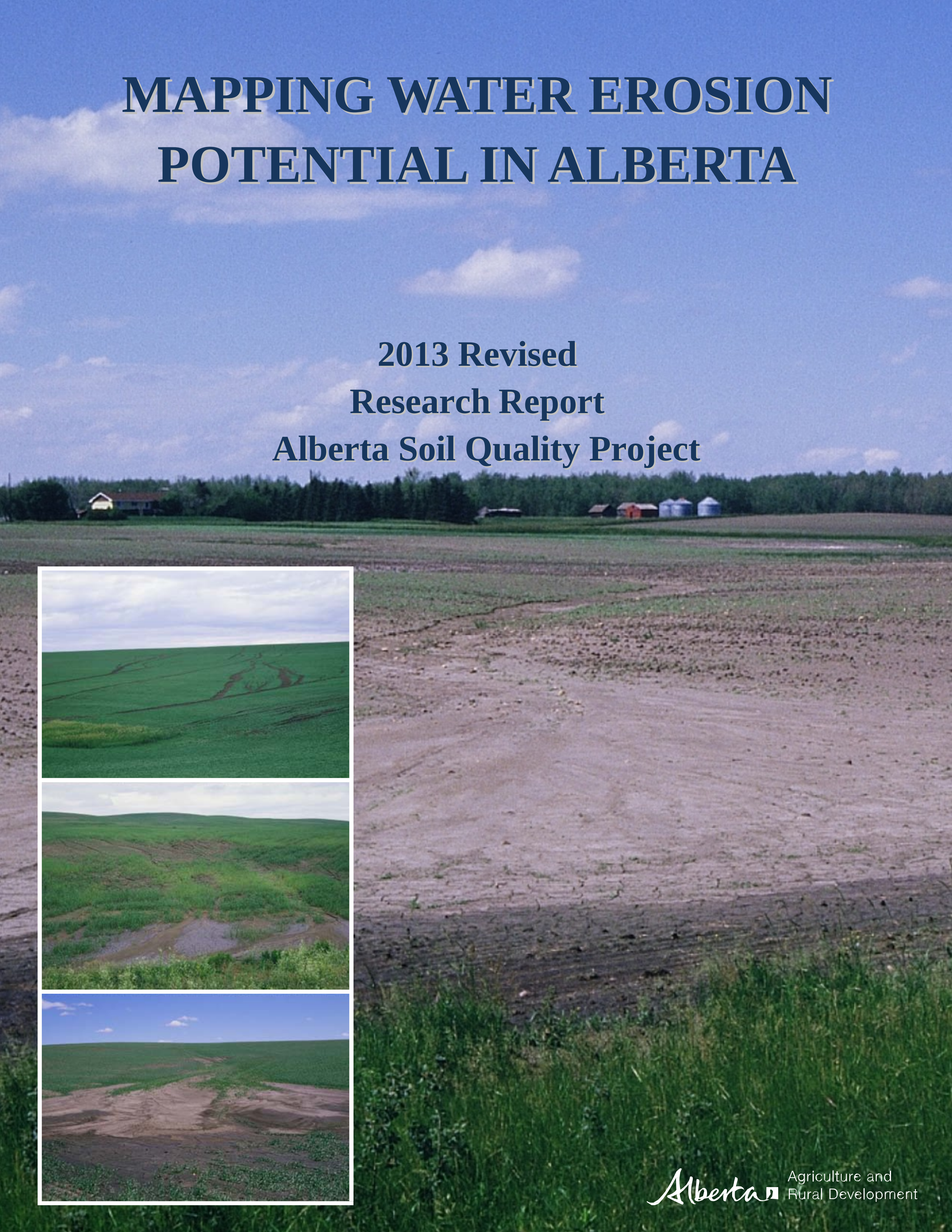
MAPPING WATER EROSION POTENTIAL IN ALBERTA

2013 Revised

Research Report

Alberta Soil Quality Project



Alberta Agriculture and Rural Development

MAPPING WATER EROSION POTENTIAL IN ALBERTA

Andrzej T. Jedrych[1] and Tim Martin[2]

[1] Water Quality Branch,
Alberta Agriculture and Rural Development,
Edmonton, Alberta, Canada

[2] Sustainability Metrics
Agriculture and Agri-Food Canada
Ottawa, Ontario, Canada

2013 Reaserch Report
Revised

Alberta Soil Quality Project

Citation

Jedrych, A.T. and Martin, T. 2013. Mapping water erosion potential in Alberta. Research report prepared for Alberta Soil Quality Project. Revised. Alberta Agriculture and Rural Development, Edmonton, Alberta, Canada. 45 pp.

Published by
Water Quality Branch,
Alberta Agriculture and Rural Development,
Edmonton, Alberta, Canada

Printed in Canada

Abstract

A map displaying water erosion potential at 1:100 000 scale was prepared for agricultural land in Alberta. The map involved calculation of erosion rates for 26 819 AGRASID soil polygons using the Water Erosion Prediction Project (WEPP) model. In the calculation, erosion rates were a function of polygon-specific information relating to climate, soil, and landscape conditions, and uniform landuse (summer fallow) scenario.

The WEPP model predicted erosion rates that ranged from 0 to 783 Mg ha^{-1} yr^{-1}. Rates were the lowest on flat hillslopes and the highest on hillslopes adjacent to river valleys where the slopes were greater than 20%. These erosion rates were generalized into five classes to prepare a water erosion potential map. According to this classification, 67% of the AGRASID polygons had low or negligible erosion potential, 14% moderate, and the remaining 19% of the polygons had either high or severe erosion potential. Additional statistical analysis showed that the improvement districts of Kananaskis and Waterton had the highest proportion of severe water erosion risk areas within the agricultural area of their respective municipalities, and the counties of Beaver and Barrhead had the lowest erosion risk rates.

A land-cover mask was prepared to evaluate the relevancy of the water erosion potential map. The test involved visual comparison of water erosion classes against the landuse classes derived from 1993 satellite image interpretation (land-cover mask). In this comparison, it was expected that areas of high or severe erosion potential would be under permanent cover, and areas of negligible and low erosion potential would be under annual crop cover. For the majority of the polygons, this was true. However, there were a small number of polygons that did not meet this assumption, and these polygons need further investigation to explain the discrepancies.

Acknowledgments

The authors wish to thank Jason Cathcart, Tony Brierley, Tom Goddard, Wayne Pettapiece, and Barry Olson for reviewing the 2006 report, and Longin Pawlowski and Gerald Stark for preparing the maps and front page coverAbstract

Table of Content

List of Figures

List of Tables

List of Appendices

1 Introduction

The impact of water erosion on soil quality is recognized as an important degradation process affecting land productivity and surface water quality in Alberta. Numerous studies reported varied annual average soil loss rates (AASLR) for rainfall and snowmelt events. Chanasyk and Woytowich (1987) reported that 1982 and 1983 snowmelt events accounted for the majority of annual runoff and soil losses. They found that the AASLR from a 75-m long and 5% steep fallow plot was 1.15 Mg ha^{-1}. However, Van Vliet and Hall (1991) measured an AASLR of 5.0 Mg ha^{-1}on a 22-m long and 13% steep plot during a 6-yr study. In the study, rainfall events accounted for 62% of the total soil loss under a summer fallow-canola-barley rotation. Toogood (1963) reported a 2.00 Mg ha^{-1} AASLR from a 21.6-m long and 10% steep fallow plot. This study was conducted on highly productive soils in central Alberta. Jedrych et al. (2006a) reported AASLR of 24.33 Mg ha^{-1} from a 0.5-ha microwatershed (4.3% slope) on Solonetzic soils in central Alberta. In a 4-yr study, an extreme rainfall event (50-yr return period) on a fallow field caused 65.50 Mg ha^{-1} soil loss that accounted for more than 65% of 4 yr of total soil loss.

In the above studies, the AASLR varied dramatically depending on the site-specific landscape conditions, soil properties, land use, and weather conditions. Most of the time, very high water erosion rates were generated by extreme rainfall or rapid snowmelt events that occured on excessively cultivated soils with low permeability and on steep slopes.

A number of scientists have studied the effects of variability of climate, soil, landscape, and landuse on water erosion potential. Wischmeier (1976) developed the most widely accepted model called the Universal Soil Loss Equation (USLE). The USLE model is based on 40-yr of data collected from 22-m long and 9% steep plots thoughout the United States and predicts AASLR through multiplication of five factors: rainfall intensity (R), soil erodibility (K), topography (LS), crop cover (C), and conservation practice (P). In Alberta, Tajek et al. (1985) and Tajek and Coote (1993) adopted this empirical model to assess water erosion at the 1:1 000 000 scale.

Recent improvements in water erosion prediction technology supported with field measurements have enabled scientists develop process-based models. Rather then multiplying single factors, these models simulate the actual processes controlling water erosion, and therefore, can be applied to a wider range of conditions. The United States Department of Agriculture's Water Erosion Prediction Project (WEPP) model is a good example of this technology (Flanagan and Livingston 1995). "The model is based on fundamentals of erosion theory, soil and plant science, channel flow hydraulics, and rainfall-runoff relationships, and contains hillslopes, channels, and impoundments as the primary components" (Ascough et al. 1997). The model can be run either in a single storm or a continuous simulation mode in a hillslope or a watershed application. Alberta Agriculture, Food and Rural Develpment selected WEPP for quantifying erosion potential in this project since extensive work has been done to adopt the model for Alberta conditions (Jedrych et al. 1995; Wright and Vanderwel 1998 unpublished).

The objectives of this project were to:

1. update the existing Alberta water erosion map of Tajek and Coote (1993) using the newest water erosion prediction technology, results from the most recent water erosion studies in Alberta, and recently developed climate and landform databases,
2. identify erosion prone areas at the 1:100 000 scale for delivery of extension programs emphasizing recommendations for better management practices in Alberta.

2 Development of WEPP Input Database

2.1 Scale of WEPP Application

Climate and soil-landscape information for WEPP input were prepared at two different scales. The climate information was derived for the Soil Landscapes of Canada (SLC) database (Shields et al. 1991). The SLC database uses 1:1 000 000 scale and identifies 894 polygons in Alberta. The soil and landscape information was derived from the Agricultural Region of Alberta Soil Inventory Database (AGRASID) (Alberta Soil Informsation Centre 2001) using an approach developed under the Canada - Alberta Environmentally Sustainable Agriculture (CAESA) Soil Inventory Project (SIP). The AGRASID database uses 1:100 000 scale and outlines 28 370 polygons in the agricultural region of Alberta. In this project, the WEPP simulations were conduced at the AGRASID scale, since this scale represents the most detailed level of soil information available in Alberta.

2.2 WEPP Input Data Requirements

The WEPP model requires the input of four datasets, which characterize climate, soil, landscape, and land management conditions. In this project, the hillslope application was used because the AGRASID database defines each soil polygon with 1 of 53 landform models. Each landform model can be represented by a single idealized hillslope model.

2.3 Climate Input File

The climate input datasets consisted of 43-yr of daily values of total precipitation, precipitation intensity, maximum and minimum temperatures, solar radiation, wind speed and direction, and dew-point temperature. These daily values (except precipitation intensity) were estimated for each SLC polygon using observed data from the nearby climate stations under the Alberta Environmentally Sustainable Agriculture (AESA) Soil Quality Program (Shen et al. 2000).

2.3.1 Esimating Daily Precipitation Characteristics from Existing 60-min Data

Precipitation in the WEPP input file was characterized by storm daily total precipitation (P_{cp}), duration (D), ratio of time to storm peak over storm duration (Tp), and ratio of 15-min maximum storm intensity over average storm intensity (Ip).

The procedure to calculate daily rainfall characteristics used a three-stage approach. First, two sets of daily storm characteristics were prepared using 60- and 15-min data, and WEPP sensitivity was assessed in relation to the input of these data sets. Then, the results from application of 60-min daily storm characteristics (D_{60}, Tp_{60}, and Ip_{60}) were compared with the results from 15-min data (D_{15}, Tp_{15}, and Ip_{15}) and the correlation coefficients were calculated. Finally, daily storm characteristics were calculated first for the SLC polygons where the selected climate stations were located, and then these daily storm characteristics were extrapolated to the remaining SLC polygons.

Testing WEPP sensitivity to the resolution of precipitation input data. The sensitivity test was conducted using 4-yr of climate, runoff, and soil loss data from the Tofield research site (Jedrych et al. 2006). Two sets of WEPP climate input files were prepared for the site using 15- and 60-min datasets. The WEPP simulations were run separately for these sets of data, and the predicted runoff and erosion values were compared with the observed field values. In addition, a "model efficiency" method (Nash and Sutcliffe 1970) was used to evaluate the impact of these two climate files on the output of the WEPP model. The method used the following eqution:

$$M = 1 - \frac{\sum_{i=1}^{n} (Oi - Pi)^2}{\sum_{i=1}^{n} (Oi - \overline{O})^2}$$

Where: M is model efficiency
Oi is observed data values
Pi is predicted data values
n is number of observations
$\bar{O}$ is mean Oi for the entire observation period

In this method, an M value of one indicates perfect agreement between an average annual observed and model predicted value. However, if M equals zero, it indicates that the predicted values are no better than the observed mean. Furthermore, when M is less than zero, it indicates that the model predictions are worse than using the observed mean.

Application of 15-min rather then 60-min storm characteristics showed that WEPP efficiency (M) in predicting runoff increased from 0.29 to 0.72, and in predicting soil loss increased from 0.36 to 0.65. This accounted an increase of model efficiency of 148% for runoff and 80% for soil loss.

Correlation between storm characteristics derived from 15- and 60-min precipitation datasets. The correlation between 15- and 60-min precipitation data was estimated using separate precipitation data from the Tofield, Threehills, and Breton research stations. First, the 15-min values from the three stations were combine into one file and the 60-min values into a second file. Next the correlation coefficients between D_{60} and D_{15}, Tp_{60} and Tp_{15}, and Ip_{60} and Ip_{15} were calculated for corresponding storm events within each station. The data showed that there was a strong correlation between D_{60} and D_{15}, $r^2 = 0.91$ (Figure 1), and between Ip_{60} and Ip_{15}, $r^2 = 0.87$ (Figure 2).

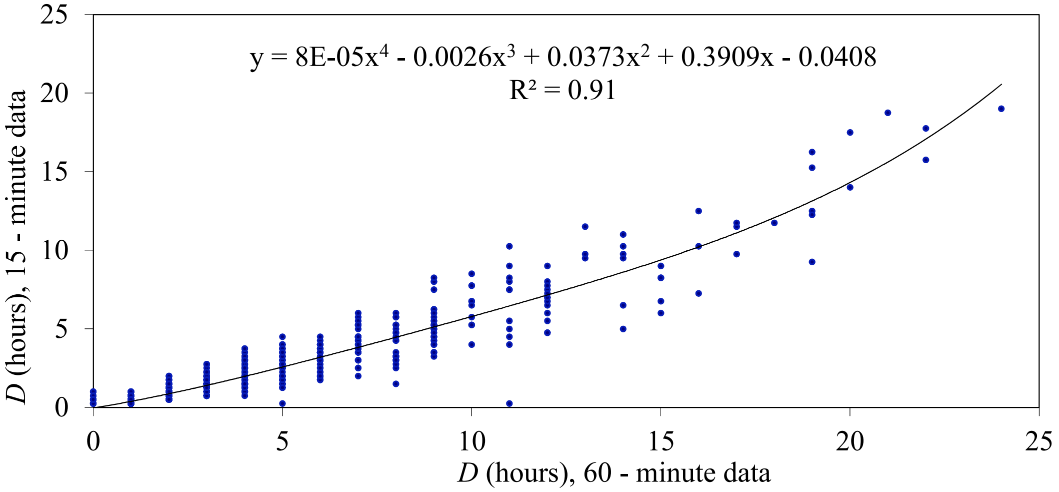


Figure 1. Comparison of storm durations (*D*) using 15- and 60-min precipitation data from the Threehills, Breton, and Tofield stations.

The correlation between the Tp_{60} and Tp_{15} values yielded an r^2 of 0.38. Due to the poor correlation and the fact that the *Tp* vales have low sensitivity for the WEPP output, the 60-min *Tp* values were assumed adequate for WEPP simulation.

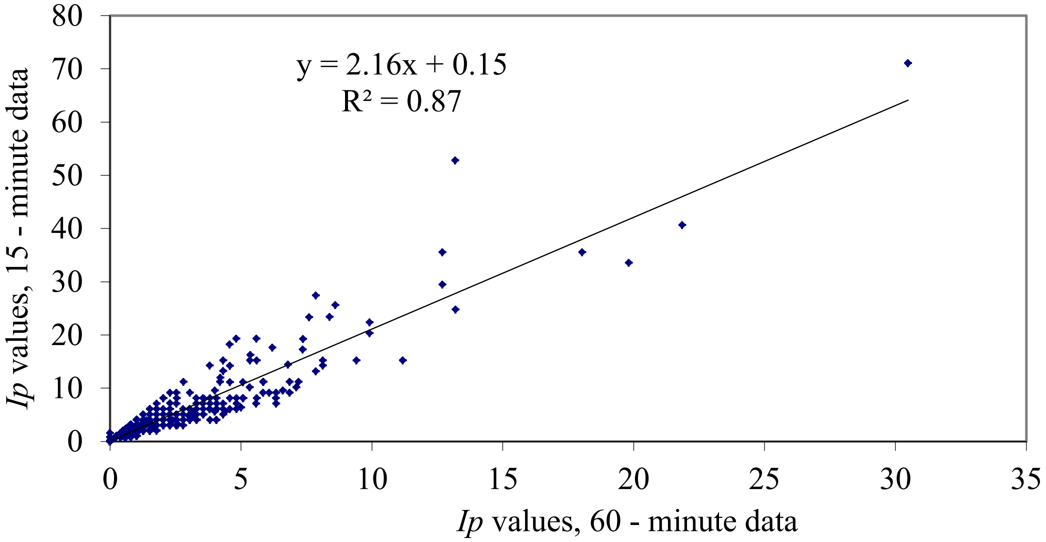


Figure 2. Comparison of storm *Ip* values using 15- and 60-min precipitation data from the Threehills, Breton, and Tofield sites.

