STOCHASTIC RISK ASSESSMENT FOR LAKE EUCHA SPAVINAW WATERSHED

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STOCHASTIC RISK ASSESSMENT FOR LAKE

EUCHA SPAVINAW WATERSHED

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It is my sincere hope that this research helps in formulating the TMDLs for the lakes Eucha and Spavinaw, which will maintain phosphorus at levels that ensure safe water for drinking, recreation, and other beneficial purposes.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

“Water is critical for economic development and indispensable for human health and well-being. The United Nations General Assembly at its 58th session in December 2003 agreed to proclaim the years 2005 to 2015 as the International Decade for Action, "Water for Life", and beginning with World Water Day, March 22, 2005. The Water for Life decade sets the world’s goals on a greater focus on water-related issues and cooperation at all levels to achieve water-related goals of the Millennium Declaration, Johannesburg Plan of Implementation of the World Summit for Sustainable Development and Agenda 21” (World Water day 2005). Agenda 21 recognizes “the complex interconnectedness of freshwater systems and demands that freshwater management be holistic (taking a catchment management approach) and based on a balanced consideration of the needs of people and the environment.” (Agenda 21, 18.36).

For purposes of this study Agenda 21 outlines important guidelines to be taken into consideration. “The multi-sectoral nature of water resources development in the context of socio-economic development must be recognized, as well as the multi-interest utilization of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low and flat lands management and other activities.”

Rational water utilization schemes for the development of surface and underground water supply sources and other potential sources have to be supported by concurrent water conservation and waste minimization measures. Priority, however, must be accorded to flood prevention and control measures, as well as sedimentation control, where required" (Agenda 21, 18.3).

As the world moves toward more concern for water, as water becomes scarce and more degraded, many countries begin to focus more on water. In the US, in the 2002 report to the Congress, Copeland writes that based on the 1998 United States data, twenty thousand water bodies did not meet water quality standards. She adds that forty percent of the surveyed US streams, lakes and estuaries that were assessed to determine national water quality standards were degraded and could not support recreation activities like swimming and fishing. Her report identifies agriculture and urban runoff as the primary sources of pollutants causing degradation (Copeland 2002).

There have been efforts over the years toward improving and maintaining water quality standards. The Total Maximum Daily Load (TMDL) Program was established under section 303 (d) of the Clean Water Act (CWA) in 1972 (P.L.92-500). States are under an obligation to identify waters that are impaired and to develop a "budget" of pollutant reductions necessary to achieve standards and allocate these reductions among sources. (Copeland 2002). The TMDL program was established to ensure water quality standards were achieved and maintained for public health as well as beneficial uses (US EPA 1998).

1.1 BACKGROUND

The Lake Eucha / Spavinaw watershed (Figure 1) is a 415 square mile drainage basin, 70 percent of which is in Mayes and Delaware Counties of Oklahoma and 30 percent of which is in Benton County, Arkansas (OWRB 2002). These lakes were constructed to supply water to the city of Tulsa metropolitan and other local water users through the 21st century. Facts about the watershed are given in Table 1.

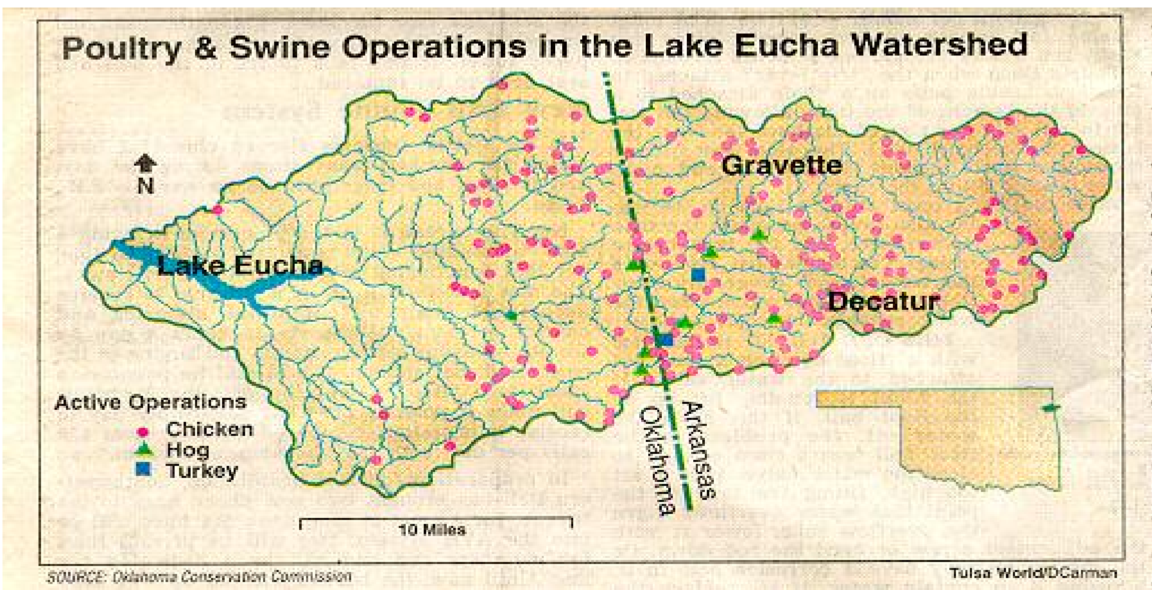

Figure 1: Eucha/Spavinaw Watershed Location: Poultry and Swine Operations

Table 1: Facts and Model Parameters on the Eucha Spavinaw Watershed

Facts		Model Parameter values	
Total area	1006km^2	Subbasins	90
Forested area	509km^2	Number of HRUs	2416
Agricultural land	458km^2	Agricultural hrus	1605
Urban area water area	13km^2	No. of broiler houses	957
Water area	17km^2		
Litter produced/ year	89 tons		
Est. P into Lakes/year	48 tons		

According to the 1998- 2000 Oklahoma Water Resources Board study (OWRB 2002), both lakes Eucha and Spavinaw were nutrient enriched and displayed high and excessive levels of algal production. The average water quality values showed both lakes to be eutrophic. The OWRB study found that phosphorus was the limiting nutrient for algae growth and that a significant increase in algal growth was concurrent with an increased phosphorus load (OWRB 2002). The 1998- 2000 Oklahoma Water Resources Board study (OWRB 2002), also found there were specific diatoms and bluegreen algae species within the lakes, and these were believed responsible for the undesirable taste and odor experienced in the drinking water from the lakes. Figure 2 shows a picture of the Lake Spavinaw.

Figure 2: Lake Spavinaw

The problem of undesirable taste and odor threatens the aesthetic and beneficial uses of the water from Lakes Eucha and Spavinaw. The OWRB 2002 study found (using Carlson's trophic index (TSI) that Lake Eucha had an average TSI value of approximately 59 and Spavinaw Lake had an average TSI value of approximately 57. The Oklahoma Water Resources Board concluded that a 45 percent phosphorus load reduction would be necessary to achieve a TSI of 50 for Lake Spavinaw. A 54 percent load reduction is required for Lake Eucha to achieve a TSI of 50. A TSI value of 50 is the highest TSI recommended for drinking water and recreation purposes (OWRB 2002).

According to the USEPA (2006), "The concept of trophic status is based on the fact that changes in nutrient levels (measured by total phosphorus) cause changes in algal biomass (measured by chlorophyll), which in turn cause changes in lake clarity (measured by Secchi disk transparency). The TSI is a convenient way to quantify this relationship. Dr. Robert Carlson's Index uses log transformation of Secchi disk values as a measure of algal biomass on a scale from 0-110."

In 1998- 2000 Oklahoma Water Resources Board study (OWRB 2002) noted that in order to achieve a 45 percent phosphorus load reduction in Lake Spavinaw, the phosphorus load to Lake Eucha would have to be reduced by 70 percent. It was also noted that a 34 percent phosphorus load reduction can be achieved by complete elimination of point source loads in the basin, and this would result in a TSI of 54 for Lake Eucha which will not meet the recommended TSI standard. Thus it would be necessary to reduce the phosphorus loads from both point source and nonpoint sources.

1.2 STATEMENT OF THE PROBLEM

Poultry and pig farming are the main agricultural economic activities (Figure 3 and 4) in the Eucha Spavinaw watershed and are significant sources of phosphorus in the watershed. The resulting manure and chicken litter from large scale operations is usually spread on land in the basin leading to phosphorus build up. This excess phosphorus is subsequently eroded ending up in Lake eucha and Spavinaw.

Figure 3: A Chicken House in the Watershed

The problem of phosphorus pollution in lakes Eucha and Spavinaw began to emerge in the late 1990s. The June 1997, *BioCycle* article, reported that the amounts of phosphorus discharged into Tulsa's watershed had exceeded permitted levels on numerous occasions. The article quotes the then director of Tulsa public works as having said, "We must find win – win solutions that protect not only the interests of the citizens of Tulsa but also our neighbors throughout the eastern Oklahoma and northwestern Arkansas. After all, we drink the water and most of us eat chicken" (Charles Hardt, 1997). This win - win goal to solve the problem of phosphorus runoff frames the debate. Figure 4 shows the location of chicken houses in the watershed.

