren-like tools OR connect similar outputs from retail to CA's
- Modelling- predictions, spatial analysis
- On a general scale, I think farmers are interested in mitigating erosion issues as they relate to economics on the farm
- Discussion of cover crops, funding
- Should I keep this land in production? How much P am I losing in my sediment?
- Design of erosion control structures
- Determine where it is worst and what is the best/most efficient solution?
- I want to improve soil mapping and zone management creation
- usually funds to support erosion control structures (water quality specialist comment)
- Requests have been minimal in past, but more interest has been recently expressed. Interest is usually expressed wanting help with erosion control design and cover crop types.
- I don't think they're thinking of other options than no-till, residue

3. Are you currently using any erosion prediction tools for your clients?

No: 14 **Yes**: 5 (includes Ag solver with RUSLE2, USLE (2), GIS approaches such as SPI, SWAT)

4. Do you think you would use the Soil Calculator this year if you had access to it?

No: 1 **Not Sure**: 6 **Yes**: 13

How often do you think you would use it?

- 20x on another project

- Possible link/layer on Ag-maps? Need access to better contour interval information to capture slope and slope complexity
- When I come across fields with issues that are not related to fertility
- To policy as a potential tool, perhaps in presentations
- Once a month
- Less than a dozen, when approached
- 5-10 times
- Fall/Spring- daily, run through fields to be sampled
- Depends on how convincing we can be to get farmers to address erosion issues
- I would take printouts with me to site visits, approx 25 per year
- Presentation/awareness tool

5. Do you think you would use RUSLE2 if you had access to it?

No: 4 **Not sure**: 8 **Yes**: 5

How often would you use it?

- There would likely need to be programs/incentives to encourage producers to access/utilize RUSLE2 and Soil Calculator information
- I have access but so far there is no interest
- 10-20 times
- more frequently on a client by client basis
- When I have specific questions from growers about erosion rates from simple slope fields. 2-5 times per year.
- Presentation and awareness tool

6. Which outputs from the Soil Calculator do you find most useful or applicable?

- costs/economic returns for farmers of soil/nutrient/yield loss, options to buy into to remediate (4)
- sediment would be great
- I see potential value in most output from the Soil Calculator
- Interesting to see gains/loss areas in the field
- scenarios that compare soil loss using different management practices
- Zone creation= better farm management
- Export maps to other platforms
- 10 year average, custom rotation, within and off field soil loss
- Tons/acre soil loss- **cm/10 years (3 comments)**
- Field loss spatial differences on a map. Yield loss and nutrient loss if accurate
- Shapefiles of economics of the alternatives/ slope steepness
- Not sure yet. I haven't worked with it yet.
- Soil savings plan
- The mapping showing zones of high and low erosion and the bar graph showing percent of field at each erosion rate.
- Show different crop rotation impacts

7. Which outputs from Soil Calculator do you find least useful or applicable?

- Limit to 1 field, doesn't showcase point of exit on the field
- Tonnes of soil' means nothing to farmer unless it is taken to nutrient loss or yield loss ($$)
- Economics- $ figures not correct for ON- will be more useful with Ontario data
- Received error message on my first soil savings plan, couldn't figure out how to fix it
- The slope steepness map/chart isn't extremely useful in its current state
- Unsure if field loss average is delivery which is the useful calculation
- Not sure yet, need to play with it (2 comments)
- Soil map layer- usually already know this
- It would be great if it could grab more data automatically- soil type, elevation maps, crop rotations incorporated with other software.

8. Ideas on using output from Soil Calculator tool?

- Reduced P runoff by reducing erosion. Demonstrate different practices and their input on erosion control
- Include yield parameters
- Identify areas and quantify spacial loss
- Need to take it to economic response to drive farmer uptake
- Will there be the ability to overlay a soil map from Soil Calculator with other software
- Prioritizing BMP placement
- Show benefit of incorporating cover crops
- I would see this being used in targeted situations ie. Specific subwatershed- approach farmers and do soil calculator with them. Emphasize BMPs
- Demonstration but confidence in economic impact is still lacking
- Economics- build management zones
- Economic losses will sum up the effects of soil loss.(4 comments)
- Although farmers often know when their gully erosion is occurring, they have less knowledge of where rill or sheet erosion is occurring: this tool will help with onsite consultations.