Extrapolation of earlier estimated daily storm characteristics from the selected climate stations to remaining SLC polygons. Hourly stations that had at least 15-yr of precipitation data were selected from all the available stations in Alberta. Based on this criterion, 20 stations were chosen for calculation of daily P_{cp}, *D, Tp*, and *Ip* values. The existing data provided means for calculating precipitation characteristics for selected SLC polygons where the stations were located and for extrapolating these values to the remaining SLC polygons.

First, the calculated hourly D_{60} and Ip_{60} values were adjusted for the difference between 60- and 15-min precipitation data using the following two equations:

$$D_{15} = 8E\text{-}05\ D_{60}^4 - 0.0026\ D_{60}^3 + 0.0373\ D_{60}^2 + 0.3909\ D_{60} + 0.0408$$
$$Ip_{15} = 2.16\ Ip_{60} + 0.15$$

Where: D_{15} = storm duration estimated using 15 min precipitation data
D_{60} = storm duration estimated using 60 min precipitation data
I_{15} = ratio of 15-min maximum storm intensity over average storm intensity
I_{60} = ratio of 60-min maximum storm intensity over average storm intensity

Then the selected stations were classified into three "Raingroups". Climate stations in Raingroup 1 correspond to the Dark Brown and Brown soil zones, stations in Raingroup 2 correspond to the Black soil zone, and stations in Raingroup 3 correspond to the Grey and Dark Grey soil zones (Table 1).

Table 1. List of selected stations for calculation of daily P_{cp}, D, Tp, and Ip values.

Station #	Station Name	Soil Zone	Raingroup	Soil_code
3011880	CORONATION A	Dark Brown	1	2
3030856	BROOKS AHRC	Brown	1	1
3033880	LETHBRIDGE A	Dark Brown	1	2
3034480	MEDICINE HAT A	Brown	1	1
3036681	VAUXHALL CDA	Brown	1	1
3044200	MANYBERRIES CDA	Brown	1	1
3012210	EDMONTON NAMAO A	Black	2	3
3012295	ELLERSLIE	Black	2	3
3016761	VEGREVILLE CDA	Black	2	3
3023720	LACOMBE CDA	Black	2	3
3031093	CALGARY INT'L A	Black	2	3
3035201	PINCHER CREEK	Black	2	3
3015520	ROCKY MTN HOUSE	Grey	3	6A
3062244	EDSON A	Grey	3	6A
3064284	MAYERTHORPE 2	Dark Grey	3	4A
3070560	BEAVERLODGE CDA	Dark Grey	3	4
3072920	GRANDE PRAIRIE A	Dark Grey	3	4
3073146	HIGH LEVEL A	Dark Grey	3	4
3075040	PEACE RIVER A	Dark Grey	3	4
3081680	COLD LAKE A	Dark Grey	3	4A

Based on the precipitation frequency of P_{cp}, five precipitation ranges (P_{rg}) were proposed for each station (Table 2). As examples, three stations, one from each Raingroup, were selected to illustrate P_{cp} frequency distribution. It appeared that precipitation frequency was similar among Alberta stations. More than 90% of daily storms fall into the 0- to 5-mm P_{rg} and hardly any fell into the larger than 50-mm P_{rg}. Therefore, daily storm characteristics from all of the corresponding stations in each Raingroup were combined into one large file.

In the next step, the adjusted *D, Tp*, and *Ip* values were used to calculate probability of random distribution (odds) of these values in each P_{rg} and Raingroup (Appendices 1.1, 1.2, and 1.3). Finally, new daily *D, Tp*, and *Ip* value*s* were randomly assigned, separated for each P_{rg} and based on P_{cp} and associated odds values. In total, storm characteristics were developed for 894 WEPP files, one file for each SLC polygon.

Table 2. Frequency distributions of daily precipitation within selected precipitation ranges (P_{rg}) by climate station.

Selected Station	Vauxhall	Ellerslie	Peace River
Years of Data	34	32	33
Raingroup	1	2	3
Precipitation ranges (P_{rg}) (mm)	Frequency (%)		
< 5	94.81	91.13	92.77
$> 5 \leq 15$	3.66	6.44	5.53
$>15 \leq 30$	1.20	1.87	1.39
$>30 \leq 50$	0.29	0.37	0.31
> 50	0.03	0.17	0.00

2.3.2 Calculation of Dewpoint Temperature

The dewpoint temperature defines air temperature at which a parcel of air would be saturated. In this project, daily dewpoint temperature calculations were based on the definition included in the *Glossary of Meteorology* (Huschke 1959) using the following set of equations:

$$T_d = \frac{b - \sqrt{b^2 - C_3}}{C_4}$$

$$b = C_{15} * \ln(e)$$

$$e = RH * e_s$$

$$e_s = \exp(C_{15} - C_1 * T - C_2 / T)$$

Where: T_d = dewpoint temperature, e = vapour pressure, RH = relative humidity (ratio), T = air temperature (K), C_{15} = 26.66082, C_1 = 0.0091379024, C_2 = 6106.396, C_3 = 223.1986, C_4 = 0.0182758048

2.4 Slope Input Files

In the hillslope application of the WEPP model, the slope input file includes data relating to slope orientation, slope length, and slope steepness. Each hillslope can be divided into ten overland flow elements (OFEs) to describe variable soil, landform, and landuse conditions. In addition, each OFE can be defined with up to 20 pair-points of slope and distance values.

In order to prepare the WEPP-input slope file, each AGRASID landform model (Appendix 2) was converted into a hillslope profile composed of three OFEs representing upper-, mid-, and lower-landform position. The depressional landform position was not incorporated into the slope file because these positions are flat and often contain organic soils, which are not simulated in the WEPP model. A PERL script (Appendix 3) was prepared to automatically generate pair-points of slope and distance values based on one of four typical landform cases derived from the AGRASID database slope characteristics (Table 3). In each landform case, certain assumptions were made while generating slope-distances values (Appendix 4).

Table 3. Slope characteristics of AGRASID landform models.

Lf_pos[v]	Parameter	Landform Cases			
		Case_A	Case_B	Case_C	Case_D
Upper Slope (UPS)	SLP_prp (%)[z]	10	10	25	30
	Slp_50 (%)[y]	5	5	5	5
	Slp_80 (%)[x]	8	8	8	8
	Slp_len (m)[w]	100	100	125	125
Mid Slope (MID)	SLP_prp (%)[z]	40	10	25	30
	Slp_50 (%)[y]	5	5	5	5
	Slp_80 (%)[x]	8	8	8	8
	Slp_len (m)[w]	200	200	125	125
Lower slope (LOW)	SLP_prp (%)[z]	40	10	25	30
	Slp_50 (%)[y]	2.5	5	2.5	5
	Slp_80 (%)[x]	4	8	4	8
	Slp_len (m)[w]	200	200	125	125
Profile with (m)		100	100	100	100

[z] SLP_prp = % of area occupied by that component, [y] Slp_50 = 50th percentile slope value of cells in that landform position, [x] Slp_80 = 80th percentile slope value of cells in that landform position, [w] Slp_len = the slope length of that landform position.

In Case_A for example, Slp_80.LOW was less than Slp_50.MID (Figure 3). In this case, only one inflection point need occur. In Case_B, Slp_80.LOW was greater than or equal to Slp_50.MID. In this case, to meet the criteria that 50% of the slopes of MID be less than Slp_50.MID, a flatter area was introduced in the middle of MID, and this increased the number of inflection points to three. Similarly, between LOW and DEP, we may or may not need an inflection point. Case_C did not need the inflection point, while Case_D needed an inflection point.

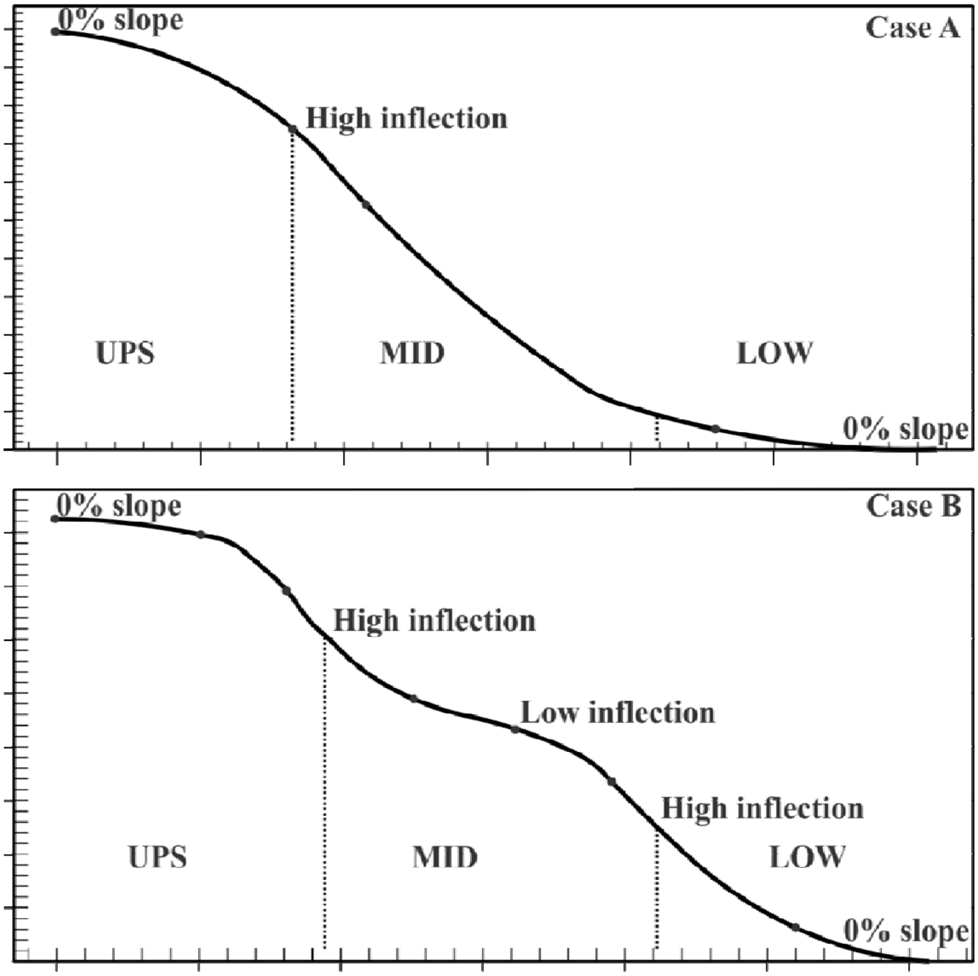


Figure 3. Graphical representation of Case_A and Case_B types of AGRASID landform models.

2.5 Soil Input Files

The soil input file was prepared for each OFE and included information on soil albedo; initial saturation level; baseline rill and interrill erodibility parameters; baseline critical shear; baseline effective hydraulic conductivity; cation exchange capacity; and content of sand, clay, organic mater, and rock fragments. The AGRASID database includes 1094 soil name series and describes soil properties of each layer to the maximum depth of 1.8 m. Most of the soil parameters required by WEPP are available in the AGRASID database. However, baseline effective hydraulic conductivity, soil albedo, and initial saturation of the soil surface were estimated using WEPP equations (Flanagan and Livingston 1995). Also, the baseline soil erodibility parameters were estimated using equations derived from Alberta water erosion studies (Wright and Vanderwel 1998 unpublished).

2.5.1 Baseline Effective Hydraulic Conductivity

In the WEPP model, the Green and AMPT equation defines infiltration in two ways. The equation can be solved using baseline effective conductivity K_b (mm h^{-1}) or time-invariant effective conductivity K_e (mm h^{-1}). In this project, the K_b equation was selected since it can be calculated using parameters available in the AGRASID database. When K_b was used, WEPP internally adjusted calculations to be a function of soil management and plant characteristics. The K_b represented the maximum hydraulic conductivity of freshly tilled soil and it was estimated using the following equations (Flanagan and Livingston 1995):

When soil clay content ≤ than 40%

$$K_b = -0.265 + 0.0086*SAND^{1.8} + 11.46*CEC^{-0.75}$$

When soil clay content > than 40%

$$K_b = 0.0088\exp(244/CLAY)$$

Where: $SAND$ and $CLAY$ are the soil sand and clay contents (%).
CEC is the cation exchange capacity of the soil (meq 100 g^{-1}).

2.5.2 Soil Albedo

Soil albedo represents a portion of solar radiation reflected back to the atmosphere. In this project, it was estimated for a dry soil surface using the Baumer (1990) equation:

$$SOL_{alb} = 0.6/\exp(0.4*ORGMAT)$$

Where: SOL_{alb} is soil albedo.
ORGMAT is the soil organic matter content (%) calculated as 1.72 times organic carbon content.

2.5.3 Initial Saturation

Initial saturation relates to soil conditions at the start of a simulation period, usually on January 1. Since this parameter is less sensitive to the model output in continuous simulation mode, it was assumed to equal 0.7 as recommended in the WEPP user manual.

2.5.4 Baseline Soil Erodibility Parameters

The baseline soil erodibility parameters consist of interrill erodibility (K_i), rill erodibility (K_r), and critical hydraulic shear (τ_c). These parameters define water erosion risk of freshly cultivated soil without crop residue present. Wright and Vanderwel (1998 unplublished) collected field data from 24 different soil/research sites in Alberta and develop the following equations.

Interrill erodibility (K_i). Relates to detachment and transport of soil particles due to rainfall action and shallow sheet flows. Measured K_i values were correlated to sand content as:

$$K_i = 702000\exp^{(0.035*SAND)} \qquad r^2=0.70$$

When *SAND* > 80% assumed 80%.

Rill erodibility (K_r). Relates to water erosion generated by concentrated flows originating from the interrill areas. Measured K_r values were also correlated to sand content as:

$$K_r = 0.00684 + 0.0000065\exp^{(0.105*SAND)} - 0.000315*\mathrm{ORGMAT} \qquad r^2=0.77$$

When *SAND* > 80% assumed 80%.

Critical hydraulic shear (τ_c). Is the shear that must be exceeded to detach soil particles in the rill. Measured τ_c values were correlated to three different sand contents in one of the following equations:

When soil sand content < 20%

$$\tau_c = 2.99 - 0.20*ORGMAT \qquad r^2=0.51$$

When soil sand content ≥ 20% and ≤40%

$$\tau_c = -0.57 + 0.2*VFS \qquad r^2=0.67$$

When soil sand content > 40%

$$\tau_c = 3.14 - 0.05*SILT \qquad r^2=0.68$$

Where: *SILT* and *VFS* are the soil silt and very fine sand contents (%), respectively.

2.6 Distribution of Soils Along Hillslope

The AGRASID database provides information on a unique allocation of one or more soils series distributed throughout the slope positions in each soil polygon. In this project, each soil polygon was associated with 1 of 53 landform models (Appendix 2) for which pair-points of slope and distance values were are defined, and soils series were allocated along hillslope using an approached developed by MacMillan and Pettapiece (2000). In reality, each area identified by an AGRASID soil polygon may contain a large number of unique field-scale hillslopes and soils series. The single landform model is an idealized simplification of these. The AGRASID database includes landscape information for 26 819 soil polygons within the agricultural region of Alberta. Within the database, there are 1551 soil polygons that did not have any soil and hillslope information because they are classified as flood plains, lakes, wetlands, or urban zones. These polygons were excluded from WEPP simulations.

2.7 Land Management Input File

The land management input file has a dominant effect on WEPP predicted erosion rate. However, actual landuse data at the AGRASID polygon scale is not available in Alberta. Also, the goal of this project was to estimate erosion potential rather than actual erosion losses. For this reason, we standardized the landuse effect on water erosion by selecting continuous summer fallow practice for all AGRASID polygons. The fallow practice included application of field cultivator tillage on May 20, July 5, and August 15 in each simulated year. Though this represents an unrealistically extreme management condition, it does emphasize relative differences in erosion potential.

3 WEPP Simulation

Estimating water erosion for agricultural land in Alberta required running the 2004.7 version of the WEPP model nearly 27 000 times. Simulation at this scale would not be possible without automation. For this reason, nearly 1 200 lines of PERL script were written to minimize manual interaction with the model (Appendix 5). The script did the following, for each AGRASID polygon in succession:

(a) collected all the WEPP input data associated with the specific location and prepared the necessary input files in the required format,
(b) ran the WEPP model,
(c) reported model run success or failure,
(d) parsed specific values from different output files and saved them in an output summary file,
(e) deleted unnecessary WEPP run files and returned to step (a) for the next AGRASID polygon.

3.1 Discussion of WEPP Predicted Results

In the WEPP simulation, the predicted erosion rates ranged from 0 to 783 Mg ha^{-1} yr^{-1}. Generally, the predicted erosion rates were predominantly driven by soil landscape conditions defined in the AGRASID database. The lowest erosion rates were estimated for the flat hillslopes and the highest erosion rates were estimated for the steep slopes. Extreme erosion rates were predicted in river valleys where the hillslope steepness was greater than 20%. These extreme landscape conditions combined with a continuous fallow landuse contributed to unrealistically high erosion rates, greater than 200 Mg ha^{-1} yr^{-1} (Dennis Flanagan, Agricultural Engineer, USDA-ARS, pers. comm.). The results are to be interpreted in terms of relative erosion potentials, rather than for absolute erosion estimates.

It should be noted that the WEPP model predictions included four possible sources of error:

1. the AGRASID database can only approximate the real soil physical, spatial, and landform properties and their varibility;
2. the SLC polygon-scale climate data can only approximate the actual weather at the soil polygon scale;
3. continuous fallow simulation may overemphasize the role of slope on the estimated erosion throughout the agricultural area; and
4. the WEPP model has its own limitations.

Within the bounds of these limitations, this application of the WEPP model enabled a consistent methodology to estimate erosion potential for variety of soil, landscape, and weather conditions, and it is believed that the results adequately reflect the relative erosion potential among AGRASID polygons. The simulations can be refined in the future with the application of the newer versions of the WEPP model; additional landscape, climate, and soil data; and other management scenarios.