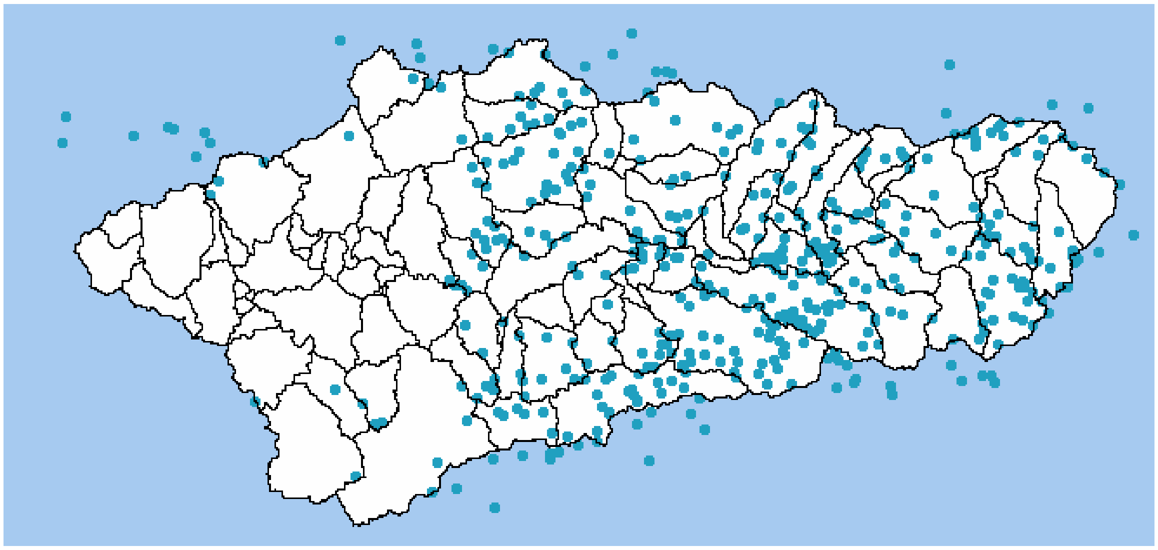

Figure 4: Location of the Chicken Houses in the Eucha/Spavinaw Watershed (2005)

In December 2002, the phosphorus pollution issue took a new turn when the City of Tulsa Metropolitan Utility Authority sued Poultry Companies and the City of Decatur, Arkansas, for discharging phosphorus into lakes Eucha and Spavinaw. The case (City of Tulsa et *al.,* 2001) has been settled, however there is still need for the TMDL (Total Maximum Daily Loads) to be set. According to the US EPA, "a TMDL specifies a maximum amount of a pollutant that a water body can receive and still meet water quality standards, and allocates the pollutant among point and non point pollutant sources" (US EPA 2006).

An important issue that arose during the court proceedings is the exclusion of the testimony about the Total Annual phosphorus loads on grounds that there was uncertainty in the data inputs, lack of a sensitivity analysis and accuracy assessment that led to these loading limits (City of Tulsa et *al.,* 2001).

In order to establish a phosphorus pollution control policy and possibly legislation including tradable permits, it is important to address uncertainty of the environmental conditions especially uncertainty due to weather.

It is important to note that in 2005 there was a fresh law suit. The State of Oklahoma verses the Poultry farmers in Arkansas.

"Oklahoma Attorney General Drew Edmondson …sued 14 poultry producers, including several owned by Tyson, alleging their waste is polluting scenic rivers across the state line..."(Centre for legal Policy, Manhattan Institute 2005).

1.3 THE PURPOSE OF THE STUDY

This study uses a Target MOTAD linear programming model to incorporate a risk measure, to ensure that the probability of exceeding a maximum annual phosphorus load under variable weather conditions at Lake Eucha and Spavinaw is less than the stated tolerance. The process involves minimizing the cost of meeting the TMDL while ensuring that the probability of violating the TMDL is less than a stated tolerance level.

Incorporating the weather risk into the model will ensure that the subsequent management practices and policies will be more reliable both in the short term and the long run. To this end the environmental risk form of Target MOTAD developed by Teague et al (1995) and Qui et al (1998) will be applied. Additional risks imposed by uncertain parameters in the simulation model and by uncertain economic returns are beyond the scope of this study.

1.4 OBJECTIVES

The overall objective is to estimate the economic costs and probabilities of meeting weather related margins of safety for alternative TMDLs in the Eucha Spavinaw watershed by only reducing litter application.

Specific objectives are:

- To determine the feasibility and economic costs of meeting alternative phosphorus TMDL's (expressed as annual loadings) at the watershed level when rainfall and hence phosphorus runoff is variable.
- To determine poultry litter application rates on each land class that will enable planners to meet possible phosphorus TMDL's for watershed with a stated probability at least cost when only poultry litter application rates are varied.

CHAPTER 2

LITERATURE REVIEW

2.1 PHOSPHORUS POLLUTION

The production of manure and nutrients from Animal Feeding Operations in the US is estimated to consist of 1.2 million tons of nitrogen and 0.71 million tons of phosphorus each year (EPA 2000b, p.64).The poultry sector produces the highest amount of total nutrients even though it contains only 15 percent of confined animal farms. In 1997 in the US, the poultry sector was estimated to generate 50 percent of all excess nitrogen from confined animal farms and 61 percent of excess phosphorus. All the manure must either be deposited on site or off site as a source of fertilizer nutrients or be treated as waste. The assimilative capacity of nearby land has been recognized as limiting in many areas of high concentration of animals (Ribaudo et al 2003). Ribaudo et al (2003) also notes that phosphorus is only moderately soluble and relatively immobile in soils, but surface runoff and erosion can transport large amounts of phosphorus to surface waters.

A number of issues contribute to phosphorus accumulation in the soil. Except under favorable conditions the phosphorus value of phosphorus in the manure is zero and this prompts farmers to apply manure to meet the needs of their crops or to over apply it on land nearest to the production facility (Roka and Hoag, 1996).

Animal manure is expensive to transport as compared to its nutrient value, and this limits the area to which it can be economically applied. It is important to note that large operations may not consider the nutrient value of manure in making livestock management decisions. This is a contributing factor resulting in most farms treating manure as a waste. Restrictions on manure application in order to meet environmental standards will increase the cost of rearing animals by increasing the amount of land that is used for spreading manure and the distance the manure must be hauled (Ribaudo. et al., 2003).

Phosphorus and nitrogen have been known to cause algal blooms and eutrophication in fresh water lakes (Conservation Information Technology Center, 2005). Phosphorus is an important nutrient for plant growth and is often added to the soil to improve cropping. Although naturally occurring, anthropogenic activities also release phosphorus into the environment through industrial effluent, agricultural runoff and wastewater. When this excess phosphorus reaches water bodies it begins to accumulate, it encourages the growth of algae. The decomposition of algae removes dissolved oxygen from water and aquatic life cannot survive. Algae can also contribute to odor and bad taste in water and clogs waterways and intake pipes (Conservation Information Technology Center, 2005).

Poultry litter has been disposed through land application over the years in the Eucha Spavinaw watershed. Phosphorus runoff especially during heavy rains and flooding causes a small part of this phosphorus to end up in the lakes, Eucha and Spavinaw.

2.2 NEGATIVE IMPACTS OF PHOSPHORUS POLLUTION

- Phosphorus is the limiting nutrient for most aquatic plants such as algae. Excess phosphorus can lead to excess growth of aquatic plants. For example 1 pound of phosphorus can produce 350-700 lbs of green algae (State Environmental Resource Center, 2005)
- Algal blooms and excessive submerged aquatic vegetation (SAV) growth can lead to the biological death or eutrophication of a body of fresh water (State Environmental Resource Center, 2005).
- Blooms of blue-green algae produce neurotoxins (affecting the nervous system) and hepatoxins (affecting the liver), and can cause a serious public health issue and well as damage aquatic habitats (State Environmental Resource Center, 2005).
- Economically, excessive SAV and algal growth due to phosphorus pollution increase water treatment costs, degrade fishing and boating, this in turn impacts tourism and property values (Sanjay et al, 1997).
- As the algal blooms build up, they die and become a source of labile organic material. These provide food for bacteria which multiply creating high biochemical oxygen demand (BOD) that will at times lower dissolved oxygen concentration levels (Mallin and Cahoon, 2003).

These negative effects necessitate measures for mitigation as is the case for the lakes Eucha and Spavinaw.

The normal process is for Total Maximum Daily Loads (TMDLs) to be established for impaired water ways and for these to be constantly monitored to ensure the phosphorus levels stay within specified limits.

2.3 PHOSPHORUS POLLUTION MITIGATION MEASURES: LAND APPLICATIION

According to Ribaudo et al (2003) livestock manure can provide important organic material and nutrients for crop and pasture growth when used as a fertilizer; however those same nutrients- nitrogen and phosphorus can pollute water resources if they are over applied to land and enter water resources through runoff or leaching.

Although EPA regulations apply mainly to large animal feeding operations, USDA policy encourages all animal-feeding operations (AFO) to adopt nutrient standards voluntarily, and provides financial aid for doing so. Land application remains the principal method of disposing manure and recycling its nutrient and organic content (USDA- EPA, 1999). Concerns have consequently arisen that crops and other vegetation are not fully assimilating nutrients such as phosphorus in manure, and that excess nutrients are increasingly likely to degrade nearby water resources. The land application rate or the quantity of manure spread on an acre of land is believed to be the most important manure management decision affecting the potential for pollution of water resources by manure nutrients (Mulla, et al, 1999).

The *Unified Strategy for Animal Feeding Operations*, jointly developed by the U.S. Department of Agriculture USA and the Environmental Protection Agency in 1999 states that "land application is the most common and usually most desirable method of utilizing manure because of the value of the nutrients and organic matter. Land application should be planned to ensure that the proper amounts of all nutrients are applied in the way that does not harm the environment or public health. Land application in accordance with a Comprehensive Nutrient Management Plan (CNMP) should minimize water quality and public health risk." An objective of the unified strategy is that all animal feeding operations in spite of size, voluntarily adopt CNMPs for managing their nutrient resources, including both commercial fertilizer and animal manure" (Ribaudo et al, 2003). "A CNMP incorporates practices to utilize animal manure and organic by-products as a beneficial resource. A CNMP addresses natural resource concerns dealing with soil erosion, manure, and organic by-products and their potential impacts on water quality, which may derive from an AFO" (USDA 2006).

Economic factors pertaining to demand for meat products and organizational changes to improve economic efficiency have led to larger confined production facilities that are often geographically concentrated (Ribaudo et al, 2003). Competition for land on which to spread manure, and the willingness of landowners to allow manure application are issues not discussed in the literature (Ribaudo et al, 2003).

Land application has a number of draw backs that include uncertainty regarding nutrient content and availability in manure, high transportation and handling costs relative to commercial fertilizer, soil compaction from spreading equipment, dispersion of weed seeds, concerns about the regulatory oversight, and public perception regarding odor and pathogen issues. The willingness of producers to accept manure will depend on the farmer's weighing of the benefits of a natural source of nutrients and organic matter against the costs of manure application (Risse et al, 2001).