9. The Soil Calculator tool was developed for a small area in Ontario. This pilot was paid for by OMAFRA to explore the applicability of it to Ontario databases. Do you believe there is value in further developing this tool in Ontario?

No: 0 **Not sure**: 6 **Yes**: 11 (But need to focus on the 'So what', why would a grower invest or change)

If yes, how do you think the Soil Calculator tool could be funded to expand it across Ontario?

Full govt funding: 5 **Partial funding**: 8 **Private ownership/licenses**: 2

List potential partnership suggestions

OMAFRA, CA/Cons Ontario (2), Retail outlets (2), MOECC, Farm Association, SMS Incorporated

10. Do you think CCAs, crop input supply/service companies, extension staff, CAs or farmers would pay for a license or subscription to have access to this tool?

	Yes	No	Not sure	Comments
CCAs	5	2	9	Lower cost but enough to make it valuable
Crop Input Supply/ Service Companies	5	2	9	
Extension Staff	5	1	8	
Conservation Authorities	8	1	7	Depends on cost but CCAs and Cas would like it to motivate decision-making discussions
Farmers		11	4	Doubt it unless substantial acreage

11. Any other comments?

- Input farmers yield potential index or map and link to economic cost of loss balance sheet under each alternative
- Quality of output is only as good as the quality of the input data and credibility
- Need to integrate gully/ephemeral erosion output
- What are the connections to off-farm sediment delivery?
- The functioning needs to improve more- drop-down menu options to select crop, tillage, etc. Too much to sort through otherwise
- Tool is very interesting to quantify movement in a field. Does not show where it exits the field
- Need to look further at economics
- Add cover crop options
- Ag groups (eg. Farmer representatives) are interested in what does this mean for policy? How confident can they be in the data behind the calculations? Will max soil loss become a regulation?
- Need to demonstrate the value before CCAs and crop input suppliers would see the use. Could see it being a tool for CAs and extension staff when approached by farmers, they could whip up a map and pick BMPs tailored to the land.
- The productivity goals of a producer need to be related to erosion rates to make the application of this technology most applicable
- Import boundaries or google earth images; export contours; depending on accuracy of imagery, erosion mapping can be an added layer for management zones
- The underlying data drives the application. Elevation model and soils- tied to elevation. Until the province has good consistent elevation models and updated soils using elevation then it is not worth it. Spend money here first to get good data (GIS survey respondent)
- I am thinking that yield maps are what management decisions might be based on. The maps are in the 'growers' heads already. The people that need these maps might be the CCAs or the extension people to know where to 'target' the BMPs. So it is not clear to me what 'benefit' there is to the producer at this stage.
- To get wide-scale adoption of a tool of this nature, it would be best to tie its use to existing programs, or develop a new provincial program with technical advice/extension to deliver it to farm community
- Realistically, the farmer, CCA, etc. knows where there is erosion and will be hard to sell software to calculate how much. Too much work, should be more incorporated with other software to automate.

Appendix 5: List of Participants

Name	Organization
Anne Loeffler	Grand River Conservation Authority
Don King	Soil Research Group
Felix Weber	Ag Business & Crop Inc
Gabe Ferguson	Ontario Ministry of Agriculture, Food and Rural Affairs
Greg Kitching	Brookside Laboratories
Jason Van Maanen	Veritas
Jill Marshall	Grand River Conservation Authority
Kelly O'Connor	A&L Canada Laboratories Inc.
Kevin McKague	Ontario Ministry of Agriculture, Food and Rural Affairs
Mark Eastman	Credit Valley Conservation
Matthew Zeibari	Agromart Group
Mike Buttenham	Grain Farmers of Ontario
Mike Wilson	Advanced Agronomy Solutions Manager
Nicole Rabe	Ontario Ministry of Agriculture, Food and Rural Affairs
Ross Kelly	Ontario Ministry of Food, Agriculture and Rural Affairs
Sam Bradshaw	Ontario Pork
Tracey McPherson	Ausable Bayfield Conservation Authority
Zoe Green	Grand River Conservation Authority