3.2 Development of Water Erosion Potential Map

Five erosion risk categories were selected to generalize erosion potential for the agricultural region of Alberta (Table 4). The selection of these categories was based on the frequency distribution of predicted erosion rates and provided a means to prepare a water erosion potential map (Figure 4). According to this classification, 67% of the AGRASID polygons have low or negligible erosion potential. It is anticipated that summer fallow practise implemented in crop rotation within these polygons will not contribute to high erosion rates. An additional 14% of polygons were categorized to have moderate erosion potential. Within these areas, some conservation tillage practice is recommended to avoid excessive soil losses. Crop rotation, for example, may limit application of deep fall cultivation and summer fallow. The remaining 19% of the polygons belongs either to the high or severe erosion categories. In most cases these polygons were identified as being characterized by steep hillslopes. Therefore, it is expected that agricultural land in these areas will be maintained under permanent crop cover, for example as hay or pasture land.

Table 4. Selected water erosion categories for preparing the water erosion potential map.

Water Erosion Risk Categories	Number of AGRASID Polygons	Proportion of Total Polygon Numbers (%)	Erosion Rate (Mg ha^{-1} yr^{-1})
Negligible	8,425	31	< 0.08
Low	8,840	33	≥ 0.08 to < 0.18
Moderate	4,170	16	≥ 0.18 to < 0.50
High	3,015	11	≥ 0.50 to < 3.5
Severe	2,368	9	≥ 3.5

Additional statistics were conducted to calculate the proportion (%) of water erosion categories within each municipality using the AGRISID defined soil polygon areas (Appendix 6). The data showed that improvement districts of Kananskis and Waterton have the highest proportion of AGRASID area categorized to have sever, high, and moderate erosion risk, while counties of Beaver and Barrhead have the lowest erosion risk.

4 Accuracy of the Water Erosion Risk Map

4.1 Preparation of Land Cover Mask

A land cover mask was prepared from a land cover map that had been prepared from satellite images acquired from October 1993 to June 1995 under the Western Grain Transition Payments Program (WGTPP) of Agriculture and Agri-Food Canada. That database identified 11 landuse categories. Only five of these categories were selected for the land cover mask: (a) forest, (b) lake/river, (c) non-agriculture, (d) rangeland/hay, and (e) wetland polygons. In addition, hydrography layer prepared by the Alberta Environment, Resource Information Management Branch in 2000 was added to the mask. The resultant land cover mask layer hid everything but areas of annual crop production (ACP). This delineated the erosion potential in these areas by overlaying the erosion risk map with the land cover mask (Figure 5).

4.2 Testing the Relevancy of the Water Erosion Risk Map

The test involved visual identification of predicted erosion potential within the ACP areas. It was assumed that normally these areas would be cultivated and they would have low to moderate erosion potential. Figure 5 showed that in fact the majority of ACP areas in Alberta displayed negligible, low, or moderate erosion potential. This observation supports our earlier assumption, and it gives credibility to WEPP predicted values. It also confirms that in most instances, ACP areas were correctly located with agricultural land of Alberta in terms of minimizing erosion due to land cultivation. Nevertheless, WEPP also predicted a small number of very high and severe erosion potential polygons within the ACP areas. Farther statistical analyzes showed that counties of Cardston and Wheatland have the highest percentage of severe and high erosion potential areas within the ACP areas (Appendix 7). These areas require further evaluation. There may be errors associated with the WGTPP land cover map, with the definition of soil and slope characteristics in the AGRASID database, in the climate database, or in the ability of the WEPP model to predict erodability in these situations. Or this may simply be due to the difference between the scale at which AGRASID represents the land and the scale at which farmers manage the land. The land represented by a single AGRASID polygon is actually composed of many different landforms at the field scale.

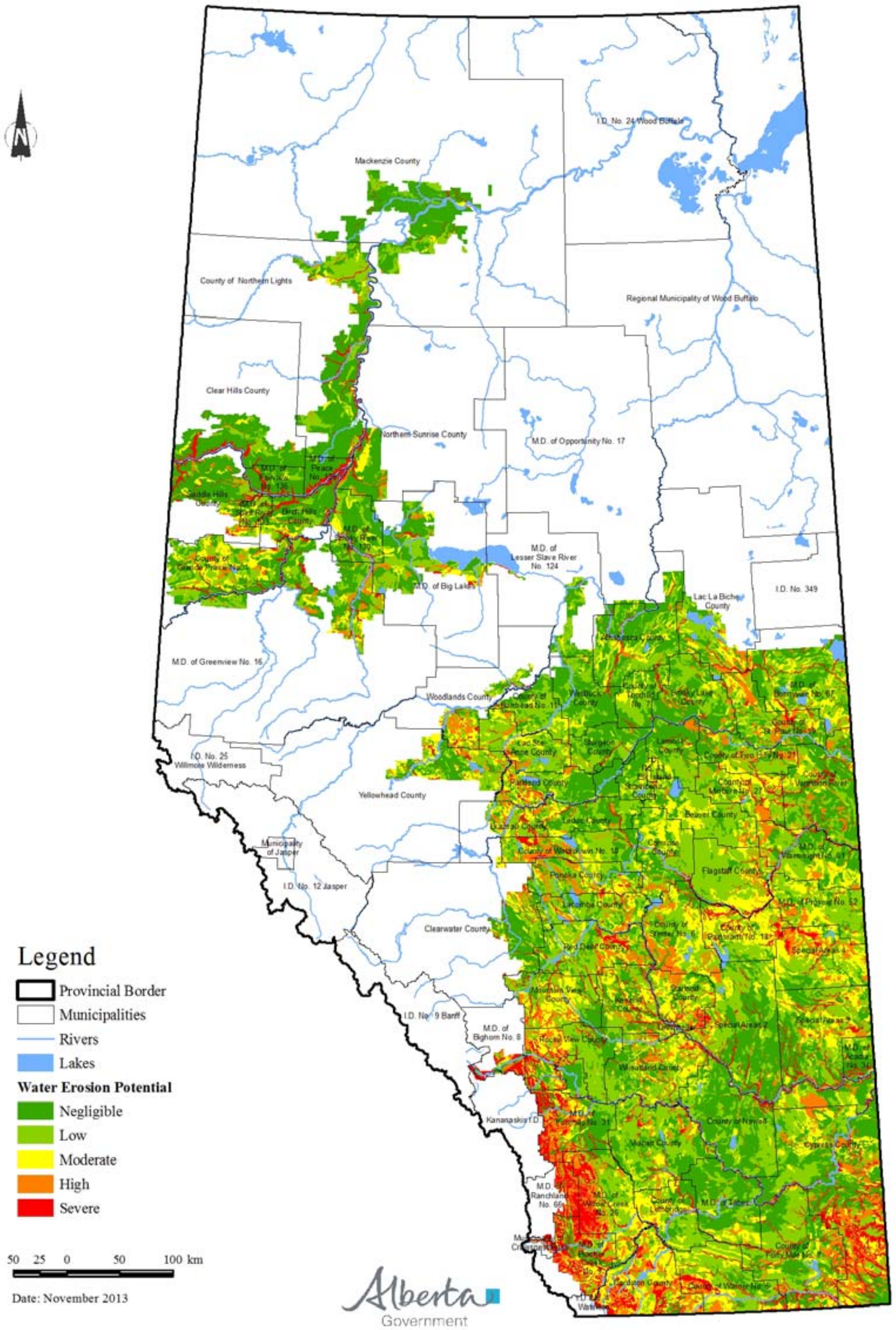


Figure 4. Generalized water erosion risk in Alberta under bare-soil summer fallow landuse conditions.

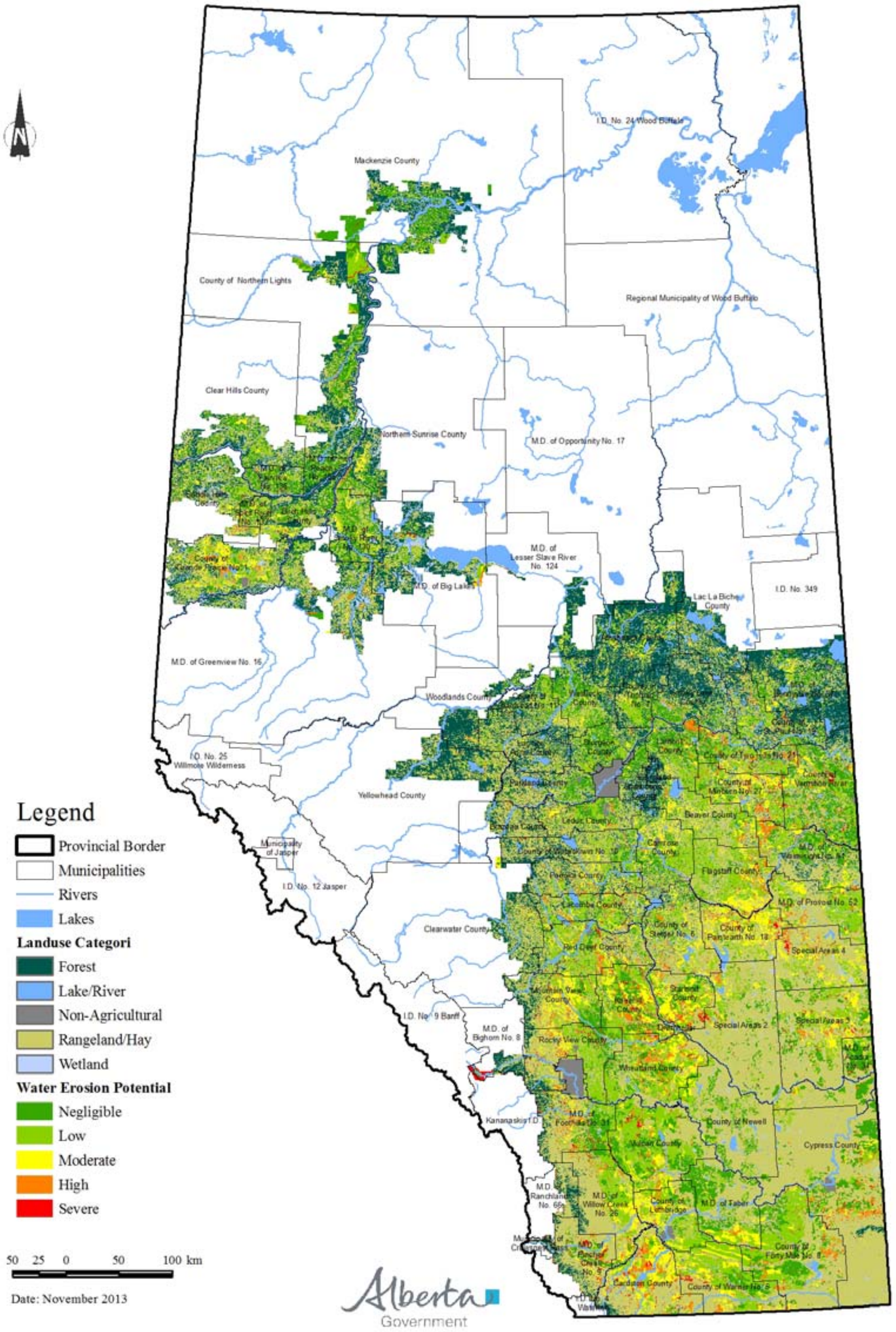


Figure 5. Water erosion risk map overlaid with the land cover mask.

5 Summary and Conclusions

A water erosion potential map was developed at a 1:100 000 scale for the agricultural area in Alberta. The map involved calculation of erosion rates for 26 819 AGRASID soil polygons using the Water Erosion Prediction Project (WEPP) model. The predicted erosion rates were a function of polygon-specific information relating to (a) one of 894 climate files each containing 43 yr of daily data, (b) one of 1097 soil series names, (c) one of 53 landform models, and (d) a uniform continuous summer fallow landuse scenario.

A procedure was developed to calculate daily storm characteristics using existing 15- and 60-min precipitation data from selected stations. The procedure involved (a) testing the sensitivity of WEPP output to the input of 15- and 60-min resolution precipitation data, (b) estimating the correlation between storm characteristics derived from 15- and 60-min precipitation data, and (c) extrapolation of earlier estimated daily storm characteristics from the selected climate stations to remaining SLC polygons.

A method was developed to convert AGRASID type landform models into WEPP format slope-input files. The method involved generating pair-points of slop and distance values based on one of 53 typical landform models, each of which fell into one of four landform “Cases”. A number of assumptions were required in this method, and PERL script was written to automate the conversion task. A second PERL script was prepared to automate WEPP simulations.

Predicted erosion rates ranged from 0 to 783 Mg ha^{-1} yr^{-1}. Erosion rates were the lowest on flat land and highest on hillslopes adjacent to river valleys where the slopes were greater than 20%. These erosion rates were further generalized into five classes and used to prepare a water erosion potential map. According to this classification, 67% of the AGRASID polygons have low or negligible erosion potential, 14% moderate, and the remaining 19% of the polygons had either high or severe erosion potential.

A land cover mask was used to test the accuracy of water erosion potential map. The test involved comparing the erosion classes against the landuse classes derived from satellite image interpretation. In this comparison, it was expected that areas of high or severe erosion potential would tend to be under permanent cover, and areas of negligible and low erosion potential would tend to be under annual cropping systems. This was observed for most polygons. A small number of polygons did not meet this assumption, and this suggests an opportunity to further investigate the causes of the discrepancies and potentially come to an improved understanding of the erosion potential of agricultural land in Alberta.

6 References

Ascough, J.C., Baffaut, C., Nearing, M.A., and Liu, B.Y. 1997. The WEPP watershed model: I. Hydrology and erosion. Trans. ASAE 40: 921-933.

Alberta Soil Information Centre. 2001. AGRASID 3.0: Agricultural Region of Alberta Soil Inventory Database (Version 3.0). J.A. Brierley, T.C. Martin, and D.J. Spiess (eds.). Agriculture and Agri-Food Canada, Research Branch; Alberta Agriculture, Food and Rural Development, Conservation and Development Branch. [Online] Available at http://www.agric.gov.ab.ca/asic [Access March 24, 2013].

Baumer, O.W. 1990. Prediction of soil hydraulic parameters. In: WEPP Data Files for Indiana. SCS National Soil Survey Lab. Lincoln, Nebraska, United States.

Chanasyk, D.S. and Woytowich, C.P.. 1987. Sediment yield as a result of snowmelt runoff in the Peace River Region. Can. Agric. Eng. 29: 1-6.

Flanagan, D.C. and Livingston, S.J. 1995. WEPP User Summary: USDA - Water erosion prediction project. NSERL report no. 11. [Online] Available at http://www.ars.usda.gov/Research/docs.htm?docid=10621 [Access March 24, 2013]

Huschke, R.E. (ed). 1959. Glossary of Meteorology. Amer. Meteor. Soc. 638 pp.

Jedrych, A.T., Wright, C.R., and Vanderwel, D.S. 1995. Water Erosion Research Annual Report 1994/1995. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta, Canada.

Jedrych, A.T., Abday, S., and Wright, C.R. 2006a. Monitoring **W**ater Erosion and Evaluation of WEPP and EPIC Models at the Tofield Site. Draft research report. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta, Canada.

MacMillan, R.A. and Pettapiece, W.W. 2000. Alberta landforms: Quantitative Morphometric Descriptions and Classification of Typical Alberta Landforms. Technical Bulletin No. 2000-2E. Research Branch, Agriculture and Agri-Food Canada, Semiarid Prairie Agricultural Research Centre, Swift Current, Saskatchewan, Canada. 118 pp. [Online] Available at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag6903 [Access March 24, 2013].

Nash, J.E. and Sutcliffe, J.E. 1970. River flow forecasting through conceptual model. A discussion of principals. J. Hydrol. 10: 282-290.

Shen, S., Dzikowski, P., and Li, G. 2000. Interpolation of 1961-1997 Daily Climate Data onto Alberta Polygons of Ecodistrict and Soil Landscape of Canada. Conservation and Development Branch, Alberta Agriculture, Food and Rural Development, Edmonton, Alberta, Canada. 60 pp. plus figures.

Shields, J.A., Tarnocai, C., Valentine, K.W.G., and MacDonald, K.B. 1991. Soil Landscapes of Canada Procedures Manual and User's Handbook. Publication 1868/E. Agriculture Canada, Ottawa, Ontario, Canada. 74 pp.

Tajek, J., Pettapiece, W.W., and Toogood, K.E. 1985. Water Erosion Potential of Soils in Alberta: Estimates Using a Modified USLE. Agriculture Canada Technical Bulletin. No. 1985-29, Ottawa. 35pp.

Tajek, J. and Coote, D.R. 1993. Water Erosion Risk, Alberta. Land Resource Research Centre, Research Branch, Agriculture Canada. Publication 5292/B. Contribution Number 92-05.

Toogood, J.A. 1963. Water erosion in Alberta. J. Soil Water Conserv. 6: 238-240.

Van Vliet, L. J. P. and Hall, J. W. 1991. Effects of two crop rotations on seasonal runoff and soil loss in the Peace River region. Can J. Soil Sci. 71: 533-544.

Wischmeier, W. H. 1976. Cropland erosion and sedimentation. Chapter 3 *in* USDA-EPA Control Water Pollution, Vol. II. U.S. GPO, Washington D.C., United States.

Wright, C.R. and Vanderwel, D.S. 1998. WEPP Soil Erodibility Parameters Adjusted for Northern Soils. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta, Canada. (draft).

7 Appendices

Appendix 1. Probability of random distribution (odds) of storm duration (*D*), ratio of time to storm peak over storm duration (*Tp*), and ratio of 15-min maximum storm intensity over average storm intensity (*Ip*) within the selected precipitation ranges (P_{rg}). Where n is number of observations.