2.4 OTHER SOLUTIONS TO PHOSPHORUS POLLUTION

There are alternatives to land application such as converting it into a more homogeneous and stabilized fertilizer product, or using it for power generation. Manure with relatively low moisture content, such as broiler litter is generally more suited for industrial purposes than wetter manure from slurry systems and lagoons. For example Perdue AgriRecycle in Seaford, Delaware is permitted to process 94,000 tons of litter annually into pelletized organic fertilizer for agricultural landscaping uses. HSV in Shandoah Valley Virginia is designed to process 60- 65000 tons per year of poultry litter as both an energy source and a feedstock in the manufacture of blended organic- inorganic fertilizer to the golf courses and landscaping markets. This reduces the total costs of land application and this manure is no longer in competition for land for application. (Ribaudo et al, 2003).

Diet modification is another way to reduce manure nutrients. According to Council for Agricultural Science and Technology (CAST) 2002, potential nutrient reduction of up to 40 percent for nitrogen and phosphorus can be achieved for poultry and up to 50 percent of nitrogen in swine and 60 percent of phosphorus in swine. Substituting phytase and synthetic amino acids for alternative ration components are some of the modifications.

2.5 BEST MANAGEMENT PRACTICES IN THE EUCHA/ SPAVINAW WATERSHED.

A field demonstration in the Eucha/Spavinaw watershed demonstrated the following best management practices. It was based on the demonstration farm which is a part of the FY2003 319(h) non-point source education project, "Spavinaw Creek Watershed Implementation Project":

- Fertilizing the soil according to soil test requirements. under Oklahoma regulations "no animal manure can be land applied if soil test phosphorus is over 400." (Zhang et al 1998)
- Riparian areas (areas around the streams)
- Cross fencing and rotational grazing, for more efficient use of pasture.
- Testing litter for nutrient content before fertilization
- Manure spreading
- Woodland management zones
- Nutrient management for forage production

- Alternative water sources

Below are some of the pictures taken during the field demonstration held on November 1st, 2005, at the Cody Bill Smith farm (refer to Figure 5, 6, 7, 8 and 9).

Note: Not used for poultry litter

Figure 5: Manure Spreader

Figure 6: Monitoring Phosphorus Runoff

Figure 7: Typical Landscape: a Farm in the Watershed Area Close to Spavinaw Creek

Figure 8: A Tributary Stream to Lake Spavinaw and a conservation area

Figure 9: Overflow Pipe at the Spavinaw Dam

2.6 LEGISLATION

There are a number of regulations that have been developed to curb the problem of water pollution, encourage water conservation and maintenance of water quality standards.

The clean water act (CWA) 1972 (P.L.92-500), was established to give basic guidelines for regulating discharges of pollutants into the waters of the United States (USEPA, 2006). Under the Clean water Act, the Total Maximum Daily Load (TMDL) Program was established in section 303 (d).

In March 1999 the USDA and the EPA adopted a "unified National Strategy for Animal Feeding Operations," aimed at minimizing water pollution from AFO and land application of manure. Under proposed current regulations for land application of manure from CAFOs, BMPs (Best Management Practices) are listed as nonnumeric effluent limitations. These include schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce water pollution (Code of federal regulations 2000. title 40). BMPs minimize water pollution through the application of conservation principles that are ecologically sound (Centner 2001)

Other regulations include the February 2003 Environmental Protection Agency requirement that the largest Confined Animal Operations should meet nutrient standards as defined in a nutrient management plan, when disposing of their manure through spreading it on crop land (Ribaudo et al, 2003).

Livestock operations meeting the federal definition of a CAFO must secure National Pollutant Discharge Elimination System (NPDES) permits or establish that they have no significant discharges before they can operate, (Code of federal regulations 2000. title 40). Violations of the permit are subject to fines and or facility closure (Ribaudo et al, 2003).

There are voluntary agricultural programs that promote various nutrient management practices and improve water quality. The Environmental Quality Initiative Program (EQIP) initiated in 1996, Federal Agriculture Improvement and Reform Act (1996 farm Act) amended by the 2002 Farm Security and Rural Investment Act (2002 farm Act). EQIP provides technical assistance, cost sharing payment and incentive payments to assist crop and livestock producers with environmental and conservation improvements on the farm (Ribaudo et al, 2003).

The unified strategy establishes that all AFO owner and operators develop and adopt technically sound, economically feasible and site specific comprehensive nutrient management plans for properly managing the animal manures produced at their firms, including farm application and off farm disposal (if any). The strategy identifies land application as the most desirable method of using manure because the value of manure is nutrients and organic matter (USDA-EPA, 1999). Nutrient management plans adopted voluntary or through regulation would address individual needs and practices of each AFO (Ribaudo et al 2003).

2.7 DEVELOPING A TMDL

Water quality is determined by a number of parameters:

- Load related parameters are total phosphorus, nitrogen, ammonia chemical and biochemical oxygen demand, suspended solids and dissolved solids, pathogens pesticides and metals.
- Non-load parameters include turbidity, pH, dissolved oxygen, chlorophyll, temperature, and habitat modification.

The limiting parameters which maybe one or two are identified, measured, and controlled through the TMDL process. The other parameters are monitored and evaluated as they relate to the quality of the water body (Conservation Information Technology Center, 2005)

To develop a TMDL the amount of pollutants a water body can assimilate without degradation needs to be established. The pollutant load is calculated in mass/day. The TMDL is the sum of waste load allocations (WLA for point sources), Load allocations (LA, for non-point sources), background loads (BL) and the margin of safety (MOS).

Load allocations for non-point sources are often based on land use types, including urban runoff for example, storm water runoff from streets, yards and other sources); agricultural runoff, (erosion of sediments, fertilizers, manure and pesticide); forestry (for instance, soil erosion from roads or tractor logging) (Conservation Information Technology Center, 2005).

Because much of the non-point source pollution is tied to runoff, its timing tends to be closely related to weather events, especially periods of intense rainfall and snowmelt. Note that non-point pollution is measured by concentration in units of mass/volume. (Conservation Information Technology Center 2005).

2.8 TMDLS AND UNCERTAINTY

In setting the TMDL, EPA requires that a margin of safety be taken into consideration. This is aimed at ensuring uncertainties are taken care of. The literature review reveals that most studies concentrate on uncertainty arising from sampling errors and prediction errors. This study however concentrates on environmental uncertainty, more specifically variability with respect to weather anomalies and the requirement for a margin of safety.

According to Reckhow (2003), information regarding uncertainty in outcomes from proposed load reductions can lead to better TMDL decisions especially when prediction uncertainty is incorporated with utility (Loss, damage, net benefits) functions to allow decision makers to maximize expected utility (or maximize net benefits). However, since

EPA views that the margin of safety can be implicit, that is arbitrarily selected; few TMDLs take into account the actual estimates of forecast uncertainty. However, they generally employ traditional modeling assumptions or an implicitly chosen MOS.

According to Reckhow (2003), if the TMDL is stated in terms of percentages, the trade off between cost and loss may be improved by the knowledge of the risk that comes from uncertainty estimates. It gives the degree of confidence. It is important to note that risk is not evident from deterministic point predictions of decision attributes. Stochastic risk assessment has therefore to be taken into consideration.

The National Council Committee to Assess the Scientific Basis of the TMDL Approach to Water Pollution Reduction (2001) recognizes the arbitrary way in which the margin of safety is being applied. They recommend to the EPA that uncertainty analysis should be the basis for MOS determination.

Reckhow (2003) recognizes the failure of most clients to realize the ubiquitous uncertainty in environmental factors. He writes that in order for decision makers to demand estimates of forecast error, they need to be aware of the magnitude of forecast error in water quality analysis, and the need to be able to use the knowledge of forecast error to improve decision making in the long run. Reckhow (2003) recommends Bayesian approaches that are compatible with adaptive assessment techniques that provide the best approach for improving forecast over time.

Reckhow (2003) adds that attitudes towards risk are a key to decision making. Important variables include implied attitude towards trade offs: Are decision makers adequately risk averse with regard to non compliance with water quality standards that they are willing to increase costs in order to increase the chance of achieving certain water uses? In the case of Eucha-Spavinaw, the question asked is “what is the tradeoff between the Chicken producer’s income and the likelihood that a particular level of water quality can be obtained from the watershed.”

2.9 MARGIN OF SAFETY

> “Predicting natural system response to anthropogenic change is highly uncertain and the relationship between pollutant loading and receiving water effects can never be perfectly known. Regardless of the accuracy and complexity of the modeled physical, chemical, and biological process, there will be residual uncertainty due to natural variation, misspecification of boundary conditions and measurement error. Thus many models are observed to ‘under represent’ the dynamics of the system missing the highest and the lowest measured values. However a few acknowledge that mathematical representation of nature is impossible and that model predictions can represent only an average effect at some scale” (Borsuk et al 2002).

According to Barnett and O’Hagan (1997), a deterministic model that claims to make precise predictions, without error is inadequate in addressing the section 303 (d) percentile-based standard listing. Such a model disregards the variability that is not explained by the model but is always present. Making use of averages in models makes the models biased towards underestimating the frequency of standard violations under future conditions (Borsuk et al 2002).

Reckhow (2003) notes that the knowledge of prediction uncertainty and risk attitudes is useful in determining the magnitude of the margin of safety.

He suggests that the MOS be set as a multiple of TMDL prediction uncertainty, with the magnitude of this multiplier reflecting the risk assessment. He recommends the emphasis to be on the advance of techniques fitting the need for error propagation and adaptive management.

Most studies place the margin of safety above the TMDL. This increases the probability that the TMDL will be exceeded especially in the case of environmental anomalies such as floods. An appropriate MOS is not only cost effective but also leads to an improvement in the expected returns. The Committee to Assess the Scientific Basis of Total Maximum Daily Load Approach to Water Pollution Reduction, Water Science and technology Board Division on Earth and life Studies, National Research Council, (2001) writes "because of the natural variability in water quality parameters and the limits of predictability, a small MOS will result in non attainment of the water quality goal; however large MOS may be inefficient and costly. The MOS should account for uncertainties in the data used for water quality assessment and variability of background water quality contributions".

2.10 TMDL MODELS

There are mechanical, statistical and stochastic models for TMDL development. There are also water body and watershed models. The lake Eucha Spavinaw study utilizes a stochastic watershed model, as this is most appropriate in meeting the objectives of the study.

Walker (2003) explains that the effects of short-term variations can be captured by correlating average phosphorus concentrations with the frequency of algal blooms or the frequency of surpassing the numeric water quality standards that are directly related to algal blooms. He considers variability and uncertainty, as important components of MOS. That would ensure the TMDLS are achieved satisfactorily. It is anticipated that the cost of the MOS rises with load reduction however additional data could reduce uncertainty and adaptive management can improve forecast models (Walker, 2003).

The Eucha Spavinaw study relates phosphorus runoff and variability in runoff associated with variability in weather to phosphorus loads in the lake. In this study alternative annual phosphorus loads (possible TMDLs) will be set and a model will be used to determine the maximum grazing income that can be obtained without exceeding the possible TMDL within a specified margin.

A range of models may be taken to characterize the correlation between external phosphorus loads and in-lake concentrations. Walker (2003) derives the TMDL from a steady-state mass balance that equates the long-term average external phosphorus load to the lake assimilative capacity. The assimilative capacity of a water body is equal to the sum of the flushing and net retention terms of the lake phosphorus budget when lake phosphorus equals the defined target. It is important to consider background loads, as it is not practical to implement a TMDL that is below the background load (Walker, 2003).

Walker (2003) divides the margin of safety (MOS) into two parts, the margin of uncertainty (MOU) and the margin of variability (MOV). The MOS, MOV and MOU consistent with a given compliance rate (β) and a confidence level (α) are estimated by attaching stochastic terms to the TMDL mass balance. Note that the alpha and beta values are arbitrarily selected (Walker, 2003). The Eucha spavinaw study takes into consideration the margin of safety with regard to weather uncertainty. The study also takes into consideration maximization of income. This would not be possible with the mass balance model.

Borsuk et al (2002) developed a mass balance equation for a well mixed water body or stream segment that relates pollutant concentration to a set of inputs or model parameters. The equations are developed in terms of accumulation and written as change in mass with time.

They numerically solve the mass balance equation into a general regression function $c=g(x,\beta)$ whereby g is a mathematical function relating to the pollutant concentration c to a set of all input variables X (including time and initial conditions) and a set of all model parameters β.

"Statistical inference with least squares regression implies that the residual errors follow a normal distribution after a suitable transformation if necessary. With a mean of zero and a variance of σ^2, the value of which is directly estimated from the data and is assumed to be a constant with respect to the value of c. Therefore, for any given set of input variables X and model parameters β the response variable c can now be viewed as being normally distributed with a mean $g(x,\beta)$ and variance σ^2", Borsuk et al (2002). They develop a probability distribution function that is then expressed as a confidence interval. Termed the confidence of compliance since the function $g(x,\beta)$ is linear the parameters are derived from the maximum likelihood or least squares regression the parameter distribution can be represented by a multivariate t-distribution (Borsuk et al, 2002)

According to Borsuk et al (2002) water quality simulation models will form an important part of the TMDLs to be developed. However they note that most models fail to incorporate residual variability and parameter uncertainty in their predictions this renders the models unsuitable for TMDL development.

The percentile based standards progressively used by the EPA in the TMDL margin of safety requirement makes it necessary for model predictions to include quantitative information on uncertainty (Borsuk et al 2002).

2.11 TMDL EXAMPLES

Borsuk et al (2002) describe a probabilistic approach to model- based TMDL assessment that addresses uncertainty in TMDL. The approach is demonstrated using a eutrophication model for Neuse River Estuary in North Carolina, and they evaluate compliance with the state chlorophyll standard. Variability in chlorophyll that was not explained by the model but was explicitly included in a residual error term that captured the effects of any process that was not considered in the model and allowed for direct assessment of the frequency of standard violation. This gave a basis for including a margin of safety. The TMDL process requires predicting future compliance after a pollutant load reduction, based on a water quality model (Borsuk et al 2002).

In developing the Neurse River (North Carolina) estuary nitrogen TMDL, Borsuk et al (2002) take into consideration the errors within the model by introducing an error term in their mass balance function. Parameter uncertainty is considered through a joint probability distribution function expressed through the Monte Carlo procedure. An important issue is that sources of error with the model as well as uncertainty in the inputs need to be addressed when setting up TMDLs.

The Vermont Agency of Natural Resources, Department of Environmental Conservation and the New York State Department of Environmental Conservation developed their TMDLs using the mass balance model a steady state modeling approach and a modified version of the US Army Corps Engineers BATHTUB Program. The TMDL includes an implicit margin of safety provided by the assumption that changes in the ratio of particulate to dissolved phosphorus entering the lake after the TMDL is achieved will not affect the internal phosphorus sedimentation balance in the lake. The ratio of particulate to dissolved phosphorus is important because dissolved phosphorus remains in the water column over time and contributes to total phosphorus levels in the lake more than does particulate phosphorus, the fraction of phosphorus bound up in the sediment (Chapra, 1997). The second implicit margin of safety is provided by the fact that the model's mean predicted phosphorus concentrations are below the applicable phosphorus criteria for most segments (Vermont DEC and New York State DEC, 1997). Seasonal variability was accounted for using tributary annual average load estimates based on phosphorus concentration vs. flow relationships for each arbitrary measured across the entire spectrum of seasonal flow conditions were used. (Vermont DEC and New York State DEC, 1997).

CHAPTER 3

METHODOLOGY

3.1 THE LAKE EUCHA SPAVINAW MATHEMATICAL MODEL

Ancev et al, (2003) developed an optimization model used to determine the feasibility and cost of meeting various total maximum annual phosphorus loads for Lake Eucha and Spavinaw. The results indicated that the minimum sum of abatement costs from point and non-point sources plus damage costs from phosphorus pollution required a reduction of phosphorus loading from a current 51 tons to between 23 and 26 tons per year. They found that when the phosphorus load was limited to 18 tons, the marginal damage cost avoided from removing a kilogram of phosphorus was $11, while the cost of removing the kilogram of phosphorus was $27. A combination of practices would be required to achieve this. Ancev (2003) assessed various technologies and policies that could be used for management of phosphorus pollution in Spavinaw- Eucha watershed. His study minimized the sum of abatement and damage costs to derive a socially optimal pattern and method of phosphorus abatement. Ancev (2003) based his study and findings on averages. These generally fall short of presenting a more practical image with environmental uncertainties.

Teague et al (1995) notes that if water quality protection policies are based on expected values of environmental damage, without considering the stochastic dimension of environmental outcomes, then water quality objectives will not be realized much of the time. His study notes that with deterministic measures there still exists a significant probability that environmental damage may occur.

Teague et al (1995) developed a farm level-programming framework to evaluate income/environmental trade offs. Using a time series of environmental risk indices, they incorporated the stochastic, multi attribute characteristics of environmental outcomes associated with agricultural production practices. The results indicated that expected income is sensitive to nitrate loading restrictions and relatively less sensitive to pesticide loading restrictions.

Qui et al (1998) extended the application of the Target MOTAD model (minimization of the total absolute deviations) by Teague et al (1995) to incorporate economic and environmental risk in agricultural production at the watershed level. They imposed a probability constrained objective function to capture yield uncertainty caused by random allocation of farming systems to soil types and by introducing environmental targets to incorporate environmental risk due to random storm events.

3.2 Target MOTAD

Tauer (1983) formulated a two-attribute risk and return model. In this model the expected return is maximized subject to some level of risk where risk is measured as the expected sum of negative deviations of solution results from a target – return level. An important feature is that most Target MOTAD solutions are second degree stochastic dominant. Teague et al modified the Target MOTAD formulation to incorporate environmental risk. The model was used to identify farm plans, which maximize net returns, but maintain environmental risk below a critical level or target.

Mathematically the formula used by Tauer (1983) and Teague (1995) was as follows

1. $\max E(z) = \sum_{j=1}^{n} C_j X_j$

   Subject to

2. $\sum_{j=1}^{n} a_{kj} X_j \leq b_k$ $\quad$ k = 1,.... M

3. $T - \sum_{j=1}^{n} C_{rj} X_j - y_r \leq 0$ $\quad$ r = 1,…..s

4. $\sum_{r=1}^{s} P_r y_r \leq \lambda$ $\quad$ $\lambda = \mathbf{M} \rightarrow \mathbf{0}$

$X_j \geq 0$ and $y_r \geq 0$

E (z) is expected returns;

C_j is expected return of activity j;

X_j is the level of activity j;

a_{kj} is the technical requirement of activity j for resource k;

b_k is the level of resource k available;

T is the target level of return;

C_{rj} is the return from activity j given the state of nature r;

y_r is the net return deviation above T for the state of nature r;

P_r is the probability that the state of nature r will occur;

λ is the risk aversion parameter which is varied from M to 0;

M is a large number.

This study applied the target MOTAD model formulated by Teague as follows;

The model remains the same except for constraint 3 and 4 that are modified and interpreted as follows:

3. $$T - \sum_{j=1}^{n} C_{rj} X_j + y_r \leq 0 \qquad r = 1, \ldots s$$

4. $$\sum_{r=1}^{s} P_r \, y_r \leq \lambda \qquad \lambda = \mathbf{M} \rightarrow \mathbf{0}$$

T is the total annual maximum phosphorus load;

C_{rj} is the phosphorus runoff from HRU j from the state of nature r;

y_r is the phosphorus runoff deviation above T for the state of nature r;

P_r is the probability that the state of nature r will occur;

λ is the risk aversion parameter which is varied from M to 0;

M is a large number.

State of nature r refers to the HRU specifications and weather patterns that affect phosphorus runoff.

Ancev (2003) used the formula below;

$$Z_q + \sum_{i=1}^{n} \sum_{j=1}^{694} Z_{ij} X_{ij} \leq Z_{\max}, \forall i, j, q \quad \text{(Total phosphorus loading less than Z max)}$$

Z_{ij} is the amount of phosphorus runoff in tons from the j_{th} HRU under the i_{th} BMP.

Z_q is the q_{th} level of phosphorus emission from the point source.

Z_{max} is total allowed phosphorus loading.