Appendix 1.1 Raingroup 1

P_{rg} = 0-5 mm, n = 5460						P_{rg} = 5-15 mm, n = 1425						P_{rg} = 15-30 mm, n = 405						P_{rg} =30-50 mm, n = 83						$P_{rg} \geq$ 50 mm, n = 18					
D (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D*(h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*	
range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds
0.67	0.408	0.05	0.000	1.44	0.004	0.67	0.022	0.03	0.001	1.44	0.003	0.67	0.017	0.02	0.002	1.60	0.002	1.34	0.048	0.03	0.012	1.98	0.012	1.34	0.056	0.02	0.056	2.25	0.056
0.99	0.000	0.13	0.048	2.13	0.608	1.23	0.000	0.11	0.079	2.14	0.071	1.34	0.000	0.11	0.111	2.40	0.052	1.99	0.000	0.11	0.120	2.58	0.048	1.99	0.000	0.11	0.000	2.93	0.167
1.31	0.000	0.21	0.065	2.83	0.217	1.78	0.076	0.20	0.134	2.84	0.221	2.02	0.081	0.19	0.128	3.20	0.173	2.63	0.024	0.20	0.108	3.18	0.145	2.63	0.000	0.19	0.056	3.62	0.167
1.64	0.238	0.30	0.167	3.53	0.106	2.34	0.126	0.29	0.114	3.55	0.256	2.69	0.057	0.28	0.079	4.00	0.296	3.27	0.012	0.28	0.181	3.78	0.181	3.27	0.000	0.28	0.111	4.30	0.278
1.96	0.000	0.38	0.045	4.23	0.044	2.89	0.124	0.37	0.072	4.25	0.201	3.36	0.054	0.37	0.106	4.81	0.205	3.92	0.036	0.37	0.096	4.38	0.181	3.92	0.000	0.37	0.167	4.99	0.056
2.28	0.150	0.46	0.006	4.93	0.015	3.45	0.120	0.46	0.096	4.96	0.128	4.03	0.059	0.45	0.126	5.61	0.136	4.56	0.096	0.45	0.120	4.98	0.133	4.56	0.000	0.46	0.278	5.67	0.111
2.60	0.000	0.54	0.482	5.63	0.005	4.00	0.000	0.54	0.139	5.66	0.060	4.70	0.000	0.54	0.111	6.41	0.064	5.20	0.048	0.54	0.096	5.59	0.145	5.20	0.056	0.54	0.000	6.36	0.056
2.92	0.091	0.62	0.006	6.33	0.001	4.56	0.108	0.63	0.101	6.36	0.030	5.38	0.126	0.63	0.109	7.21	0.022	5.84	0.012	0.63	0.036	6.19	0.072	5.84	0.000	0.63	0.056	7.05	0.000
3.24	0.000	0.70	0.039	7.03	0.000	5.11	0.091	0.71	0.062	7.07	0.013	6.05	0.086	0.71	0.059	8.01	0.020	6.49	0.036	0.71	0.060	6.79	0.036	6.49	0.056	0.72	0.000	7.73	0.000
3.56	0.054	0.79	0.090	7.73	0.000	5.67	0.088	0.80	0.078	7.77	0.012	6.72	0.064	0.80	0.059	8.81	0.020	7.13	0.060	0.80	0.072	7.39	0.024	7.13	0.000	0.80	0.111	8.42	0.000
3.89	0.000	0.87	0.031	8.43	0.000	6.22	0.074	0.88	0.069	8.47	0.003	7.39	0.057	0.89	0.049	9.62	0.002	7.77	0.036	0.88	0.048	7.99	0.012	7.77	0.111	0.89	0.056	9.10	0.056
4.21	0.028	0.95	0.021	9.13	0.000	6.78	0.048	0.97	0.055	9.18	0.002	8.06	0.077	0.98	0.059	10.42	0.007	8.41	0.072	0.97	0.048	8.60	0.012	8.41	0.000	0.98	0.111	9.79	0.056
4.53	0.000					7.33	0.000					8.74	0.067					9.06	0.036					9.06	0.056				
4.85	0.019					7.89	0.034					9.41	0.000					9.70	0.024					9.70	0.000				
5.17	0.000					8.44	0.025					10.08	0.081					10.34	0.072					10.34	0.056				
5.49	0.007					9.00	0.025					10.75	0.044					10.99	0.072					10.99	0.000				
5.81	0.000					9.55	0.008					11.42	0.000					11.63	0.048					11.63	0.000				
6.14	0.003					10.11	0.009					12.10	0.047					12.27	0.048					12.27	0.056				
6.46	0.000					10.66	0.000					12.77	0.027					12.91	0.048					12.91	0.167				
6.78	0.001					11.22	0.013					13.44	0.020					13.56	0.048					13.56	0.056				
7.10	0.000					11.77	0.005					14.11	0.010					14.20	0.024					14.20	0.111				
7.42	0.001					12.33	0.002					14.78	0.010					14.84	0.048					14.84	0.056				
7.74	0.000					12.88	0.001					15.46	0.000					15.49	0.024					15.49	0.000				
8.06	0.000					13.44	0.001					16.13	0.015					16.13	0.024					16.13	0.167				

Appendix 1.2 Raingroup 2

P_{rg} = 0-5 mm, n = 8520						P_{rg} = 5-15 mm, n = 2576						P_{rg} = 15-30 mm, n = 763						P_{rg} =30-50 mm, n = 188						$P_{rg} \geq$ 50 mm, n = 53					
D (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*	
range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds
0.67	0.375	0.04	0.000	1.35	0.006	0.67	0.025	0.03	0.002	1.35	0.001	0.67	0.005	0.02	0.003	1.35	0.001	1.34	0.005	0.02	0.005	1.99	0.005	3.36	0.019	0.06	0.019	2.03	0.019
1.05	0.000	0.13	0.055	1.80	0.483	1.31	0.000	0.11	0.082	2.23	0.083	1.34	0.000	0.11	0.113	2.35	0.037	1.99	0.000	0.11	0.144	2.67	0.074	3.92	0.000	0.15	0.132	2.75	0.000
1.43	0.253	0.21	0.067	2.26	0.150	1.96	0.067	0.20	0.113	3.11	0.300	2.02	0.072	0.19	0.105	3.35	0.257	2.63	0.005	0.20	0.106	3.34	0.170	4.47	0.038	0.23	0.094	3.47	0.226
1.81	0.000	0.29	0.179	2.71	0.150	2.60	0.108	0.28	0.108	3.99	0.304	2.69	0.045	0.28	0.113	4.35	0.334	3.27	0.048	0.28	0.112	4.01	0.207	5.03	0.000	0.31	0.151	4.19	0.189
2.19	0.157	0.38	0.046	3.16	0.095	3.24	0.129	0.37	0.081	4.87	0.179	3.36	0.062	0.37	0.085	5.34	0.182	3.92	0.011	0.37	0.059	4.68	0.170	5.58	0.019	0.40	0.094	4.92	0.226
2.57	0.000	0.46	0.008	3.61	0.055	3.89	0.118	0.46	0.105	5.75	0.079	4.03	0.059	0.46	0.118	6.34	0.105	4.56	0.016	0.46	0.101	5.35	0.128	6.14	0.019	0.48	0.113	5.64	0.094
2.95	0.091	0.54	0.451	4.06	0.031	4.53	0.106	0.54	0.154	6.64	0.029	4.70	0.000	0.54	0.094	7.34	0.041	5.20	0.032	0.54	0.117	6.02	0.096	6.69	0.000	0.56	0.094	6.36	0.057
3.33	0.000	0.63	0.030	4.51	0.014	5.17	0.093	0.63	0.099	7.52	0.015	5.38	0.145	0.63	0.101	8.34	0.025	5.84	0.016	0.63	0.080	6.69	0.059	7.25	0.019	0.65	0.075	7.08	0.057
3.71	0.057	0.71	0.014	4.96	0.007	5.81	0.087	0.71	0.069	8.40	0.005	6.05	0.085	0.72	0.072	9.34	0.005	6.49	0.069	0.72	0.101	7.37	0.043	7.80	0.019	0.73	0.132	7.80	0.019
4.09	0.032	0.80	0.093	5.41	0.004	6.46	0.075	0.80	0.083	9.28	0.003	6.72	0.060	0.80	0.073	10.33	0.005	7.13	0.037	0.80	0.064	8.04	0.005	8.36	0.019	0.81	0.038	8.53	0.057
4.47	0.000	0.88	0.046	5.86	0.002	7.10	0.050	0.88	0.064	10.16	0.002	7.39	0.072	0.89	0.071	11.33	0.005	7.77	0.043	0.89	0.053	8.71	0.021	8.91	0.019	0.90	0.019	9.25	0.019
4.85	0.015	0.96	0.010	6.32	0.002	7.74	0.038	0.97	0.041	11.04	0.000	8.06	0.051	0.98	0.052	12.33	0.003	8.41	0.053	0.98	0.059	9.38	0.021	9.47	0.038	0.98	0.038	9.97	0.038
5.23	0.000					8.39	0.036					8.74	0.064					9.06	0.074					10.02	0.000				
5.61	0.008					9.03	0.017					9.41	0.000					9.70	0.074					10.58	0.057				
5.99	0.000					9.67	0.017					10.08	0.097					10.34	0.090					11.13	0.019				
6.37	0.006					10.31	0.009					10.75	0.052					10.99	0.053					11.69	0.094				
6.75	0.002					10.96	0.009					11.42	0.000					11.63	0.064					12.24	0.094				
7.13	0.000					11.60	0.006					12.10	0.058					12.27	0.048					12.80	0.057				
7.51	0.001					12.24	0.005					12.77	0.016					12.91	0.064					13.35	0.000				
7.89	0.000					12.88	0.002					13.44	0.022					13.56	0.048					13.91	0.057				
8.27	0.001					13.53	0.001					14.11	0.013					14.20	0.048					14.46	0.075				
8.65	0.000					14.17	0.001					14.78	0.005					14.84	0.043					15.02	0.094				
9.03	0.000					14.81	0.000					15.46	0.000					15.49	0.037					15.57	0.075				
9.41	0.000					15.46	0.000					16.13	0.016					16.13	0.021					16.13	0.170				

Appendix 1.3 Raingroup 3

P_{rg} = 0-5 mm, n = 8936						P_{rg} = 5-15 mm, n = 2569						P_{rg} = 15-30 mm, n = 702						P_{rg} = 30-50 mm, n =151						$P_{rg} \geq$ 50 mm, n = 25					
D (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*		*D* (h)		*Tp*		*Ip*	
range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds	range	odds
0.67	0.362	0.03	0.000	1.51	0.000	0.67	0.018	0.03	0.000	1.51	0.000	0.67	0.006	0.03	0.006	1.56	0.001	0.67	0.007	0.02	0.007	1.51	0.007	4.03	0.040	0.02	0.080	2.33	0.040
1.08	0.000	0.12	0.027	2.17	0.581	1.34	0.000	0.11	0.079	2.31	0.079	1.34	0.000	0.11	0.110	2.79	0.075	1.34	0.000	0.11	0.126	2.43	0.020	4.56	0.000	0.10	0.080	3.11	0.160
1.49	0.243	0.20	0.100	2.83	0.215	2.02	0.170	0.20	0.106	3.11	0.254	2.02	0.087	0.20	0.130	4.01	0.383	2.02	0.026	0.20	0.126	3.35	0.212	5.08	0.000	0.18	0.160	3.89	0.240
1.90	0.000	0.29	0.171	3.48	0.122	2.69	0.117	0.28	0.120	3.91	0.261	2.69	0.044	0.28	0.124	5.24	0.275	2.69	0.007	0.28	0.099	4.27	0.331	5.61	0.000	0.26	0.000	4.67	0.240
2.31	0.156	0.37	0.021	4.14	0.050	3.36	0.122	0.37	0.084	4.72	0.206	3.36	0.043	0.37	0.073	6.47	0.142	3.36	0.013	0.37	0.179	5.19	0.179	6.14	0.000	0.33	0.080	5.45	0.040
2.72	0.101	0.45	0.041	4.80	0.020	4.03	0.106	0.46	0.098	5.52	0.100	4.03	0.057	0.46	0.097	7.70	0.074	4.03	0.013	0.46	0.119	6.11	0.106	6.66	0.000	0.41	0.040	6.24	0.120
3.13	0.000	0.54	0.440	5.46	0.008	4.70	0.000	0.54	0.132	6.32	0.052	4.70	0.000	0.54	0.107	8.93	0.030	4.70	0.000	0.54	0.099	7.03	0.053	7.19	0.000	0.49	0.080	7.02	0.040
3.54	0.063	0.62	0.008	6.12	0.003	5.38	0.176	0.63	0.095	7.12	0.025	5.38	0.118	0.63	0.098	10.15	0.007	5.38	0.073	0.63	0.079	7.94	0.033	7.71	0.040	0.57	0.160	7.80	0.040
3.94	0.000	0.71	0.038	6.78	0.001	6.05	0.073	0.71	0.065	7.92	0.014	6.05	0.067	0.72	0.073	11.38	0.007	6.05	0.033	0.72	0.073	8.86	0.033	8.24	0.040	0.65	0.080	8.58	0.040
4.35	0.035	0.79	0.091	7.44	0.000	6.72	0.057	0.80	0.085	8.72	0.004	6.72	0.063	0.80	0.060	12.61	0.003	6.72	0.033	0.80	0.040	9.78	0.020	8.77	0.040	0.73	0.080	9.36	0.000
4.76	0.020	0.87	0.034	8.09	0.000	7.39	0.046	0.88	0.073	9.52	0.004	7.39	0.060	0.89	0.067	13.84	0.000	7.39	0.033	0.89	0.026	10.70	0.000	9.29	0.000	0.81	0.080	10.14	0.000
5.17	0.000	0.96	0.029	8.75	0.000	8.06	0.032	0.97	0.063	10.33	0.001	8.06	0.056	0.98	0.057	15.07	0.001	8.06	0.033	0.98	0.026	11.62	0.007	9.82	0.040	0.88	0.080	10.93	0.040
5.58	0.009					8.74	0.024					8.74	0.057					8.74	0.026					10.34	0.040				
5.99	0.000					9.41	0.000					9.41	0.000					9.41	0.000					10.87	0.000				
6.40	0.005					10.08	0.035					10.08	0.105					10.08	0.179					11.39	0.000				
6.81	0.002					10.75	0.009					10.75	0.064					10.75	0.040					11.92	0.080				
7.22	0.000					11.42	0.000					11.42	0.000					11.42	0.000					12.45	0.120				
7.63	0.001					12.10	0.009					12.10	0.071					12.10	0.119					12.97	0.080				
8.03	0.000					12.77	0.003					12.77	0.031					12.77	0.053					13.50	0.040				
8.44	0.001					13.44	0.000					13.44	0.033					13.44	0.093					14.02	0.000				
8.85	0.000					14.11	0.001					14.11	0.017					14.11	0.046					14.55	0.080				
9.26	0.000					14.78	0.000					14.78	0.011					14.78	0.040					15.08	0.080				
9.67	0.000					15.46	0.000					15.46	0.000					15.46	0.000					15.60	0.000				
10.08	0.000					16.13	0.001					16.13	0.010					16.13	0.132					16.13	0.280				

Appendix 2. General landform models included in AGRASID database.

Landform Position		Upper Slope				Mid Slope				Lower Slope				Depressional			
Land form name	Landform description	SLP_prp (%)^{z}	Slp_50 (%)^{y}	Slp_80 (%)^{x}	Slp_len (m)^{w}	SLP_prp (%)^{z}	Slp_50 (%)^{y}	Slp_80 (%)^{x}	Slp_len (m)^{w}	SLP_prp (%)^{z}	Slp_50 (%)^{y}	Slp_80 (%)^{x}	Slp_len (m)^{w}	SLP_prp (%)^{z}	Slp_50 (%)^{y}	Slp_80 (%)^{x}	Slp_len (m)^{w}
FP1	meander floodplain	10	2.0	3.0	50	40	1.0	2.0	200	40	1.0	2.0	200	10	0.5	1.0	50
FP2	braided channel	0	0.0	0.0	0	50	1.0	2.0	250	20	1.0	2.0	100	30	0.5	1.0	150
FP3	confined, terraced	10	2.0	5.0	50	20	2.0	3.0	100	60	2.0	3.0	300	10	0.5	1.0	50
L1	level plain	0	0.0	0.0	0	45	0.5	1.0	450	45	0.5	1.0	450	10	0.5	1.0	100
L2	closed basin	10	1.0	2.0	50	10	1.0	1.0	50	40	0.5	1.0	300	40	0.5	1.0	300
L3	level, terraced	15	1.0	2.0	100	60	1.0	1.0	500	20	1.0	1.0	150	5	0.5	1.0	50
U1l2	undulating - low	20	1.0	2.0	50	50	1.0	2.0	120	15	1.0	2.0	40	15	0.5	0.5	40
U1h	undulating - high	25	2.0	4.0	60	45	3.0	4.0	115	20	2.0	3.0	50	10	0.5	1.0	25
IUl	inclined & undulating - low	20	1.0	2.0	80	55	1.0	2.0	220	20	1.0	2.0	80	5	0.5	1.0	20
IUh	inclined & undulating -high	20	2.0	4.0	100	50	3.0	4.0	250	25	2.0	3.0	125	5	0.5	1.0	25
H1l	hummocky - low	30	3.0	6.0	45	40	4.0	6.0	60	20	3.0	4.0	30	10	0.5	1.0	15
H1m	hummocky -med	30	6.0	9.0	50	35	6.0	9.0	50	25	5.0	7.0	35	10	1.0	1.0	15
H1h	hummocky -high	35	15.0	25.0	70	30	18.0	25.0	60	25	10.0	15.0	50	10	1.0	5.0	20
H5l	hummocky over BR - low	30	3.0	6.0	60	45	4.0	6.0	90	20	3.0	4.0	40	5	0.5	1.0	10
H5m	hummocky over BR -med	30	6.0	9.0	90	40	6.0	9.0	120	25	5.0	7.0	75	5	1.0	1.0	15
H5h	hummocky over BR -high	35	15.0	25.0	140	35	18.0	25.0	140	25	10.0	15.0	100	5	1.0	5.0	20
R2l	ridged - low	20	3.0	6.0	40	55	4.0	6.0	110	20	3.0	4.0	40	5	0.5	1.0	10
R2m	ridged - med	20	6.0	9.0	60	60	6.0	9.0	180	15	5.0	7.0	45	5	1.0	1.0	15
R2h	ridged - high	15	15.0	25.0	70	65	18.0	25.0	250	15	10.0	15.0	60	5	1.0	5.0	20
D1l	longitudinal dune - low	20	3.0	6.0	40	55	4.0	6.0	110	20	3.0	4.0	40	5	0.5	1.0	10
D1m	Longitudinal dune - med	20	6.0	9.0	60	60	6.0	9.0	180	15	5.0	7.0	45	5	1.0	1.0	15
D1h	longitudinal dune - high	15	15.0	25.0	70	65	18.0	25.0	250	15	10.0	15.0	60	5	1.0	5.0	20
D2l	parabolic dune - low	20	3.0	6.0	20	45	4.0	6.0	45	15	3.0	4.0	15	20	0.5	1.0	20
D2m	parabolic dune - med	20	6.0	9.0	20	50	6.0	9.0	60	10	5.0	7.0	15	20	1.0	1.0	25
D2h	parabolic dune - high	15	15.0	25.0	25	55	18.0	25.0	75	10	10.0	15.0	20	20	1.0	5.0	30
M1l	rolling - low	25	3.0	4.0	125	45	4.0	5.0	225	25	3.0	5.0	125	5	0.5	1.0	25
M1m	rolling -med	25	5.0	8.0	150	50	6.0	9.0	300	20	4.0	7.0	125	5	1.0	1.0	25
M1h	rolling - high	20	7.0	12.0	150	55	8.0	13.0	450	20	5.0	8.0	150	5	1.0	1.0	50

Landform Position		Upper Slope				Mid Slope				Lower Slope				Depressional			
Land form name	Landform description	SLP_prp (%)[z]	Slp_50 (%)[y]	Slp_80 (%)[x]	Slp_len (m)[w]	SLP_prp (%)[z]	Slp_50 (%)[y]	Slp_80 (%)[x]	Slp_len (m)[w]	SLP_prp (%)[z]	Slp_50 (%)[y]	Slp_80 (%)[x]	Slp_len (m)[w]	SLP_prp (%)[z]	Slp_50 (%)[y]	Slp_80 (%)[x]	Slp_len (m)[w]
HP1m	hummocky/plateau - med	30	6.0	9.0	50	35	6.0	9.0	50	25	5.0	7.0	35	10	1.0	1.0	15
HP1h	hummocky/plateau - high	35	15.0	25.0	70	30	18.0	25.0	60	25	10.0	15.0	50	10	1.0	5.0	20
HR2m	hummocky/ridged - med	25	6.0	9.0	50	40	6.0	9.0	80	25	5.0	7.0	50	10	1.0	1.0	20
HR2h	hummocky/ridged - high	30	15.0	25.0	90	35	18.0	25.0	100	25	10.0	15.0	80	10	1.0	5.0	30
I1l	inclined plain - low	20	1.0	2.0	200	60	1.0	2.0	600	20	1.0	2.0	200	0	0.0	0.0	0
I3l	inclined to steep - low	20	4.0	9.0	50	60	5.0	9.0	200	20	4.0	7.0	50	0	0.0	0.0	0
I3m	inclined to steep - med	15	8.0	15.0	75	70	10.0	15.0	350	15	7.0	12.0	75	0	0.0	0.0	0
I3h	inclined to steep - high	10	15.0	30.0	100	80	25.0	35.0	600	10	15.0	20.0	100	0	0.0	0.0	0
I4l	inclined with BR - low	20	4.0	9.0	50	60	5.0	9.0	200	20	4.0	7.0	50	0	0.0	0.0	0
I4m	inclined with BR - med	15	8.0	15.0	75	70	10.0	15.0	350	15	7.0	12.0	75	0	0.0	0.0	0
I4h	inclined with BR - high	10	15.0	30.0	100	80	25.0	35.0	600	10	15.0	20.0	100	0	0.0	0.0	0
I5	steep with slumps	20	12.0	25.0	200	55	25.0	35.0	550	20	10.0	20.0	200	5	3.0	8.0	50
SC1l	valley with floodplain - low	10	8.0	15.0	30	50	10.0	15.0	150	30	2.0	3.0	90	10	0.0	1.0	30
SC1h	valley with floodpl - steep	10	15.0	30.0	40	40	25.0	35.0	160	40	2.0	3.0	160	10	0.0	1.0	40
SC2	valley with terraces	10	15.0	30.0	50	30	25.0	35.0	175	50	2.0	3.0	225	10	0.0	1.0	50
SC3	v-shaped valley	15	8.0	15.0	30	70	10.0	15.0	140	15	7.0	12.0	30	0	0.0	0.0	0
SC4	sub-glacial channel	30	6.0	9.0	120	30	6.0	9.0	120	30	5.0	7.0	120	10	1.0	1.0	40
O1	level organic	5	0.5	1.0	20	10	0.5	1.0	40	30	0.5	1.0	120	55	0.0	0.5	220
O2	basin (bowl)	0	0.0	0.0	0	0	0.0	0.0	0	30	1.0	3.0	100	70	0.5	1.0	200
O3	channelled, ribbed, net	5	1.0	2.0	10	10	1.0	2.0	30	20	1.0	2.0	50	65	1.0	1.0	200
O4	sloping organic	0	0.0	0.0	0	20	1.0	2.0	50	50	1.0	2.0	150	30	1.0	1.0	100
O5	organic with mineral	10	2.0	3.0	40	20	3.0	4.0	80	20	2.0	3.0	80	50	1.0	2.0	200
W1	channel sloughs	10	3.0	6.0	40	20	4.0	6.0	80	20	3.0	4.0	80	50	0.0	0.0	200
W2	>50% sloughs	10	2.0	3.0	40	20	3.0	4.0	80	20	2.0	3.0	80	50	0.0	0.0	200
W3	large single water body	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	100	0.0	0.0	1000

[z] SLP_prp = % of area occupied by that component.

[y] Slp_50 = 50th percentile slope value of cells in that Lf_pos.

[x] Slp_80 = 80th percentile slope value of cells in that Lf_pos.

[w] Slp_len = the slope length of that landform position.

Appendix 3. PERL script to prepare automatically WEPP slope input files from AGRASID landform models.

```
#!/usr/local/bin/perl
#
# By Tim Martin
# Feb 2000

open(INFILE,"<landsegdata.txt")||die"Can't read
landsegdata.txt\n";

while (<INFILE>) {
  $curstr = $_;
  chop($curstr);

  ($symbol, $upsp, $ups5, $ups8, $upsl,
       $midp, $mid5, $mid8, $midl,
       $lowp, $low5, $low8, $lowl,
       $depp, $dep5, $dep8, $depl, $width) = split(/,/,$curstr);

  print "Landscape Model: $symbol ";

# Calculate 60 distance points
  $dist[0] = 0;
  $dist[20] = $upsl;
  $dist[40] = $upsl + $midl;
  $dist[60] = $upsl + $midl + $lowl;

  $upsdf = $upsl / 20.0;
  $middf = $midl / 20.0;
  $lowdf = $lowl / 20.0;

  for($i=1;$i<=19;$i++) {$dist[$i] = $upsdf * $i; }
  for($i=21;$i<=39;$i++) {$dist[$i] = $dist[20] + ($middf *
($i - 20)); }
  for($i=41;$i<=59;$i++) {$dist[$i] = $dist[40] + ($lowdf *
($i - 40));}

# Calculate the upslope gradients.

  $grad[0] = 0.0;
  if ($ups8 > $mid8) { $grad[20] = $ups8 * 1.25;}
  else {$grad[20] = $mid8 * 1.25; }

  $s1 = $ups5 / 10.0;
  $s2 = ($ups8 - $ups5) / 6.0;
  $s3 = ($grad[20] - $ups8) / 4.0;

  $grad[10] = $ups5;
  $grad[16] = $ups8;
  for ($i=1;$i<=9;$i++) { $grad[$i] = $s1 * $i; }
```

```
  for ($i=11;$i<=15;$i++) { $grad[$i] = $s2 * ($i - 10) +
$ups5; }
  for ($i=17;$i<=19;$i++) { $grad[$i] = $s3 * ($i - 16) +
$ups8; }

# Calculate mid and lower depending on slope Case
# Case A
  if (($low8 < $mid5) && ($dep8 < $low5)) {
   print " Case A\n";
   $grad[40] = (($low8 * 5 + $mid5 * 2) / 7.0);
   $s1 = ($mid8 - $grad[20]) / 4.0;
   $s2 = ($mid5 - $mid8) / 6.0;
   $s3 = ($grad[40] - $mid5) / 10.0;

  $grad[24] = $ups5;
  $grad[30] = $ups8;
   for ($i=1;$i<=3;$i++) { $grad[$i+20] = ($s1 * $i) +
$grad[20]; }
   for ($i=5;$i<=9;$i++) { $grad[$i+20] = $s2 * ($i - 4) +
$mid8; }
   for ($i=11;$i<=19;$i++) { $grad[$i+20] = $s3 * ($i - 10) +
$mid5; }

   $grad[60] = ($dep8 * 5 + $low5 * 2) / 7.0;
   $s1 = ($low8 - $grad[40]) / 4.0;
   $s2 = ($low5 - $low8) / 6.0;
   $s3 = ($grad[60] - $low5) / 10.0;

  $grad[44] = $ups5;
  $grad[50] = $ups8;
   for ($i=1;$i<=3;$i++) { $grad[$i+40] = ($s1 * $i) +
$grad[40]; }
   for ($i=5;$i<=9;$i++) { $grad[$i+40] = $s2 * ($i - 4) +
$low8; }
   for ($i=11;$i<=19;$i++) { $grad[$i+40] = $s3 * ($i - 10) +
$low5; }
  }

# Case B
  if (($low8 >= $mid5) && ($dep8 < $low5)) {
   print " Case B\n";
   if ($low8 > $mid8) { $grad[40] = ($low8 * 1.25);}
   else { $grad[40] = $mid8 * 1.25;}

   $infl = $mid5 / 2.0;
   $s1 = ($mid8 - $grad[20]) / 2.0;
   $s2 = ($mid5 - $mid8) / 3.0;
   $s3 = ($infl - $mid5) / 5.0;
   $s4 = ($mid5 - $inflex) / 5.0;
```

```
   $s5 = ($mid8 - $mid5) / 3.0;
   $s6 = ($grad[40] - $mid8) / 2.0;

  $grad[22] = $mid8;
  $grad[25] = $mid5;
  $grad[30] = $infl;
  $grad[35] = $mid5;
  $grad[38] = $mid8;
   $grad[21] = $s1 + $grad[20];
   for ($i=3;$i<=4;$i++) { $grad[$i+20] = $s2 * ($i - 2) + $mid8; }
   for ($i=6;$i<=9;$i++) { $grad[$i+20] = $s3 * ($i - 5) + $mid5; }
   for ($i=11;$i<=14;$i++) { $grad[$i+20] = $s4 * ($i - 10) + $infl; }
   for ($i=16;$i<=17;$i++) { $grad[$i+20] = $s5 * ($i - 15) + $mid5; }
   $grad[39] = $s6 + $mid8;

   $grad[60] = ($dep8 * 5 + $low5 * 2) / 7.0;
   $s1 = ($low8 - $grad[40]) / 4.0;
   $s2 = ($low5 - $low8) / 6.0;
   $s3 = ($grad[60] - $low5) / 10.0;

  $grad[44] = $ups5;
  $grad[50] = $ups8;
   for ($i=1;$i<=3;$i++) { $grad[$i+40] = ($s1 * $i) + $grad[40]; }
   for ($i=5;$i<=9;$i++) { $grad[$i+40] = $s2 * ($i - 4) + $low8; }
   for ($i=11;$i<=19;$i++) { $grad[$i+40] = $s3 * ($i - 10) + $low5; }
  }

# Case C
  if (($low8 < $mid5) && ($dep8 >= $low5)) {
   print " Case C\n";
   $grad[40] = ($low8 * 5 + $mid5 * 1) / 6.0;
   $s1 = ($mid8 - $grad[20]) / 4.0;
   $s2 = ($mid5 - $mid8) / 6.0;
   $s3 = ($grad[40] - $mid5) / 10.0;

  $grad[24] = $ups5;
  $grad[30] = $ups8;
   for ($i=1;$i<=3;$i++) { $grad[$i+20] = ($s1 * $i) + $grad[20]; }
   for ($i=5;$i<=9;$i++) { $grad[$i+20] = $s2 * ($i - 4) + $mid8; }
   for ($i=11;$i<=19;$i++) { $grad[$i+20] = $s3 * ($i - 10) + $mid5; }

   if ($low8 > $dep8) { $grad[60] = $low8 * 1.25; }
   else { $grad[60] = $dep8 * 1.25; }

   $infl = $low5 / 2.0;
   $s1 = ($low8 - $grad[40]) / 2.0;
   $s2 = ($low5 - $low8) / 3.0;
   $s3 = ($infl - $low5) / 5.0;
   $s4 = ($low5 - $infl) / 5.0;
   $s5 = ($low8 - $low5) / 3.0;
   $s6 = ($grad[60] - $low8) / 2.0;

  $grad[42] = $low8;
  $grad[45] = $low5;
  $grad[50] = $infl;
  $grad[55] = $low5;
  $grad[58] = $low8;
   $grad[41] = $s1 + $grad[40];
   for ($i=3;$i<=4;$i++) { $grad[$i+40] = $s2 * ($i - 2) + $low8; }
   for ($i=6;$i<=9;$i++) { $grad[$i+40] = $s3 * ($i - 5) + $low5; }
   for ($i=11;$i<=14;$i++) { $grad[$i+40] = $s4 * ($i - 10) + $infl; }
   for ($i=16;$i<=17;$i++) { $grad[$i+40] = $s5 * ($i - 15) + $low5; }
   $grad[59] = $s6 + $low8;
  }

# Case D
  if (($low8 >= $mid5) && ($dep8 >= $low5)) {
   print " Case D\n";
   if ($low8 > $mid8) { $grad[40] = $low8 * 1.25;}
   else { $grad[40] = $mid8 * 1.25;}

   $infl = $mid5 / 2.0;

   $s1 = ($mid8 - $grad[20]) / 2.0;
   $s2 = ($mid5 - $mid8) / 3.0;
   $s3 = ($infl - $mid5) / 5.0;
   $s4 = ($mid5 - $infl) / 5.0;
   $s5 = ($mid8 - $mid5) / 3.0;
   $s6 = ($grad[40] - $mid8) / 2.0;

  $grad[22] = $mid8;
  $grad[25] = $mid5;
  $grad[30] = $infl;
  $grad[35] = $mid5;
  $grad[38] = $mid8;
   $grad[21] = $s1 + $grad[20];
   for ($i=3;$i<=4;$i++) { $grad[$i+20] = $s2 * ($i - 2) + $mid8; }
   for ($i=6;$i<=9;$i++) { $grad[$i+20] = $s3 * ($i - 5) + $mid5; }
   for ($i=11;$i<=14;$i++) { $grad[$i+20] = $s4 * ($i - 10) + $infl; }
   for ($i=16;$i<=17;$i++) { $grad[$i+20] = $s5 * ($i - 15) + $mid5; }
   $grad[39] = $s6 + $mid8;

   if ($low8 > $dep8) { $grad[60] = $low8 * 1.25; }
   else { $grad[60] = $dep8 * 1.25; }
```

```
   $infl = $low5 / 2.0;
   $s1 = ($low8 - $grad[40]) / 2.0;
   $s2 = ($low5 - $low8) / 3.0;
   $s3 = ($infl - $low5) / 5.0;
   $s4 = ($low5 - $infl) / 5.0;
   $s5 = ($low8 - $low5) / 3.0;
   $s6 = ($grad[60] - $low8) / 2.0;

  $grad[42] = $low8;
  $grad[45] = $low5;
  $grad[50] = $infl;
  $grad[55] = $low5;
  $grad[58] = $low8;
   $grad[41] = $s1 + $grad[40];
   for ($i=3;$i<=4;$i++) { $grad[$i+40] = $s2 * ($i - 2) +
$low8; }
   for ($i=6;$i<=9;$i++) { $grad[$i+40] = $s3 * ($i - 5) +
$low5; }
   for ($i=11;$i<=14;$i++) { $grad[$i+40] = $s4 * ($i - 10) +
$infl; }
   for ($i=16;$i<=17;$i++) { $grad[$i+40] = $s5 * ($i - 15) +
$low5; }
   $grad[59] = $s6 + $low8;
  }

# Write the results to the file
  open(OUTFILE,">$symbol")||die"Can't create hillslope
description file\n";
  printf OUTFILE "num\t  dist\t slope\t  elev\t diffy\t
diffx\n";
  printf OUTFILE "
0\t%7.2f\t%7.2f\t%7.2f\t%6.2f\t%6.2f\n",
         $dist[0], $grad[0], 1000, 0, 0;
  $elev[0] = 1000;
  for ($i=1;$i<=60;$i++) {
   $elev[$i] = $elev[$i-1] - ($grad[$i] * ($dist[$i] - $dist[$i-
1]) / 100);
   printf OUTFILE "%3d\t%7.2f\t%7.2f\t", $i, $dist[$i],
$grad[$i];
   printf OUTFILE "%7.2f\t%6.2f\t%6.2f\n", $elev[$i],
      $elev[$i-1] - $elev[$i], $dist[$i] - $dist[$i-1];
  }
  close(OUTFILE);
}
```

Appendix 4. Assumption made in generating pair-points of slop and distance values.

(a) Depressional landform positions were ignored because no erosion risk exists in these areas. Therefore:

Tot_len = (Slp_len.UPS + Slp_len.MID + Slp_len.LOW)

TOP slope The slope at point 0 (the start of the hillslope) is 0%.
Slope increases to Slp_50.UPS at (Slp_len.UPS * 0.5).
Slope increases to Slp_80.UPS at (Slp_len.UPS * 0.8).
Slope at Slp_len.UPS (the start of MID) is > both Slp_80.UPS and Slp_80.MID. This point is an inflection point.

LOW slope If Slp_80.DEP < Slp_50.LOW then slope can decrease continually through LOW.
Cases_A & B Slope at (Slp_len.UPS + Slp_len.MID) is > Slp_80.LOW.
Slope at Tot_len - (Slp_len.LOW * 0.8) is Slp_80.LOW.
Slope at Tot_len - (Slp_len.LOW * 0.5) is Slp_50.LOW.
Slope at Tot_len is between Slp_50.LOW and Slp_80.DEP.

LOW slope If Slp_80.DEP >= Slp_50.LOW then slope decreases to the middle of LOW
Cases_C & D Slope increases again to where LOW meets DEP.
Slope at (Slp_len.UPS + Slp_len.MID) is > Slp_80.LOW.
Slope at Tot_len - (Slp_len.LOW * 0.10) is Slp_80.LOW.
Slope at Tot_len - (Slp_len.LOW * 0.25) is Slp_50.LOW.
Slope at Tot_len - (Slp_len.LOW * 0.50) < Slp_50.LOW.
Slope at Tot_len - (Slp_len.LOW * 0.75) is Slp_50.LOW.
Slope at Tot_len - (Slp_len.LOW * 0.90) is Slp_80.LOW.
Slope at Tot_len is > Slp_80.LOW and > Slp_80.DEP.