The study modifies and applies the formula used by Ancev (2003) to incorporate the risk aspect as follows.

$$Z_{\max} - \left[\sum_{i=1}^{n} \sum_{j=1}^{2416} Z_{ij} X_{ij} \right] + y_r \leq 0 \quad \sum_{r=1}^{s} \mathrm{P}_r \, y_r \leq \lambda \qquad \lambda = \mathbf{M} \rightarrow \mathbf{0}$$

3.3 DATA

The version of SWAT model Storm and White (2005) used in this study covers slightly less geographic area but has more finely developed soil type and land cover areas (HRUs) than the earlier SWAT model used by Ancev (2003). SWAT was used to evaluate non-point source nutrient loading into the Lake Eucha and Lake Spavinaw watershed. GIS and Next Generation Weather Radar (NEXRAD) data as well as the National Weather Service COOP (Cooperative Observing Network) data were utilized. Gaps in the station records were estimated by taking into consideration weather from neighboring stations. Shepard's weighted interpolation (Shepard 1968) was used as it is computationally efficient. Shepard's method uses weighting factors derived from the distance to nearby stations within a fixed radius

$$Zo = \sum_{i=1}^{n} ZiWi \,/\, \sum_{i=1}^{n} Wi$$

Where:

Zo is the precipitation at the station of interest in mm,

Z_i is the precipitation at station *i* in mm. and

W_i is the weighting factor at station *i*.

Weighting factors are calculated using the distance between stations:

$$w_i = \left(1 - \frac{d_i}{R}\right)^2 \; for \; \frac{d_i}{R} < 1 \quad \text{and} \quad w_i = 0 \; for \; \frac{d_i}{R} \geq 1$$

Where **R** is the radius of influence in meters, and d_i is the distance from station of interest to station *i* in meters.

The SWAT model, as developed and calibrated by Storm and White (2005), delineated the watershed into 90 sub-basins and 2416 HRUs. "HRUs (Hydrologic Response Units) are portions of a sub-basin that posses unique land use/ management/ soil attributes" (Arnold J.G., et al 2002). SWAT generated parameters for the Eucha and Spavinaw watershed, that include both qualitative and quantitative data for soil type, area, slope, slope length, land use, litter application, phosphorus runoff, economic output, and precipitation.

The SWAT simulation model was used to estimate the phosphorus loss from each HRU for each of the litter management practices developed by (Ancev 2003). The management practices involved applying from 1 to 6 tons of litter per hectare with or without alum. The pasture improvement and conversion of cropland to well maintained pasture were also be considered.

Specifically daily weather records (rainfall and temperature) 1950 through 2004 were used. Weather data from 1993 through 1995 were used for the warm up and the base run of the simulation model.

The warm up was done to avoid bias at the start of the simulation. The calibration and set up of the SWAT model was completed by Storm and White (2005).

Thirteen years of daily weather data are included in the model used for this study. In each run of the model the time span was limited to thirteen years (collecting only the last 10 years of the output) to avoid problems of phosphorus buildup under each litter application rate. The last 10 years in run consisted of a randomly selected sequence of actual years' data (Appendix 6).These 10 years are referred to as weather set. The random selection was done by assigning each year between 1950 and 2004 a uniform random number between 0 and 1. The 10 random years with the first run were the 10 years with the highest random numbers. The 10 years with the next highest random numbers were assigned to the second run and so forth. For the last run it was necessary to assign a second set of random numbers and reuse 5 of the years. This was done to maintain the same number of years in each simulation run.

3.4 USE OF THE SWAT MODEL TO GENERATE COEFFICIENTS FOR THE PROGRAMMING MODEL.

The SWAT simulation model provides a consistent method to evaluate each management practice on each HRU in the watershed. The procedure involved:

a) 1. Each management practice was simulated on each pasture HRU in the watershed (for example 1 ton of poultry litter). Appendix 1, 2, and 3 show the modified SWAT management files used. Note that the grazing values used in this model were different from the ones used by Storm and White (2005).

   A spreadsheet macro was used to modify each management file for the level of poultry litter used and the simulation model was run.

   The bold numbers in the Appendix 1, 2 and 3 show the values that were changed to indicate the amount of poultry litter applied.

2. A simulation run was conducted and the values for biomass removed by grazing and the annual phosphorus runoff from each HRU from the last 10 years of the simulation were recorded. This was repeated by using the next random series of weather years. Step 2 is repeated 6 times for each change in step 1

3. Steps 1 and 2 were repeated until all management practices 1-6 tons of litter was simulated. The quantity of litter applied to each hectare was incremental by one metric ton ach time

b) The next 10 years of rainfall, temperature and wind records from the coop weather stations were randomly selected, Missing records were estimated. Steps a) 1-3 were repeated.

c) Step b was repeated an additional four times.

d) The target MOTAD linear programming model was set to maximize farm income from crop and pasture/ cattle production subject to limiting the expected phosphorus loss from the watershed to 40 tons per year with deviations not exceeding 10 tons. This was repeated by reducing allowable deviations by 2.5 tons until zero or infeasibility is reached.

e) The expected annual phosphorus was reduced by 5 tons per year to 30, 25, 20, 15 tons and repeat step d) until the model become infeasible.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 SWAT RESULTS

The SWAT model divided the watershed into 90 sub-basins and 2416 HRUs. The delineation of the Sub-basins and the elevation in the watershed is shown in Figure 10 and Figure 11 respectively.

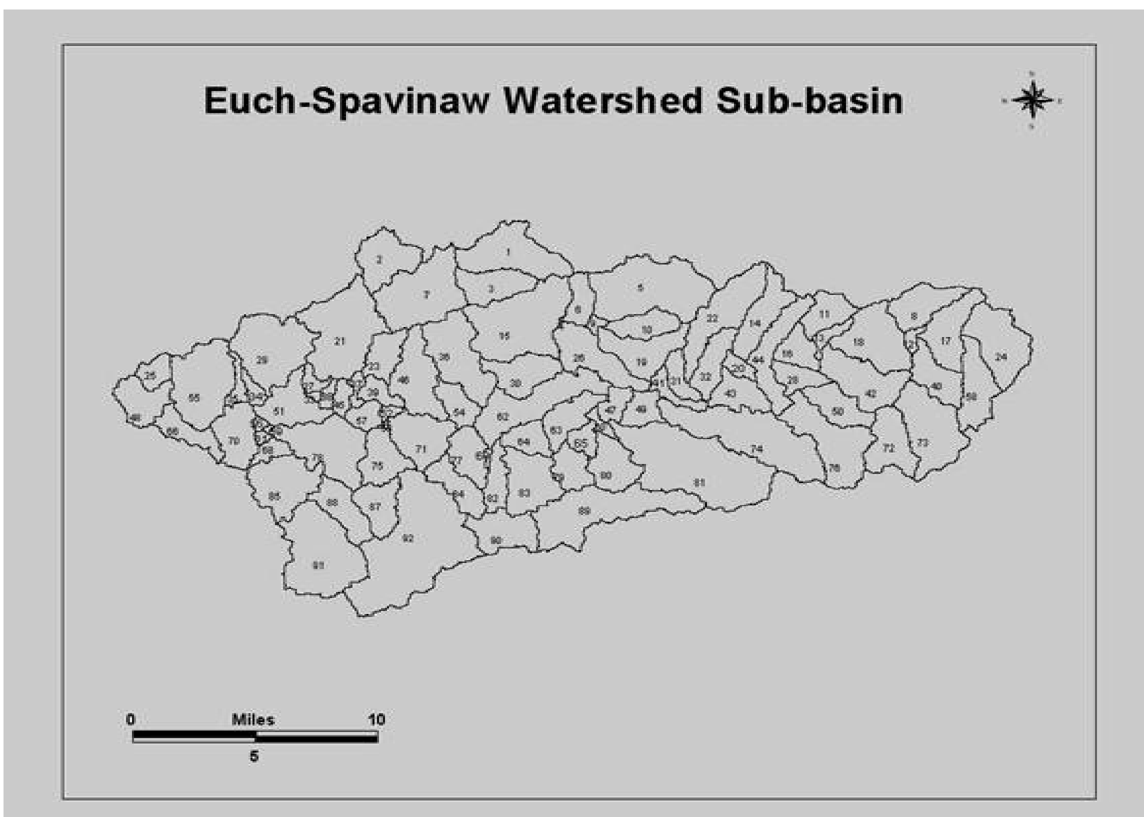

Figure 10: Location of the Sub- basins in the Eucha Spavinaw Watershed

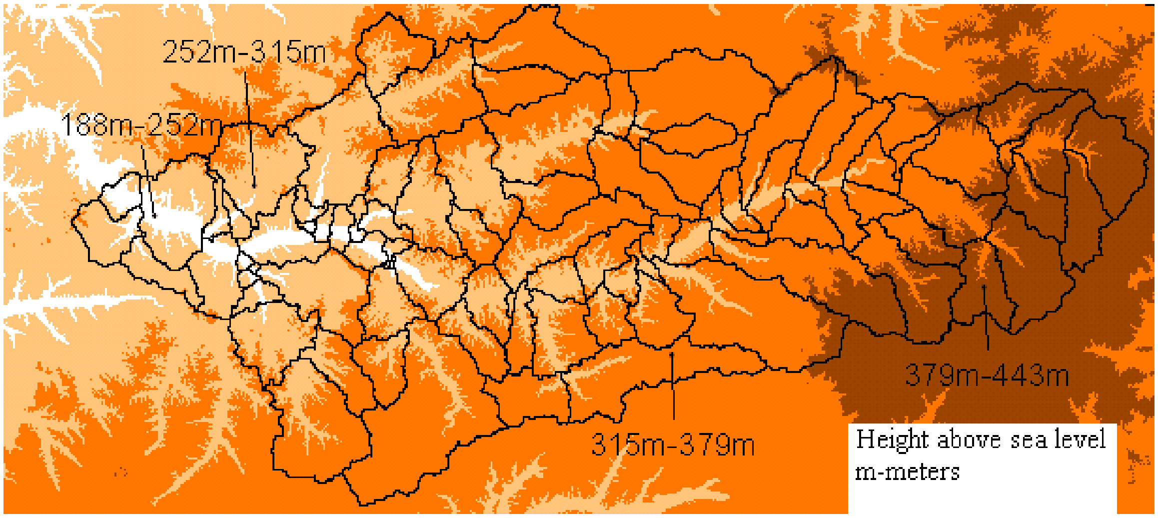

Figure 11:The Eucha Spavinaw Watershed Elevation

After the SWAT simulations had been completed, the data were summarized by sub-basin over the ten year period using annual rainfall averages and phosphorus runoff. The results are presented in a graph below.

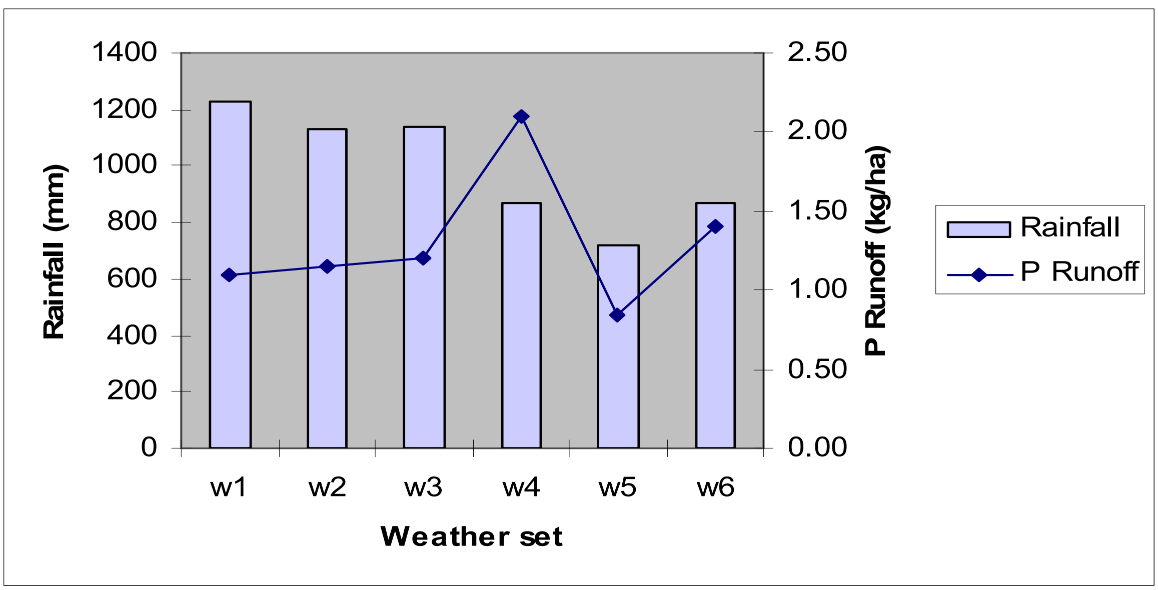

Figure 12: Annual Average Rainfall and P Runoff by Weather Set

Figure 12 shows that weather set 1 had the highest annual average rainfall and weather set 5 had the lowest. Weather sets 2 and 3 had about the same annual and was relatively higher than weather sets 4 and 6 which also had somewhat similar annual averages. The weather sets refer to the 6 sets of weather data, 10 years each discussed in subtitles 3.3 and 3.4 in the methodology. Figure 12 also shows a graph of annual average phosphorus runoff. From the results it was not conclusive that higher rainfall alone would lead to higher levels of phosphorus runoff. Phosphorus runoff could be more associated with slope, land cover and soil type. Phosphorus runoff could therefore be higher or lower when all these factors come in to play a combined role.

The watershed contains 35,916 hectares of pasture. If the total annual phosphorus loading were to be reduced to 22 Mg and all phosphorus leaving the field entered the lake, then the average field phosphorus losses would have to be less than 0.6 kg per hectare.

Table 2 shows the effect of weather variability on phosphorus runoff from selected sub-basins in the Eucha Spavinaw watershed.

Table 2: Effects of Weather Variability on Phosphorus Runoff on Selected Sub-basins.

Sub-basins with the highest phosphorus run off											
	w1f0		**w2f0**		**w3f0**		**w4f0**		**w5f0**		**w6f0**
Sub	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**
10	1.10	**26**	1.73	**10**	1.66	**10**	1.85	**10**	1.37	**10**	1.85
13	1.03	**10**	1.70	**26**	1.65	**2**	1.75	**26**	1.34	**2**	1.75
28	0.99	28	1.58	28	1.51	**26**	1.67	28	1.19	**26**	1.67
2	0.88	**2**	1.55	5	1.46	30	1.60	13	1.19	30	1.60
5	0.80	5	1.53	**2**	1.45	5	1.60	5	1.16	5	1.60
26	0.77	17	1.50	17	1.41	1	1.59	17	1.14	1	1.59
24	0.74	13	1.41	13	1.38	28	1.54	2	1.12	28	1.54
14	0.73	33	1.40	33	1.36	17	1.48	30	1.08	17	1.48
Sub-basins with the lowest phosphorus runoff											
	w1f0		**w2f0**		**w3f0**		**w4f0**		**w5f0**		**w6f0**
Sub	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**	**Sub**	**Kg/ha**
45	0.04	31	0.50	89	0.49	85	0.21	41	0.18	85	0.21
87	0.03	89	0.49	42	0.49	77	0.21	56	0.17	77	0.21
88	0.03	43	0.49	43	0.48	48	0.21	55	0.16	48	0.21
32	0.03	42	0.49	56	0.48	59	0.20	89	0.15	59	0.20
42	0.03	56	0.49	49	0.48	51	0.18	73	0.14	51	0.18
41	0.02	86	0.44	86	0.45	87	0.17	48	0.14	87	0.17
86	0.02	84	0.39	84	0.39	76	0.17	45	0.13	76	0.17
56	0.02	50	0.34	50	0.33	89	0.16	51	0.12	89	0.16
50	0.02	41	0.34	41	0.31	56	0.16	76	0.12	56	0.16
55	0.01	55	0.29	55	0.28	45	0.16	87	0.12	45	0.16

w= weather, f= poultry litter in tons, w1f0= weather set 1 with 0 tons of poultry litter applied

The Table shows eighteen sub-basins, eight of which are the highest ranking in terms of phosphorus runoff (kg/ha). The other ten are the lowest in phosphorus runoff (kg/ha). The data analysis revealed that the same sub-basins tended to have higher levels of phosphorus runoff under all weather data sets.

Table 2 indicates that the sub-basins maintain somewhat the same position regardless of the weather. The same sub-basins remained high in rank (sub-basin 10, 2, 26 (highlighted in Table 2) and similarly the same sub-basins (55, 50, and 41) remained low in rank. This is a strong indication that there are other contributing factors that influence phosphorus runoff besides the rainfall, for example the amount of poultry manure applied or date of application.

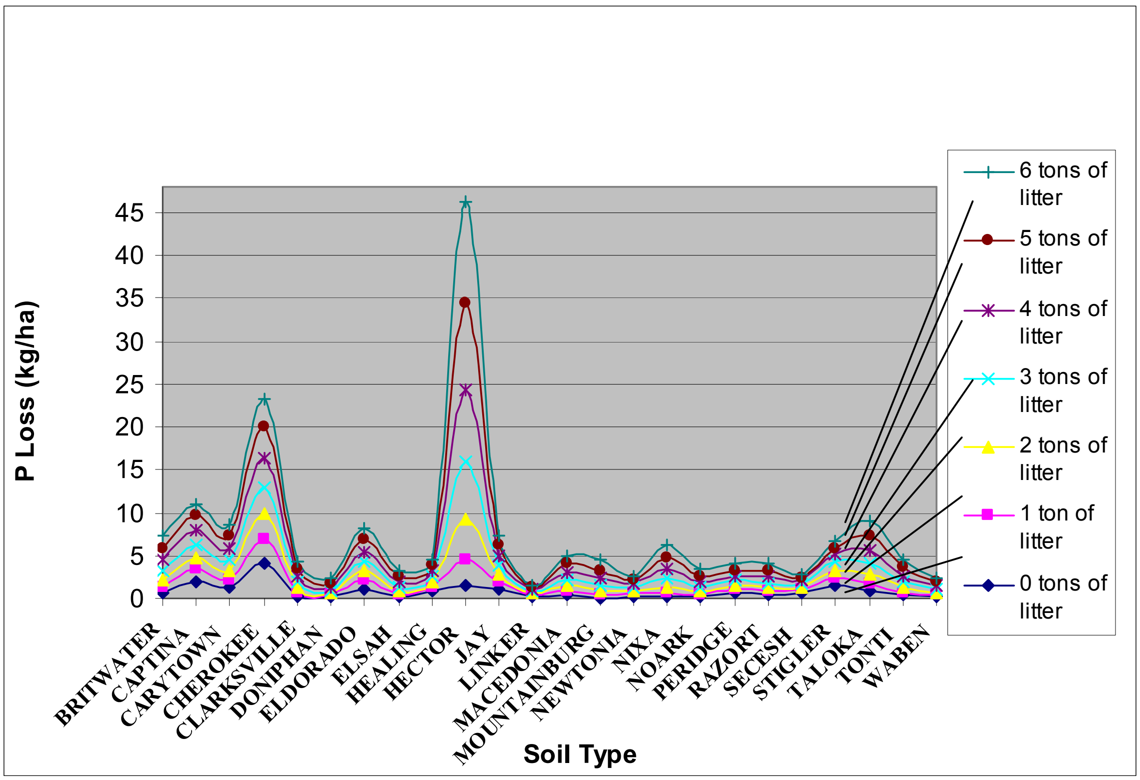

Figure 13: Average Phosphorus Runoff per hectare by Soil Type and Poultry Litter (tons) Applied

Figure 13 shows average phosphorus runoff per hectare by soil type and poultry manure applied fro pasture HRUs. It can be seen that Phosphorus loss varies with the amount of poultry manure being applied from 0 to 6 tons. The amount of phosphorus runoff increases for all soil types.

However the change in the amount of phosphorus loss per hectare depends on the soil type. For example Hector, Cherokee and Captina tend to have higher runoff regardless of the amount of manure being applied. On the other hand soil types Linker, Doniphan, and Secesh have the lowest phosphorus runoff per hectare (Figure 13 and Figure 14), for all the litter application levels. The implication is that on average we could apply manure as high as 6 ton per hectare to an HRU with Linker soil type and get less than 1kg of phosphorus runoff. At the same time applying no litter on Cherokee soil results in more than 4kg of phosphorus runoff (Table 3).