MID slope If Slp_80.LOW < Slp_50.MID then slope can increase continually to where UPS
Cases_A & C meets MID, then decrease continually to where MID meets LOW.
Slope at Slp_len.UPS + (Slp_len.MID * 0.2) is Slp_80.MID.
Slope at Slp_len.UPS + (Slp_len.MID * 0.5) is Slp_50.MID.
Slope at Slp_len.UPS + Slp_len.MID is > Slp_80.LOW and < Slp_50.MID.

MID slope If Slp_80.LOW >= Slp_50.MID then the middle of the mid-slope
Cases B&D is a lows lope area, with a low inflection point. The two ends are
high inflection points.
Slope at Slp_len.UPS + (Slp_len.MID * 0.10) is Slp_80.MID.
Slope at Slp_len.UPS + (Slp_len.MID * 0.25) is Slp_50.MID.
Slope at Slp_len.UPS + (Slp_len.MID * 0.50) < Slp_50.MID.
Slope at Slp_len.UPS + (Slp_len.MID * 0.75) is Slp_50.MID.
Slope at Slp_len.UPS + (Slp_len.MID * 0.90) is Slp_80.MID.
Slope at Slp_len.UPS + Slp_len.MID is > Slp_80.LOW and > Slp_80.MID.

(b) Additional assumptions:

Between two known points, slope increases linearly.

High inflection points have slope of 1.25 times (the maximum neighbouring slope).

Low inflection points have slope of 0.5 times (the minimum neighbouring slope).

The entire hillslope has 60 calculated slope points; 20 for each landform position. This is because the maximum number permitted by WEPP, per Overland Flow Element (OFE), is 20. The number of OFEs varies, but the minimum number is one per landform position.