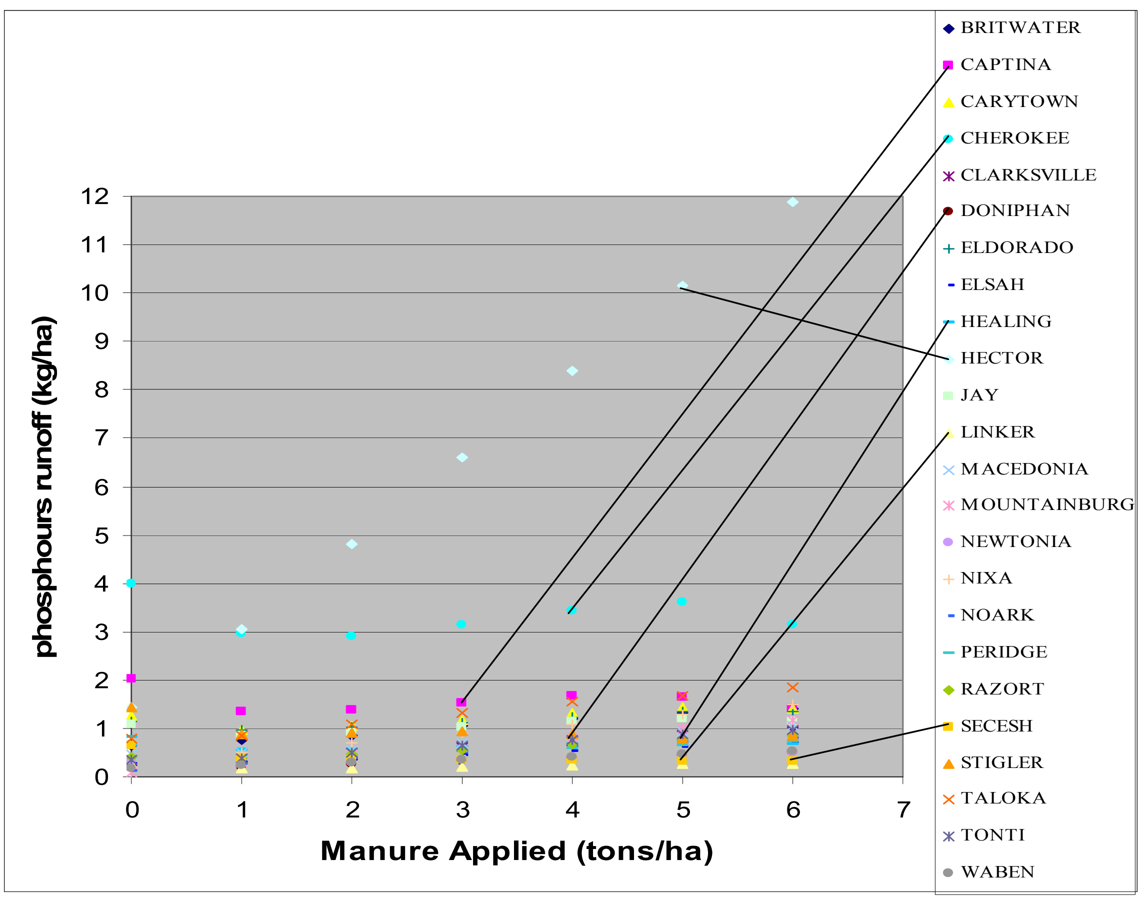

Figure 14: Phosphorus Runoff from Each Soil Type Based on the Amount of poultry Litter Applied

Similarly, Figure 14 shows the magnitude of change in phosphorus runoff as the amount of manure being applied is increased. The Hector soil type shows an increasing trend on phosphorus runoff as more poultry litter is applied as compared to the other soils. The Linker soil type does not show much increase in phosphorus runoff regardless of the application rate. The implication of the difference in magnitude of phosphorus runoff implies that certain soil types have more capacity to hold and retain phosphorus than others. The results suggest that Linker would be a more suitable soil type for litter application than the Hector soil (Table 3).

Table 3: Phosphorus loss (Kg/ha) by Soil Type by Tons (0-6) of Poultry Manure applied

		Manure Applied (Kg/ha)						
Soil Type	Hectares	0	1	2	3	4	5	6
HECTOR	6.2	1.5	3.1	4.8	6.6	8.4	10.1	11.9
CHEROKEE	19.5	4.0	3.0	2.9	3.1	3.4	3.6	3.2
CAPTINA*	5150.5	2.0	1.4	1.4	1.5	1.7	1.7	1.4
TALOKA	1948.2	0.8	0.8	1.1	1.3	1.5	1.7	1.9
CARYTOWN	127.3	1.3	1.0	1.0	1.2	1.3	1.4	1.4
ELDORADO	26.1	1.1	1.0	1.0	1.1	1.2	1.4	1.4
JAY	985.0	1.1	0.8	0.9	1.0	1.1	1.2	1.1
BRITWATER	1111.0	0.6	0.8	0.9	1.1	1.2	1.3	1.4
STIGLER	367.5	1.5	0.9	0.9	0.9	0.9	0.8	0.8
NIXA*	5752.4	0.2	0.5	0.7	0.9	1.1	1.3	1.5
MACEDONIA	1460.1	0.5	0.5	0.6	0.7	0.8	0.9	1.0
HEALING	174.9	0.8	0.5	0.6	0.6	0.7	0.7	0.7
TONTI*	3039.2	0.4	0.4	0.5	0.6	0.8	0.9	1.0
MOUNTAINBURG	0.7	0.1	0.3	0.5	0.6	0.8	1.0	1.2
CLARKSVILLE*	5932.4	0.3	0.4	0.5	0.6	0.7	0.9	1.0
RAZORT	1118.4	0.4	0.4	0.5	0.6	0.7	0.8	0.9
PERIDGE	1338.6	0.6	0.5	0.5	0.5	0.6	0.6	0.7
NOARK	393.6	0.1	0.3	0.4	0.5	0.6	0.7	0.8
ELSAH	85.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7
SECESH	209.8	0.7	0.4	0.3	0.4	0.3	0.3	0.3
NEWTONIA	2223.8	0.3	0.3	0.3	0.3	0.4	0.4	0.5
WABEN	44.0	0.2	0.2	0.3	0.3	0.4	0.5	0.5
DONIPHAN*	4352.8	0.2	0.2	0.3	0.3	0.4	0.4	0.5
LINKER	44.0	0.3	0.2	0.2	0.2	0.2	0.3	0.3

*major soil type

Table 3 shows the effect of the alternative manure application levels (0-6) tons and the resultant average phosphorus runoff by soil type. The soils are sorted in descending order by average phosphorus loss.

For soil types Linker and Doniphan, the runoff (kg/ha) remains less than 0.6kg/ha for all levels of phosphorus runoff simulated. Hector on the other hand shows increasing levels of phosphorus runoff as poultry litter application is increased.

However the amount of area for each soil type is important in determining which soil types are of more importance in the watershed. Table 3 also shows the major soil types. These constitute 67 percent of the total watershed acreage.

When considered by area (Figure 15), Captina and Nixa soils result in higher phosphorus runoff, while Mountainburg and Hector have the lowest runoff. Figure 15 reveals that zero litter does not necessarily imply low levels of phosphorus runoff especially for the Captina, Jay and Peridge soil types. The graph shows higher levels of runoff for nine of the soil types when zero litter was applied than when 1Mg litter was applied. It would therefore be more advisable to put some litter as opposed to no litter at all in the watershed. Note that land cover is an important factor to consider as biomass prevents erosion and loss of phosphorus in eroded soil sediments.

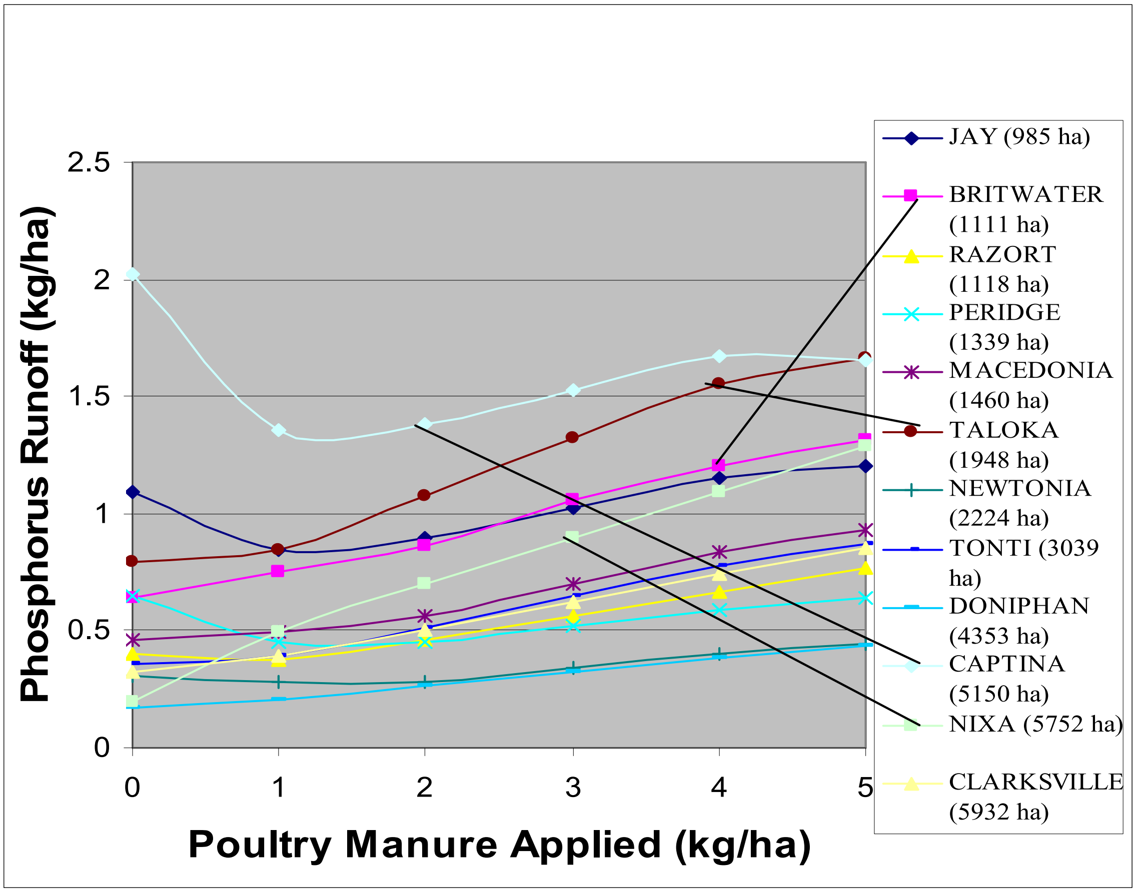

Figure 15: Phosphorus Runoff from Soils with more than 500 Ha in the Watershed.