Appendix 5. PERL script to prepare automatically necessary WEPP input files, run WEPP model, and extract the output data.

```
#!/usr/local/bin/perl
#
# For use in the Water Erosion Potential mapping & # P-
Limits projects
#
# INPUTS
# ------
# - weppmaster.txt: based on agrasid SLM file, with added
manregion, slc
# - landsegshape.txt: lengths and widths of hillslope
segments, by model
# - hillslope model stub files, one for each hillslope model
# - soil stub files, one for each soil
# - management stub files, one for each manregion
# - weather files, one for each SLC
#
# ALGORITH
# --------
# Open weppmaster.txt
# Skip to the next runnum to be processed
# N = 0
# Read runnum, Sl_Model, Mu_name, Lf_pos, Lf_pct,
New_symbol,
#   Extent, Mannum, Slcnum
# Run DoHeader
# Run DoLine
# While lines
#  Read runnum, Sl_Model, Lf_pos, New_symbol, Extent
#  If Newrunnum
#    Run DoFinish
#    N = 0
#    Run DoHeader
#  Run DoLine
# Run DoFinish
# Close weppmaster.txt
#
#
# By Tim Martin, August, 2000
#
# Modified Sept 2004, Tim Martin & Andy Jedrych
#
# Bugs removed:
#   a) hillslope gradient string had two start points (0
distance
#     between) - FIXED
#   b) error in channel structure if only one hillslope in run
#     - FIXED
#
# Routines added:
#   a) output and store snowmelt data
#
```

```
#
# Modified Sept 2005, Andy Jedrych and Tim Martin
# Single Hillslope with multiple OFE's, no channels
#
################################################
#######

$numyears = 43;            # All climate files are 43 years
$tc='n';
$numfails = 0;             # Count of failed runs
$fdnum = 0;            # failure directory number

open(INFILE,"<wepp-in.txt")||die"Can't read wepp-in.txt\n";

$curstr = <INFILE>;          # parse the first line
chop($curstr);

($runnum, $sl_model, $mu_name, $lf_pos, $lf_pct,
$new_symbol,
  $extent, $mannum, $slcnum) = split(/,/,$curstr);

&CheckForPreviousRuns;         # Pick up where we left off

$n = 0;

&DoHeader;              # Start a new set of run files
&DoLine;               # Process the first line

while (<INFILE>) {        # Read the whole file, line by line.
  $orunnum = $runnum;
  $oslcnum = $slcnum;
  $curstr = $_;
  chop($curstr);
  ($runnum, $sl_model, $mu_name, $lf_pos, $lf_pct,
$new_symbol,
   $extent, $mannum, $slcnum) = split(/,/,$curstr);
  $n++;

  if ($orunnum ne $runnum) {       # If a new polygon,
   &DoFinish;            # finish the previous run
   $n = 0;            # and start a new one
   &DoHeader;
  }
  &DoLine;              # Process the line that was read
}

$orunnum = $runnum;
$oslcnum = $slcnum;
&DoFinish;              # Process the last run

close INFILE;
```

```
close OUTFILE;
close STORMFILE;
close GENLOGFILE;


##################################################
########
# Sub CheckForPreviousRuns
#  To avoid restarting at the beginning
#  last.txt has the run number to continue from
#  If last.txt exists, genlog.txt out.txt and
#  maxevents.txt are appended to. Otherwise they
#  are started new.
##################################################
########
sub CheckForPreviousRuns
{
  if( -f "d:/run/last.txt" ) {
   open(LASTFILE,"<d:/run/last.txt")||die"Can't read
run/last.txt\n";
   $lastline = <LASTFILE>;
   close LASTFILE;
   chop($lastline);
   ($lastdone, $numfails, $fdnum) = split(/,/,$lastline);

   open(GENLOGFILE,">>d:/run/genlog.txt")
     ||die"Can't reopen d:/run/genlog.txt\n";
   print GENLOGFILE "********* Oops: Restart
*********\n";

   open(OUTFILE,">>d:/run/out.txt")||
     die "Can't open output file out.txt\n";

   open(STORMFILE,">>d:/run/maxevents.txt")||
     die "Can't open output file maxevents.txt\n";
  }

  else {
   $lastdone = ";               # Starting a new run
   if( !( -d "d:/failed$fdnum") ) {
     system "mkdir failed$fdnum";
   }

   open(GENLOGFILE,">d:/run/genlog.txt")
     ||die"Can't create d:/run/genlog.txt\n";

   open(OUTFILE,">>d:/run/out.txt")||
     die "Can't open output file out.txt\n";

   open(STORMFILE,">>d:/run/maxevents.txt")||
     die "Can't open output file maxevents.txt\n";

   print OUTFILE
"Runnum\tNumRain\tTotRain\tNumSnow\tTotSnow\tMnPc
pt\tRainRun\t";
   print OUTFILE
"SnowRun\tSoiLoss\tMaxLoss\tMaxDist\tSSARat\tTotDet\t
IntDet\t";
   print OUTFILE "TotDep\tSedYld\tSedEnr\t";
   print OUTFILE
"Sand1\tSilt1\tClay1\tOM1\tFract1\tExit1\t";
   print OUTFILE
"Sand2\tSilt2\tClay2\tOM2\tFract2\tExit2\t";
   print OUTFILE
"Sand3\tSilt3\tClay3\tOM3\tFract3\tExit3\t";
   print OUTFILE
"Sand4\tSilt4\tClay4\tOM4\tFract4\tExit4\t";
   print OUTFILE
"Sand5\tSilt5\tClay5\tOM5\tFract5\tExit5\t";
   print OUTFILE
"TotDet\tIntrDet\tDRatio\tRain\tSnow\tYield\t";
   print OUTFILE
"MPcpt\tSPcpt\tslPcpt\tbPcpt\tMVol\tSVol\tslVol\tbVol\t";
   print OUTFILE
"MPeak\tSPeak\tslPeak\tbPeak\tMSed\tSSed\tslSed\tbSed\n
";

   print STORMFILE
"Runnum\tRank\tPcpt\tRunVol\tPkRun\tSed\n";
  }

  if($lastdone ne ") {       # Read through lines to one after
last
   while ($lastdone ne $runnum) { # Find first line of last run
done
     $curstr = <INFILE>;
     chop($curstr);
     ($runnum, $sl_model, $mu_name, $lf_pos, $lf_pct,
$new_symbol,
      $extent, $mannum, $slcnum) = split(/,/,$curstr);
   }
   while ($lastdone eq $runnum) { # Skip to the first line of
the next run
     $curstr = <INFILE>;
     chop($curstr);
     ($runnum, $sl_model, $mu_name, $lf_pos, $lf_pct,
$new_symbol,
      $extent, $mannum, $slcnum) = split(/,/,$curstr);
   }
  }
  if($runnum eq ") {die "All runnum records finished!\n";}
}


##################################################
########
# Sub DoHeader
#   Set run start time,
#   write run header information to genlog.txt,
#   set some counters to 0.
```

```
##################################################
########
sub DoHeader
{
  $stimestring = time;

($ssec,$smin,$shour,$smday,$smon,$syear,$swday,$syday,$
sisdst) =
    localtime($stimestring);

  print "Processing: Runnum=$runnum
MapUnit=$mu_name";
  print "  $shour:$smin:$ssec\n";
  print GENLOGFILE "Runnum=$runnum\tMap
Unit=$mu_name";
  print GENLOGFILE "\tStartTime: 2000/$smon/$smday
$shour:$smin:$ssec\n";

  &SetHillInfo;

  $numups = 0; $nummid = 0; $numlow = 0;
  $numhills = 0;
}

##################################################
########
# Sub DoLine
#  Set values in soil and slope position arrays,
#  and count the hillslope positions
##################################################
########
sub DoLine
{
  $soilname[$n] = $new_symbol;
  $soilpos[$n] = $lf_pos;
  $soilpct[$n] = $lf_pct;

  if ($lf_pos eq 'UPS') {$numups++;}
  if ($lf_pos eq 'MID') {$nummid++;}
  if ($lf_pos eq 'LOW') {$numlow++;}
}


##################################################
########
# Sub DoFinish
#   Most of the work happens here, through subroutines
#   Information is written to the log file, as well.
##################################################
########

sub DoFinish
{
  print GENLOGFILE "#UPS=$numups  #MID=$nummid
#LOW=$numlow  ";
```

```
  &CalcSoilsandHills;
  &DoHillslopeFiles;
  &DoOfeFiles;
  &DoMasterRunFile;
  &RunWEPP;
  &TestFailure;
  &ParseWEPPOutput;
  &CleanWEPPInputs;
  &CleanWEPPOutput;

  open(LASTFILE,">d:/run/last.txt")||die"Can't write
run/last.txt\n";
   print LASTFILE "$orunnum,$numfails,$fdnum\n";
  close LASTFILE;

  $etimestring = time;

($esec,$emin,$ehour,$emday,$emon,$eyear,$ewday,$eyday,
$eisdst) =
    localtime($etimestring);

  $timediff = $etimestring - $stimestring;
  print GENLOGFILE "End Time:  $ehour:$emin:$esec  ";
  print GENLOGFILE "Total: $timediff seconds\n";
  print GENLOGFILE "  ------------------------------\n";
}


##################################################
########
# Sub SetHillInfo
#   A second set of information is needed, for the
#   hill descriptions. It is in the file landseg.txt
#   which is read by this routine.
##################################################
########
sub SetHillInfo
{
  open(HILLDESC,"<landseg.txt")||die"Can't open
landseg.txt\n";
  while (<HILLDESC>) {
   $hillstr = $_;
   chop($hillstr);

   ($tsymbol, $tupsl, $tupsw, $tmidl, $tmidw, $tlowl,
$tloww)
        = split(/,/,$hillstr);

   if($tsymbol eq $sl_model) {
   ($symbol, $upsl, $upsw, $midl, $midw, $lowl, $loww)
        = split(/,/,$hillstr);
   }
  }
  #   print GENLOGFILE "Landform=$symbol  UPS=$upsl
";
  #   print GENLOGFILE "MID=$midl  LOW=$lowl\n";
```

```
      print GENLOGFILE "Landform=$symbol\n;";

  close HILLDESC;
}


#################################################
########
# Sub CalcSoilsandHills
#   Figure out the soil and hill pieces
#   Note that n is the number of lines read for this run
#################################################
########
sub CalcSoilsandHills
{
  $numhills = 0;              # set counters to 0 to start
  $upsptot = 0;
  $midptot = 0;
  $lowptot = 0;

  for($i=0;$i<$n;$i++) {     # count the number of each hill
position
   if($soilpos[$i] eq 'UPS') {$upsptot += $soilpct[$i];}
   if($soilpos[$i] eq 'MID') {$midptot += $soilpct[$i];}
   if($soilpos[$i] eq 'LOW') {$lowptot += $soilpct[$i];}
  }

  for($i=0;$i<$n;$i++) {  # calculate the lengths and widths
of each hill
   $hillsoil[$numhills] = $soilname[$i];

   if($soilpos[$i] eq 'UPS') {
     $hilllen[$numhills] = $soilpct[$i] * $upsl / $upsptot;
   }
   if($soilpos[$i] eq 'MID') {
     $hilllen[$numhills] = $soilpct[$i] * $midl / $midptot;
   }
   if($soilpos[$i] eq 'LOW') {
     $hilllen[$numhills] = $soilpct[$i] * $lowl / $lowptot;
   }
   $numhills++;
  }
#################################################
#########
# new code Oct 2005 to simplify number of OFEs and
lengths
#################################################
#########

  $totlen = $upsl + $midl + $lowl;
  $newn = 1;

  for($i=1;$i<$n;$i++) {          # compress the records,
reduce n
   if($soilname[$i] eq $soilname[$i-1]) {
     $soilpct[$newn-1] += $soilpct[$i];
     $hilllen[$newn-1] += $hilllen[$i];
   }
   else {
     $soilpct[$newn] = $soilpct[$i];
     $hilllen[$newn] = $hilllen[$i];
     $hillsoil[$newn] = $hillsoil[$i];
     $newn++;
   }
  }
  $n = $newn;              # the reduced number of hills
  $numhills = $newn;

#################################################
#########
# end new code Oct 2005 to simplify number of OFEs and
lengths
#################################################
#########


  print GENLOGFILE "#OFEs=$numhills  ";
  print GENLOGFILE "\tWeather=$oslcnum\n";
}


#################################################
########
# Sub DoHillslopeFiles
#   Write the hillslope files
#   To do this, we need to read the hilltype description
#   file, and build hillslope descriptions from it, based
#   on the correct pieces at each step.
#################################################
########
sub DoHillslopeFiles
{
  $hilllensofar = 0;

  open(HILLSLOPE,"<hilltype/$symbol")     # Read
hillslope coordinates
    ||die"Can't read hilltype/$symbol\n";

  for($i=0;$i<61;$i++) {
   $ptstr = <HILLSLOPE>;
   chop($ptstr);
   ($ptnum, $ptlen[$i], $ptslope[$i]) = split(/,/,$ptstr);
   if($ptnum != $i) {die"something wrong with
hilltype/$symbol at $i\n";}
   $ptslope[$i] /= 100;
  }
  close HILLSLOPE;

  $j = 0;       # Count through the 61 points in hillslope/nnn
  if($soilpos[0] eq 'MID') {$j = 20;}       # there may be no
UPS
```

```
  if($soilpos[0] eq 'LOW') {$j = 40;}       # maybe no MID
either

  for($i=0;$i<$numhills;$i++) {          # hill by hill
   $hilllen[$i] = ((int($hilllen[$i] * 100)) / 100);       # round
   $hillstart[$i] = $hilllensofar;
   $hillstart[$i] = ((int($hillstart[$i] * 100)) / 100);     # round
   $hilllensofar += $hilllen[$i];
   $hillend[$i] = $hilllensofar;
   $hillend[$i] = ((int($hillend[$i] * 100)) / 100);       # round

   print GENLOGFILE "Hill
$i:\tLength=$hilllen[$i]\tSoil=$hillsoil[$i]\t";
   print GENLOGFILE
"Start=$hillstart[$i]\tEnd=$hillend[$i]\n";

   open(HILLFILE,">d:/run/h$orunnum$tc$i")
     ||die"Can't create hill file h$orunnum$tc$i\n";
   print HILLFILE "99.1\n1\n90 $hillwidth[$i]\n";

   $numpts = 0;
   $hillptlen[0] = 0;

                      # Calculate first point
   if(($hillstart[$i] - $ptlen[$j]) < ($hilllen[$i] / 50)) { # close
enough
     $hillptslope[$numpts] = $ptslope[$j];
     $j++;
   }
   else {               # between two of the 61 set points
     $ptdiff = $ptlen[$j] - $ptlen[$j - 1];
     $ptdiffl = $hillstart[$i] - $ptlen[$j - 1];
     $ptdiffh = $ptlen[$j] - $hillstart[$i];
     $hillptslope[$numpts] =
       ($ptslope[$j] * $ptdiffl + $ptslope[$j-1] * $ptdiffh) /
$ptdiff;
   }

   $numpts++;
                      # Calculate middle points
   while ($hillend[$i] > $ptlen[$j]) {
     $hillptlen[$numpts] = $ptlen[$j] - $hillstart[$i];
     $hillptslope[$numpts] = $ptslope[$j];
     if ($hillptlen[$numpts] > $hillptlen[$numpts - 1]) {
      $j++; $numpts++;
     }
   }

                      # Calculate last point
   $hillptlen[$numpts] = $hilllen[$i];

   if($hillend[$i] == $ptlen[$j]) {
     $hillptslope[$numpts] = $ptslope[$j];
   }
   else {
     $ptdiff = $ptlen[$j] - $ptlen[$j-1];
     $ptdiffl = $hillend[$i] - $ptlen[$j-1];
     $ptdiffh = $ptlen[$j] - $hillend[$i];
     $hillptslope[$numpts] =
       ($ptslope[$j] * $ptdiffl + $ptslope[$j-1] * $ptdiffh) /
$ptdiff;
   }

   $numpts++;                 # Was counting 0 to n-1

              # Can't allow more than 20 points in total
##################################################
########
# new code for reducing number of points to max 20 by
# rounding to 20 points nearest to increment
##################################################
########
   if($numpts > 20) {
     $ptratio = $numpts / 20;
     for($k = 1;$k < 19; $k++) {       #only reset middle 18 pts
      $hillptslope[$k] = $hillptslope[int($k*$ptratio + 0.5)];
      $hillptlen[$k] = $hillptlen[int($k*$ptratio + 0.5)];
     }
                   # then reset last point
     $hillptslope[19] = $hillptslope[$numpts - 1];
     $hillptlen[19] = $hillptlen[$numpts - 1];
     $numpts = 20;
   }
##################################################
########
# end new code for reducing number of points to max 20 by
# rounding to 20 points nearest to increment
##################################################
########

   printf HILLFILE "%1d %3.2f\n",$numpts,$hilllen[$i];

   for($k=0;$k<$numpts;$k++) {
    $lenfraction = $hillptlen[$k] / $hilllen[$i];
    printf HILLFILE "%3.2f, %5.4f ", $lenfraction,
$hillptslope[$k];
   }

   print HILLFILE "\n";
   close HILLFILE;
  }
}


##################################################
########
# Sub DoOfeFiles
#   Write the slope file and soil file
#   First the headers are written,
#   Then the ofes are worked through.
##################################################
########
```

```
sub DoOfeFiles
{
  open(OFESOILFILE,">d:/run/s$orunnum")
    ||die"Can't create soil file cs$orunnum\n";
  print OFESOILFILE "99.1\n#\tWEPP Soils File for
$orunnum\n";
  print OFESOILFILE "#\tBy Tim Martin, Fall 2005\n";
  print OFESOILFILE "Soils for polygon $orunnum\n";
  print OFESOILFILE "$numhills  1\n";

  open(OFESLOPEFILE,">d:/run/h$orunnum")
    ||die"Can't create slope file ch$orunnum\n";
  print OFESLOPEFILE "99.1\n#\tWEPP Slope File for
$orunnum\n";
  print OFESLOPEFILE "#\tBy Tim Martin, Fall 2005\n";
  print OFESLOPEFILE "#\n";
  print OFESLOPEFILE "#\n";
  print OFESLOPEFILE "$numhills\n";
  print OFESLOPEFILE "90  5.00\n";

  for($i=0;$i<$numhills;$i++) {
   &AddHillSlope($i);
   &AddHillSoil($i);
  }

  close OFESOILFILE;
  close OFESLOPEFILE;

  &DoManFile;
}


##################################################
########
# Sub AddHillSlope
#   Build the slope file
#   Called once for each ofe
#   The needed information is read in from the hill
#   description files just prepared a couple subroutines
#   previously
##################################################
########
sub AddHillSlope
{
  local($hnum) = $_[0];

  open(HILLFILE,"<d:/run/h$orunnum$tc$hnum")
    ||die"Can't read hill file h$orunnum$tc$hnum\n";

  $tmpstr = <HILLFILE>;                 # skip three lines
  $tmpstr = <HILLFILE>;
  $tmpstr = <HILLFILE>;

  $tmpstr = <HILLFILE>;                # write the next two
  print OFESLOPEFILE $tmpstr;
  $tmpstr = <HILLFILE>;
  print OFESLOPEFILE $tmpstr;
  close HILLFILE;
}


##################################################
########
# Sub AddHillSoil
#   Build the soils file
#   Called once for each ofe
##################################################
########
sub AddHillSoil
{
  local($hnum) = $_[0];

  open(SOILFILE,"<soils/$hillsoil[$hnum]")
    ||die"Can't read soil file soils/$hillsoil[$hnum]\n";

  for($ih=0;$ih<9;$ih++) {               # skip nine lines
   $tmpstr = <SOILFILE>;
  }

  $tmpstr = <SOILFILE>;            # get the number of
horizons

($jnk,$jnk,$numhorizons,$jnk,$jnk,$jnk,$chnk[$hnum],$ch
ntcr[$hnum],$jnk)
    = split(" ",$tmpstr);
  print OFESOILFILE $tmpstr;

  for($ih=0;$ih<$numhorizons;$ih++) {          # skip seven
lines
   $tmpstr = <SOILFILE>;
   print OFESOILFILE $tmpstr;
  }
  close SOILFILE;
}


##################################################
########
# Sub DoManFile
#   The management file has one repeat for each
#   ofe.
##################################################
########
sub DoManFile
{
  open(OFETMPFILE,"<mngement/fallow-till")||
    die"Can't create management file cm$orunnum\n"; # FIX
THIS

  open(OFEMANFILE,">d:/run/m$orunnum")||
    die"Can't create management file m$orunnum\n";
```

```
  for($i=0;$i<6;$i++) {       # print header management lines
   $chanstr = <OFETMPFILE>;
   print OFEMANFILE $chanstr;
  }

  $chanstr = <OFETMPFILE>;      # skip line saying 1 OFE
  print OFEMANFILE "$numhills   # number of OFEs\n";

  while (<OFETMPFILE>) {       # print the rest of the
management lines
   print OFEMANFILE ;
  }
  close OFETMPFILE;

  print OFEMANFILE "$numhills\n"; # need entries for each
ofe and year

  for($i=0;$i<$numhills;$i++) {
   print OFEMANFILE "   1\n";
  }

  print OFEMANFILE "43\n1\n";

  for($i=0;$i<(43*$numhills);$i++) {
   print OFEMANFILE "   1\n      1\n";
  }

  close OFEMANFILE;
}


##################################################
########
# Sub DoMasterRunFile
#   This is a pretty straightforward selection of WEPP
#   run options.
##################################################
########
sub DoMasterRunFile
{
  open(RUNFILE,">d:/run/r$orunnum")||die"Can't create run
file r$orunnum\n";
  print RUNFILE "M\n";
  print RUNFILE "y\n";
  print RUNFILE "1\n";
  print RUNFILE "1\n";
  print RUNFILE "no\n";

   print RUNFILE "1\n";
   print RUNFILE "no\n";
   print RUNFILE "d:\\output\\m$orunnum.sum\n"; #Annual,
abbreviated summaries
   print RUNFILE "no\n";
   print RUNFILE "no\n";
   print RUNFILE "no\n";
   print RUNFILE "no\n";
   print RUNFILE "no\n";
   print RUNFILE "yes\n";
   print RUNFILE "d:\\output\\m$orunnum.evo\n"; #event
summaries
   print RUNFILE "no\n";
   print RUNFILE "yes\n";
   print RUNFILE "d:\\output\\m$orunnum.evs\n"; # Brief
summary
   print RUNFILE "no\n";
   print RUNFILE "yes\n";
   print RUNFILE "d:\\output\\m$orunnum.yld\n"; # crop
yield

   print RUNFILE "d:\\run\\m$orunnum\n";
   print RUNFILE "d:\\run\\h$orunnum\n";
   print RUNFILE
"d:\\WEPPRUN\\Weather\\slc$oslcnum\n";
   print RUNFILE "d:\\run\\s$orunnum\n";
   print RUNFILE "0\n";
   print RUNFILE "$numyears\n";
   print RUNFILE "1\n";

  close RUNFILE;
}


##################################################
########
# Sub RunWEPP
##################################################
########
sub RunWEPP
{
  system "d:\\wepp\\wepp\\wepp <d:\\run\\r$orunnum
>d:\\output\\log$orunnum";
#  system "wepp <run\\r$orunnum >output\\log$orunnum";
}


##################################################
########
# Sub TestFailure
#   If WEPP succeeded, a specific line will be in the
#   log file. Look for this line, and assume a failure
#   if it is not found.
##################################################
########
sub TestFailure
{
  open(ITMPFILE,"<d:/output/log$orunnum")||
    die "Can't parse output file log$orunnum\n";

  $runresult = "Failed";
  $flagsuccess = 0;

  while (<ITMPFILE>) {
```

```
   $parsestr = $_;
   if (/WEPP COMPLETED HILLSLOPE SIMULATION
SUCCESSFULLY/) {
     $runresult = "Completed Successfully";
     $flagsuccess = 1;
    }
  }
  close ITMPFILE;
  print GENLOGFILE "RESULT: $orunnum $runresult\n";

  if($flagsuccess) {
   system "erase d:\\output\\log$orunnum";
  }
  else {
   $numfails++;
   if($numfails > 100) {
     $numfails = 0;
     $fdnum++;
     if(!( -d "failed$fdnum") ) {
      system "mkdir failed$fdnum";
     }
   }
   system "move d:\\output\\log$orunnum failed$fdnum\\";
  }
}


##################################################
########
# Sub ParseWEPPOutput
#   If the run was successful, then the WEPP output files
#   can be parsed for the variables we want to keep.
##################################################
########
sub ParseWEPPOutput
{
  if($flagsuccess) {
   printf OUTFILE "%1.0f\t", $orunnum;

   &ParseSumFile;        # Look for mean annual erosion data
   &ParseEvsFiles;       # Process event by event data
   &ParseYldFiles;       # Check the crop yields
   &ParseEvoFile;        # Find annual peak events

   print OUTFILE "\n";
  }
}


##################################################
########
# Sub ParseSumFile
#   Mean annual erosion summary data is collected
##################################################
########
sub ParseSumFile
{
 $numrains = -999;
 $numsnows = -999;
 $rainrunofftot = -999;
 $snowrunofftot = -999;
 $meanpcptmm = -999;
 $rainrunoffmean  = -99;
 $snowrunoffmean  = -99;
 $avenetdetarea = -99;
 $maxsoilloss = -99;
 $maxlossdist = -999;
 $ssaenrich = -99;
 $totdetach = -99;
 $interdetach = -99;
 $totdeposit = -99;
 $sedyield = -99;
 $sedenrich = -99;

 for($i=0;$i<5;$i++) {
  $ssand[$i] = -99;
  $ssilt[$i] = -99;
  $sclay[$i] = -99;
  $som[$i]  = -99;
  $sfract[$i] = -99;
  $sexit[$i] = -99;
 }

 $foundtable = 0;

 if(-r "d:\\output\\m$orunnum.sum") {
  open(ITMPFILE,"<d:/output/m$orunnum.sum");

  while(<ITMPFILE>) {
    $parsestr = $_;

    if(/rain storm runoff events produced/) {
     ($numrains,$jnk,$jnk,$jnk,$jnk,$jnk,$rainrunofftot,$jnk)
      = split(" ",$parsestr);
    }

    if(/ snow melts and/) {
     ($numsnows,$jnk)
      = split(" ",$parsestr);
    }

    if(/events during winter produced/) {
     ($jnk,$jnk,$jnk,$jnk,$snowrunofftot,$jnk)
      = split(" ",$parsestr);
    }

    if(/Mean annual precipitation/) {
     ($jnk,$jnk,$jnk,$meanpcptmm,$jnk)
      = split(" ",$parsestr);
    }

    if(/Mean annual runoff from rainfall/) {
```

```
     ($jnk,$jnk,$jnk,$jnk,$jnk,$rainrunoffmean,$jnk)
      = split(" ",$parsestr);
    }

    if(/or rain storm during winter/) {
     ($jnk,$jnk,$jnk,$jnk,$jnk,$snowrunoffmean,$jnk)
      = split(" ",$parsestr);
    }

    if(/Avg. of Net Detachment Areas/) {

($jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$avenetdetare
a,$jnk)
       = split(" ",$parsestr);
    }

    if(/ Maximum Soil Loss /) {

($jnk,$jnk,$jnk,$jnk,$jnk,$maxsoilloss,$jnk,$jnk,$maxlossd
ist,$jnk)
       = split(" ",$parsestr);
    }

    if(/Average annual SSA enrichment ratio leaving profile/)
{

($jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$ssaenrich,$jnk)
       = split(" ",$parsestr);
    }

    if(/AVG ANN/) {

($jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$totdetach,$interdetach,
$totdeposit,
       $sedyield,$sedenrich,$jnk)
       = split(" ",$parsestr);
    }

    if(/ Silt  % Clay  % O.M. Fraction Exiting/) {
     $foundtable = 1;
     $tabstep = -2;
    }

    if($foundtable) {
     if(($tabstep > -1) && ($tabstep < 5)) {
      ($jnk,$jnk,$jnk,$ssand[$tabstep],$ssilt[$tabstep],
      $sclay[$tabstep],$som[$tabstep],$sfract[$tabstep],
$sexit[$tabstep])
       = split(" ",$parsestr);
     }
     $tabstep++;
    }
   }
  }

  close ITMPFILE;

  printf OUTFILE
"%1d\t%4.2f\t%1d\t%4.2f\t%4.2f\t%4.2f\t%4.2f\t%5.3f\t%5
.3f\t%4.2f\t",
    $numrains, $rainrunofftot, $numsnows, $snowrunofftot,
$meanpcptmm,
    $rainrunoffmean, $snowrunoffmean, $avenetdetarea,
$maxsoilloss, $maxlossdist;

  printf OUTFILE
"%4.2f\t%5.3f\t%5.3f\t%5.3f\t%5.3f\t%5.3f\t",
    $ssaenrich, $totdetach, $interdetach, $totdeposit,
$sedyield, $sedenrich;

  for($i=0;$i<5;$i++) {
   printf OUTFILE
"%3.1f\t%3.1f\t%3.1f\t%3.1f\t%5.3f\t%5.3f\t",
    $ssand[$i], $ssilt[$i], $sclay[$i], $som[$i], $sfract[$i],
$sexit[$i];
  }

}


################################################
########
# Sub ParseEvsFiles
#   Find what portion of the erosion is interrill
################################################
########
sub ParseEvsFiles
{
  $totaldetach = 0;
  $interdetach = 0;
  $totalrain = 0;
  $totalsnow = 0;
  $totalarea = 0;
  if(-r "d:\\output\\m$orunnum.evs") {
   open(ITMPFILE,"<d:/output/m$orunnum.evs");
   while(<ITMPFILE>) {
    $parsestr = $_;
    if(/AVG ANN/) {

($jnk,$jnk,$jnk,$jnk,$totalrain,$totalsnow,$jnk,$totaldetach,
$interdetach,$jnk)
      = split(" ",$parsestr);
    }

   }
   close ITMPFILE;
  }

  if($totaldetach > 0) {
   $detachratio = $interdetach / $totaldetach;
  }
  else {
```

```
  $detachratio = 0;
 }

 printf OUTFILE "%4.3f\t%4.3f\t%4.3f\t%3.2f\t%3.2f\t",
    $totaldetach, $interdetach, $detachratio, $totalrain,
$totalsnow;
}


##################################################
########
# Sub ParseYldFiles
#   Find the crop yields
##################################################
########
sub ParseYldFiles
{
 $sumyld = 0;
 $avgyld = 0;

 if(-r "d:\\output\\m$orunnum.yld") {
  open(ITMPFILE,"<d:/output/m$orunnum.yld");

  while(<ITMPFILE>) {
    $parsestr = $_;

    if(/Average Yield of /) {
     ($jnk,$jnk,$jnk,$jnk,$jnk,$jnk,$s1,$jnk)
      = split(" ",$parsestr);
     $sumyld += $s1;
    }

  }
  close ITMPFILE;
 }

 $avgyld = $sumyld / $numhills;

 printf OUTFILE "%4.3f\t", $avgyld;
}


##################################################
########
# Sub ParseEvoFile
#   Find maximum events for each year, and collect some
#   stats
##################################################
########
sub ParseEvoFile
{
 $sumpcpt  = 0;
 $sumrunvol = 0;
 $sumpkrun = 0;
 $sumsed  = 0;
```

```
 $sum2pcpt  = 0;
 $sum2runvol = 0;
 $sum2pkrun = 0;
 $sum2sed  = 0;

 $sumrankpcpt  = 0;
 $sumrankrunvol = 0;
 $sumrankpkrun = 0;
 $sumranksed  = 0;

 $sumlogrank = 0;
 $sumlogrank2 = 0;

 for($i=0;$i<43;$i++) {
  $evtpcpt[$i]  = 0;
  $evtrunvol[$i] = 0;
  $evtpkrun[$i] = 0;
  $evtsed[$i]  = 0;

  $logpcpt[$i]  = 0;
  $logrunvol[$i] = 0;
  $logpkrun[$i] = 0;
  $logsed[$i]  = 0;
 }

 if(-r "d:\\output\\m$orunnum.evo") {
  open(ITMPFILE,"<d:/output/m$orunnum.evo");

  for($i=0;$i<9;$i++) {
    $parsestr = <ITMPFILE>;
  }

  while(<ITMPFILE>) {
    $parsestr = $_;


($tmpday,$tmpmonth,$tmpyear,$tmppcpt,$tmprunvol,$jnk,$
jnk,$tmppkrun,
    $jnk,$jnk,$jnk,$jnk,$tmpsed) = split(" ",$parsestr);
    $i = $tmpyear - 1;
    if($tmppcpt  > $evtpcpt[$i])  {$evtpcpt[$i]  = $tmppcpt;}
    if($tmprunvol > $evtrunvol[$i]) {$evtrunvol[$i] =
$tmprunvol;}
    if($tmppkrun > $evtpkrun[$i]) {$evtpkrun[$i] =
$tmppkrun;}
    if($tmpsed  > $evtsed[$i])  {$evtsed[$i]  = $tmpsed;}
  }
  close ITMPFILE;
 }

 @sortpcpt  = sort numerically @evtpcpt;
 @sortrunvol = sort numerically @evtrunvol;
 @sortpkrun = sort numerically @evtpkrun;
 @sortsed  = sort numerically @evtsed;

 $npcpt  = 0;
```

```
  $nrunvol = 0;
  $npkrun = 0;
  $nsed  = 0;

  for($i=0;$i<43;$i++) {
   $sumpcpt  += $evtpcpt[$i];
   $sumrunvol += $evtrunvol[$i];
   $sumpkrun += $evtpkrun[$i];
   $sumsed  += $evtsed[$i];

   $sum2pcpt  += $evtpcpt[$i] * $evtpcpt[$i];
   $sum2runvol += $evtrunvol[$i] * $evtrunvol[$i];
   $sum2pkrun += $evtpkrun[$i] * $evtpkrun[$i];
   $sum2sed  += $evtsed[$i] * $evtsed[$i];

   $logpcpt[$i]  = $sortpcpt[$i]  > 0 ? log ($sortpcpt[$i])  : 0;
   $logrunvol[$i] = $sortrunvol[$i] > 0 ? log ($sortrunvol[$i])
: 0;
   $logpkrun[$i] = $sortpkrun[$i] > 0 ? log ($sortpkrun[$i]) :
0;
   $logsed[$i]  = $sortsed[$i]  > 0 ? log ($sortsed[$i])  : 0;

   $sumlogpcpt  += $logpcpt[$i];
   $sumlogrunvol += $logrunvol[$i];
   $sumlogpkrun += $logpkrun[$i];
   $sumlogsed  += $logsed[$i];

   $lograrank[$i] = log (44 / (43 - $i));
   $sumlogrank += $logrank[$i];

   $npcpt  += $sortpcpt[$i]  > 0 ? 1 : 0;
   $nrunvol += $sortrunvol[$i] > 0 ? 1 : 0;
   $npkrun += $sortpkrun[$i] > 0 ? 1 : 0;
   $nsed  += $sortsed[$i]  > 0 ? 1 : 0;
  }

  $meanpcpt  = $npcpt  > 0 ? $sumpcpt  / $npcpt  : 0;
  $meanrunvol = $nrunvol > 0 ? $sumrunvol / $nrunvol : 0;
  $meanpkrun = $npkrun > 0 ? $sumpkrun / $npkrun : 0;
  $meansed  = $nsed  > 0 ? $sumsed  / $nsed  : 0;

  $meanlogpcpt  = $npcpt  > 0 ? $sumlogpcpt  / $npcpt  : 0;
  $meanlogrunvol = $nrunvol > 0 ? $sumlogrunvol /
$nrunvol : 0;
  $meanlogpkrun = $npkrun > 0 ? $sumlogpkrun / $npkrun :
0;
  $meanlogsed  = $nsed  > 0 ? $sumlogsed  / $nsed  : 0;

  $meanlogrank = $sumlogrank / 43;

  for($i=0;$i<43;$i++) {
   $sumrankpcpt +=
    ($logpcpt[$i]  - $meanlogpcpt)  * ($logrank[$i] -
$meanlogrank);
   $sumrankrunvol+=
    ($logrunvol[$i] - $meanlogrunvol) * ($logrank[$i] -
$meanlogrank);
   $sumrankpkrun +=
    ($logpkrun[$i] - $meanlogpkrun) * ($logrank[$i] -
$meanlogrank);
   $sumranksed  +=
    ($logsed[$i]  - $meanlogsed)  * ($logrank[$i] -
$meanlogrank);

   $sumlogrank2 +=
    ($logrank[$i] - $meanlogrank) * ($logrank[$i] -
$meanlogrank);
  }

  $slopepcpt  = $sumrankpcpt  / $sumlogrank2;
  $sloperunvol = $sumrankrunvol / $sumlogrank2;
  $slopepkrun = $sumrankpkrun / $sumlogrank2;
  $slopesed  = $sumranksed  / $sumlogrank2;

  $intpcpt  = $meanlogpcpt  - ($slopepcpt * $meanlogrank);
  $intrunvol = $meanlogrunvol - ($sloperunvol *
$meanlogrank);
  $intpkrun = $meanlogpkrun - ($slopepkrun *
$meanlogrank);
  $intsed  = $meanlogsed  - ($slopesed * $meanlogrank);

  $stdpcpt  = sqrt(($sum2pcpt  - (($sumpcpt * $sumpcpt) /
43)) / 42);
  $stdrunvol = sqrt(($sum2runvol - (($sumrunvol *
$sumrunvol) / 43)) / 42);
  $stdpkrun = sqrt(($sum2pkrun - (($sumpkrun *
$sumpkrun) / 43)) / 42);
  $stdsed  = sqrt(($sum2sed  - (($sumsed * $sumsed) / 43)) /
42);

  printf OUTFILE "%5.3f\t%5.3f\t%5.3f\t%5.3f\t",
       $meanpcpt, $stdpcpt, $slopepcpt, $intpcpt;
  printf OUTFILE "%5.3f\t%5.3f\t%5.3f\t%5.3f\t",
       $meanrunvol, $stdrunvol, $sloperunvol, $intrunvol;
  printf OUTFILE "%7.5f\t%7.5f\t%6.4f\t%6.4f\t",
       $meanpkrun, $stdpkrun, $slopepkrun, $intpkrun;
  printf OUTFILE "%5.3f\t%5.3f\t%5.3f\t%5.3f\t",
       $meansed, $stdsed, $slopesed, $intsed;

  for($i=0;$i<43;$i++) {
   printf STORMFILE
"%1.0f\t%1.0f\t%5.3f\t%5.3f\t%7.5f\t%5.3f\n",
     $orunnum, ($i+1), $sortpcpt[$i], $sortrunvol[$i],
     $sortpkrun[$i], $sortsed[$i];
  }
}


################################################
########
# Sub numerically
```

```
#   Returns -1,0,1 for $a < = > $b
#   Used to sort numerically instead of by ascii value
##################################################
########
sub numerically
{$a <=> $b;}


##################################################
########
# Sub CleanWEPPInputs
#   Save failed WEPP input files,
#   Delete successful ones
##################################################
########
sub CleanWEPPInputs
{
 if($flagsuccess) {
  for($i=0;$i<$numhills;$i++) {
    if(-f "d:\\run\\h$orunnum$tc$i") {
     system "erase d:\\run\\h$orunnum$tc$i";
    }
  }

  if(-f "d:\\run\\r$orunnum") {
    system "erase d:\\run\\r$orunnum";
  }
  if(-f "d:\\run\\h$orunnum") {
    system "erase d:\\run\\h$orunnum";
  }
  if(-f "d:\\run\\m$orunnum") {
    system "erase d:\\run\\m$orunnum";
  }
  if(-f "d:\\run\\s$orunnum") {
    system "erase d:\\run\\s$orunnum";
  }
 }

 else {
  for($i=0;$i<$numhills;$i++) {
    if(-f "d:\\run\\h$orunnum$tc$i") {
     system "move d:\\run\\h$orunnum$tc$i failed$fdnum\\";
    }
  }

  if(-f "d:\\run\\r$orunnum") {
    system "move d:\\run\\r$orunnum d:\\failed$fdnum\\";
  }
  if(-f "d:\\run\\h$orunnum") {
    system "move d:\\run\\h$orunnum d:\\failed$fdnum\\";
  }
  if(-f "d:\\run\\m$orunnum") {
    system "move d:\\run\\m$orunnum d:\\failed$fdnum\\";
  }
  if(-f "d:\\run\\s$orunnum") {
    system "move d:\\run\\s$orunnum d:\\failed$fdnum\\";
  }
 }
}
##################################################
########
# Sub CleanWEPPOutput
#   Save failed WEPP output files
#   delete successful ones
##################################################
########
sub CleanWEPPOutput
{
 if($flagsuccess) {

  if(-f "d:\\output\\m$orunnum.yld") {
    system "erase d:\\output\\m$orunnum.yld";
  }
  if(-f "d:\\output\\m$orunnum.evs") {
    system "erase d:\\output\\m$orunnum.evs";
  }
  if(-f "d:\\output\\m$orunnum.pas") {
    system "erase d:\\output\\m$orunnum.pas";
  }
  if(-f "d:\\output\\m$orunnum.sum") {
    system "erase d:\\output\\m$orunnum.sum";
  }
  if(-f "d:\\output\\m$orunnum.evo") {
    system "erase d:\\output\\m$orunnum.evo";
  }
 }
 else {
  if(-f "d:\\output\\m$orunnum.yld") {
    system "move d:\\output\\m$orunnum.yld
d:\\failed$fdnum\\";
  }
  if(-f "d:\\output\\m$orunnum.evs") {
    system "move d:\\output\\m$orunnum.evs
d:\\failed$fdnum\\";
  }
  if(-f "d:\\output\\m$orunnum.pas") {
    system "move d:\\output\\m$orunnum.pas
d:\\failed$fdnum\\";
  }
  if(-f "d:\\output\\m$orunnum.sum") {
    system "move d:\\output\\m$orunnum.sum
d:\\failed$fdnum\\";
  }
  if(-f "d:\\output\\m$orunnum.evo") {
    system "move d:\\output\\m$orunnum.evo
d:\\failed$fdnum\\";
  }
 }
}
```

Appendix 6. Ranking of municipalities based on the proportion (%) of sever water erosion risk areas within agricultural area of municipality.

	Proportion of agricultural area within AGRASID defined polygon area (%)				
	Water erosion risk				
Municipality Name	Severe	High	Moderate	Low	Negligible
KANANASKIS I.D.	70.5	2.1	2.7	0.4	24.3
I.D. WATERTON	61.5	21.9	13.8	0.4	2.3
M.D. RANCHLAND	57.8	33.3	2.4	4.7	1.9
N/A	48.1	5.7	19.8	22.9	3.5
M.D. BIGHORN	43.0	20.3	7.3	9.6	19.8
M.D.PINCHER CREEK	32.6	20.5	19.9	14.0	13.0
M.D. FOOTHILLS	25.7	17.3	10.5	17.6	28.8
M.D. WILLOW CREEK	23.0	17.4	20.1	32.3	7.2
CARDSTON C.O.	19.8	23.7	37.2	16.7	2.6
M.D. PEACE	19.4	0.2	1.6	4.0	74.8
M.D. ROCKY VIEW	14.3	9.3	16.9	42.2	17.3
CYPRESS C.O.	13.5	16.2	13.4	24.1	32.8
M.D. BRAZEAU	12.9	10.4	29.2	39.5	8.0
M.D. FAIRVIEW	12.2	1.6	2.5	9.1	74.6
WOODLANDS C.O.	11.0	17.9	24.8	31.5	14.8
M.D. GREENVIEW	10.9	7.7	10.8	33.3	37.2
C.O. WARNER	10.6	9.4	23.4	45.2	11.3
C.O. PAINTEARTH	10.1	7.1	43.8	32.0	7.0
NORTHERN SUNRISE C.O.	9.9	9.5	12.9	10.2	57.5
C.O. FORTY MILE	9.7	10.0	10.0	37.7	32.5
KNEEHILL C.O.	9.5	11.4	19.4	33.4	26.3
RED DEER C.O.	9.1	11.7	14.3	45.4	19.5
M.D. CLEAR HILLS	8.9	2.1	2.7	12.4	74.0
M.D. SPIRIT RIVER	8.6	2.7	14.8	43.9	30.2
SADDLE HILLS C.O.	8.5	7.6	8.1	12.7	63.2
M.D. SMOKY RIVER	8.5	1.2	9.6	30.3	50.4
C.O. MINBURN	8.2	9.4	27.5	42.0	13.0
M.D. NORTHERN LIGHTS	8.0	1.9	4.9	28.0	57.2
STARLAND C.O.	7.9	16.8	29.3	29.7	16.2
M.D. LESSER SLAVE RIVER	7.4	0.9	7.6	41.5	42.6
MOUNTAN VIEW C.O.	7.3	10.6	28.3	35.7	18.0
C.O. LETHBRIDGE	7.3	3.5	30.5	39.0	19.7
SPECIAL AREA 3	7.0	8.6	17.2	33.9	33.3
CLEARWATER C.O.	6.8	7.1	16.5	22.2	47.3
M.D. ACADIA	6.8	4.0	7.9	24.6	56.7

Municipality Name	Proportion of agricultural area within AGRASID defined polygon area (%)				
	Water erosion risk				
	Severe	High	Moderate	Low	Negligible
C.O. WETASKIWIN	6.6	12.3	12.4	45.3	23.4
PARKLAND C.O.	6.4	12.3	18.0	30.1	33.2
C.O. ST. PAUL	6.2	21.4	15.9	30.2	26.3
PONOKA C.O.	6.2	15.1	18.1	44.2	16.4
C.O. GRANDE PRAIRIE	6.0	7.0	22.9	33.2	30.9
YELLOWHEAD C.O.	6.0	6.4	26.6	34.2	26.7
SPECIAL AREA 2	5.9	7.2	9.7	34.3	42.8
C.O. VERMILION RIVER	5.9	9.1	7.6	33.3	44.0
BIRCH HILLS C.O.	5.9	0.0	93.2	0.3	0.6
M.D. OPPORTUNITY	5.9	0.0	24.3	11.1	58.7
WHEATLAND C.O.	5.8	10.2	19.2	43.8	21.0
SPECIAL AREA 4	5.5	15.8	31.8	33.5	13.4
VULCAN C.O.	5.1	5.5	10.5	50.7	28.2
LEDUC C.O.	5.0	6.2	11.4	41.3	36.1
M.D. BONNYVILLE	4.8	4.3	20.0	37.9	33.0
LACOMBE C.O.	4.8	13.5	16.3	44.5	20.9
C.O. TWO HILLS	4.6	14.3	12.1	41.4	27.6
C.O. ATHABASCA	4.5	2.0	16.5	31.4	45.7
LAKELAND C.O.	4.5	14.0	20.8	40.0	20.9
FLAGSTAFF C.O.	4.3	7.2	19.4	64.6	4.4
M.D. WAINWRIGHT	4.2	10.5	19.1	37.4	28.7
SMOKY LAKE C.O.	3.9	5.6	6.3	35.5	48.8
C.O. STETTLER	3.8	19.5	23.1	38.3	15.3
C.O. NEWELL	3.5	1.4	5.0	38.0	52.0
C O. CAMROSE	3.1	5.4	24.8	39.4	27.2
C.O.THORHILD	3.1	0.5	13.6	42.4	40.4
M.D. BIG LAKES	2.9	8.2	11.9	37.3	39.6
STURGEON C.O.	2.9	2.2	3.3	38.8	52.8
M.D. MACKENZIE	2.9	0.9	2.2	19.6	74.4
M.D. TABER	2.6	4.7	10.1	30.3	52.2
M.D. PROVOST	2.5	9.8	23.9	52.5	11.4
LAC STE ANNE C.O.	2.3	10.3	19.4	59.0	8.9
LAMONT C.O.	1.8	6.4	5.8	39.5	46.5
WESTLOCK C.O.	1.5	0.1	4.9	34.2	59.4
STRATHCONA C.O.	0.9	0.0	15.6	38.1	45.5
C.O. BARRHEAD	0.7	3.3	11.1	58.4	26.4
BEAVER C.O.	0.2	5.4	22.5	53.5	18.4
I.D. ELK ISLAND	0.0	1.6	59.3	38.7	0.4
Grand Total	8.1	9.1	16.8	34.3	31.6

Appendix 7. Ranking of municipalities based on the extent of severe and high water erosion risks areas within cultivated area of municipality.

	Cultivated land area (ha)		
		Water erosion risk	
Municipality Name	Total	Severe	High
CARDSTON C.O.	199418	10302	43221
WHEATLAND C.O.	324289	7257	31055
CYPRESS C.O.	218662	5647	30170
KNEEHILL C.O.	254167	9262	23499
C.O. FORTY MILE	367487	4910	21258
C.O. VERMILION RIVER	302188	8998	16447
C.O. TWO HILLS	148100	3981	19720
SPECIAL AREA 3	241786	5808	17221
C.O. MINBURN	168981	8461	13421
M.D. FOOTHILLS	146981	9389	12326
STARLAND C.O.	166404	5737	15862
VULCAN C.O.	382179	8641	11749
RED DEER C.O.	188262	6160	14168
M.D. WAINWRIGHT	165869	1643	17232
C.O. GRANDE PRAIRIE	177215	1260	17151
M.D. WILLOW CREEK	182450	5730	12530
SPECIAL AREA 4	133372	4284	13968
M.D. ROCKY VIEW	195640	8718	9494
C.O. WARNER	274217	7262	10079
C.O. PAINTEARTH	149977	7239	9859
M.D.PINCHER CREEK	56699	8859	7518
FLAGSTAFF C.O.	228430	3410	12693
C.O. STETTLER	134180	1755	13081
LACOMBE C.O.	126477	2817	10824
MOUNTAN VIEW C.O.	168742	3293	10207
LAMONT C.O.	133482	1403	11635
SPECIAL AREA 2	167289	3097	9593
C.O. ST. PAUL	87964	1539	10496
M.D. PROVOST	163757	2208	9066
C.O. LETHBRIDGE	185963	3305	6373
PONOKA C.O.	68553	2116	7547
M.D. GREENVIEW	61774	1203	6651
BEAVER C.O.	138260	71	7224
M.D. TABER	212082	834	5636
LEDUC C.O.	96810	1573	4870
SMOKY LAKE C.O.	64308	925	3779

	Cultivated land area (ha)		
		Water erosion risk	
Municipality Name	Total	Severe	High
NORTHERN SUNRISE C.O.	53779	289	4281
C O. CAMROSE	163954	1277	3083
SADDLE HILLS C.O.	92962	970	3028
M.D. BIG LAKES	43477	1762	2219
C.O. WETASKIWIN	78078	1470	2247
C.O. NEWELL	136143	1188	2096
YELLOWHEAD C.O.	29331	923	2210
PARKLAND C.O.	50947	979	2014
LAC STE ANNE C.O.	34881	576	2298
M.D. BONNYVILLE	89896	875	1948
STURGEON C.O.	104421	1189	1215
LAKELAND C.O.	17248	320	2080
BIRCH HILLS C.O.	81967	624	1521
M.D. BRAZEAU	11230	613	1465
M.D. NORTHERN LIGHTS	123497	1837	128
M.D. SMOKY RIVER	124707	642	1308
M.D. ACADIA	67097	1202	508
CLEARWATER C.O.	27709	776	793
C.O. ATHABASCA	67780	572	980
C.O. BARRHEAD	53257	302	868
WOODLANDS C.O.	11951	775	292
M.D. FAIRVIEW	63688	440	502
M.D. MACKENZIE	114854	787	137
M.D. SPIRIT RIVER	37005	219	700
M.D. PEACE	42649	665	34
M.D. CLEAR HILLS	92803	165	412
WESTLOCK C.O.	116051	336	42
C.O.THORHILD	57376	215	147
N/A	1728	110	0
STRATHCONA C.O.	32969	109	0
M.D. LESSER SLAVE RIVER	10052	96	7
M.D. BIGHORN	474	77	15
M.D. RANCHLAND	174	38	51
KANANASKIS I.D.	103	1	0
R.M. WOOD BUFFALO	4	0	0
M.D. OPPORTUNITY	478	0	0
I.D. ELK ISLAND	3	0	0