It is important to find out if there was significant difference in phosphorus runoff between the different poultry litter application levels.

4.2 CHARACTERIZATION OF PHOSPHORUS RUNOFF ESTIMATES BY SWAT.

The analysis above summarizes phosphorus losses by soil type which is used as a qualitative variable. Current policy limits application of poultry litter based on soil test phosphorus. The provision makes no reference to individual soil characteristics. A question was raised as to whether the differences caused by soil type could be better explained by quantitative differences in slope, slope length, and soil texture. Linear Regression was used as a tool to summarize the average phosphorus runoff estimates generated from each HRU by the SWAT simulation model under each level of litter application. The purpose was to estimate the means and deviations of the parameters to determine the amount of phosphorus loss that could be predicted by knowing the poultry litter application rate, the slope, slope length, the soil texture, and average rainfall. The basic model was expressed as

$$p_{h1} = po + \sum_{i=0,6} q_i Q_i + rRkls_h + \sum_{j=1,24} a_i S_j + \sum_{k=1,6} b_k L_k + \sum_i Q_i RKLS_h + \sum_i \sum_j q_{ij} Q_i S_j$$

Where,

p_{h1} is the average phosphorus runoff from HRUh when l units of litter are applied.

q_i is the amount of runoff when Q_i tons of litter applied.

RKLS is the value proposed by Wischmeier and Smith (Stone and Hilborn 2000) to explain soil erosion by the universal soil loss equation. The RKLS is an estimate of the erosion from a bare acre of soil having a rainfall intensity value of R, a soil value of K, and an LS factor based on the length and steepness of the slope of the HRU. This value is felt to be appropriate since much of the phosphorus from poultry litter applied to pastures is on the soil surface and would be removed by runoff.

a_i is the average amount of phosphorus lost from soil type i.

b_k is the average amount of phosphorus lost from land use of pasture type L_k.

The interaction terms Qi*RKLS, and QiSj measure if Phosphorus runoff changes significantly with changes in RKLS and/or soil type. Based on physical terrain and soil texture, phosphorus loss should be largely explained the RKLS and litter variable. If the coefficients of variables related to soil type are significant in the presence of the physical variables this indicates that phosphorus lost is not sufficiently explained by surface terrain and soil texture.

The SAS (statistical Analysis System) GLM (General Linear Model) procedure (SAS Institute 2004) was used to obtain the regression results detailed in Tables 4, 5, and 6.

Table 4: Regression Results, Phosphorus Loss as a Function of Soil Type, Land Use, Quantity of Litter (Qlit) applied, Universal Soil Loss Equation (RKLS), Qlit and RKLS, Qlit and Soil Type.

The GLM Procedure: Dependent Variable: Plos

Source	Df	Sum of Squares	Mean Square	F	Pr > F
Model	54.00	2844.44	52.67	545.79	<.0001
Error	9710.00	937.13	0.10		
Corrected Total	9764.00	3781.57			

R-Square	Coeff Var	Root MSE	Plos Mean
0.75	39.56	0.31	0.79

Source	Type III SS	Mean Square	F Value	Pr > F
SoilType	780.27	33.92	351.51	<.0001
LandUse	246.94	49.39	511.72	<.0001
Qlit	60.32	60.32	624.96	<.0001
RKLS	45.10	45.10	467.34	<.0001
Qlit*RKLS	0.65	0.65	6.78	0.0093
Qlit*SoilType	296.39	12.89	133.52	<.0001

Table 4 shows the analysis of variance for the regression results in terms of the Type III sums of squares and that the model explained 75 percent of the variability in phosphorus loss in the watershed. The Type III ANOVA shows the amount of variation explained by each group of variables if they were added to a model which already contained the other variables.

Table 4 shows that each group of independent variables (soil type, land use, quantity of litter applied, RKLS, quantity of litter and RKLS, quantity of litter and soil type) significantly explained phosphorus phosphorus loss (Pr>│F│ ~ <.05). Most importantly, it indicates the differences explained by reference to soil type and soil type*litter application rate were significant even in the presence of physical variables. That is, knowing the soil type enables one to predict Phosphorus loss better.

Table 5: Regression Results, Phosphorus Loss as a Function of Soil Type, Land Use, Quantity of Litter (Qlit) applied, Universal Soil Loss Equation (RKLS), Qlit and RKLS, Qlit and Soil Type, Parameter estimates

	Parameter	Estimate	Standard Error	t Value	Pr > |t|
	Intercept	0.0598 B	0.0812	0.74	0.4619
	Cherokee	**2.4098 B**	**0.1464**	**16.46**	**<.0001**
	Captina	**1.5263 B**	**0.0819**	**18.64**	**<.0001**
	Hector	**0.9496 B**	**0.2265**	**4.19**	**<.0001**
	Stigler	**0.8905 B**	**0.0915**	**9.73**	**<.0001**
	Carytown	**0.8556 B**	**0.1241**	**6.9**	**<.0001**
	Jay	**0.7501 B**	**0.0892**	**8.41**	**<.0001**
	Eldorado	**0.5546 B**	**0.1697**	**3.27**	**0.0011**
	Taloka	**0.5519 B**	**0.0871**	**6.33**	**<.0001**
	Healing	**0.3347 B**	**0.0945**	**3.54**	**0.0004**
	Secesh	**0.2265 B**	**0.0910**	**2.49**	**0.0129**
	Peridge	**0.2160 B**	**0.0850**	**2.54**	**0.0111**
	Macedonia	0.1459 B	0.0840	1.74	0.0824
	Mountainburg	0.1260 B	0.2266	0.56	0.5783
	Linker	0.1231 B	0.1328	0.93	0.3539
	Newtonia	0.0956 B	0.0852	1.12	0.2620
	Britwater	0.0917 B	0.0830	1.10	0.2693
	Tonti	0.0597 B	0.0826	0.72	0.4702
	Waben	0.0000 B	.	.	.
	Nixa	-0.0304 B	0.0819	-0.37	0.7106
	Razort	-0.0332 B	0.0837	-0.40	0.6917
	Clarksville	-0.0452 B	0.0810	-0.56	0.5767
	Elsah	-0.0572 B	0.0961	-0.60	0.5515
	Doniphan	-0.0725 B	0.0828	-0.88	0.3809
	Noark	-0.0873 B	0.0889	-0.98	0.3261
LandUse	MPAS	0.0000 B	.	.	.
LandUse	**LPAS**	**0.2242 B**	**0.0100**	**22.37**	**<.0001**
LandUse	**LLPA**	**-0.1512 B**	**0.0112**	**-13.49**	**<.0001**
LandUse	**LMPA**	**-0.1944 B**	**0.0109**	**-17.85**	**<.0001**
LandUse	**HPAS**	**-0.1982 B**	**0.0103**	**-19.25**	**<.0001**
LandUse	**LHPA**	**-0.2040 B**	**0.0109**	**-18.67**	**<.0001**

Table 5 is a continuation of Table 4 (regression results). The coefficients in Table 5 show the estimates of phosphorus losses by major soil type and management practices relative to the overall intercept. The intercept combines the effect of the Waben soil type, MPAS land use, and the Qlit*Waben soil type. A positive coefficient means that the soil type or management practice had a greater per hectare phosphorus loss than the intercept while a negative coefficient means the opposite. The T value and probability values indicate whether these differences are significantly different from zero.

The soil variables in Table 5 have been sorted in descending order by the size of the regression coefficient. The bold values in Table 5 indicate the soil types where the amount of phosphorus lost per hectare was significantly greater than the intercept term (Waben soil, MPAS, Qlit*Waben) at the five percent level (Pr>|F|~<.05). The soils with significantly higher phosphorus loss were Cherokee, Captina, Stickler, Carytown, Jay, Eldorado, Taloka, Healing, Secesh, and Peridge. For example, 1 more hectare of Cherokee soil would increase phosphorus loss by 2.4 kg if all other variables were constant at their means. These soil types measure the extra amount of phosphorus loss that is explained by the presence of a soil type variable in addition to other variables such as RKLS, pasture management, and litter application rate.

Only the LPAS pasture management variable had higher than average phosphorus losses. This management has less cover and is the most likely to have erosion and phosphorus loss from the surface. More land cover would be expected to reduce phosphorus runoff. The remaining pasture management variables have significantly lower phosphorus losses.

Table 6: Regression Results, Phosphorus Loss as a Function of Soil Type, Land Use, Quantity of Litter (Qlit) applied, Universal Soil Loss Equation (RKLS), Qlit and RKLS, Qlit and Soil Type. Parameter Estimates Continued

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Qlit	**0.0683**	**B**	**0.0224**	**3.05**	**0.0023**
RKLS	**0.0076**	**B**	**0.0004**	**21.62**	**<.0001**
Qlit*RKLS	**-0.0003**	**B**	**0.0001**	**-2.60**	**0.0093**
Qlit*SoilType Hector	**1.6875**	**B**	**0.0628**	**26.88**	**<.0001**
Qlit*SoilType Nixa	**0.1554**	**B**	**0.0227**	**6.85**	**<.0001**
Qlit*SoilType Taloka	**0.1207**	**B**	**0.0241**	**5.00**	**<.0001**
Qlit*SoilType Mountainburg	0.1133	B	0.0628	1.80	0.0712
Qlit*SoilType Britwater	**0.0743**	**B**	**0.0230**	**3.23**	**0.0012**
Qlit*SoilType Tonti	**0.0659**	**B**	**0.0229**	**2.88**	**0.0040**
Qlit*SoilType Noark	**0.0638**	**B**	**0.0246**	**2.59**	**0.0097**
Qlit*SoilType Macedonia	**0.0504**	**B**	**0.0233**	**2.17**	**0.0303**
Qlit*SoilType Clarksville	0.0422	B	0.0224	1.88	0.0600
Qlit*SoilType Razort	0.0181	B	0.0232	0.78	0.4341
Qlit*SoilType Elsah	0.0171	B	0.0266	0.64	0.5195
Qlit*SoilType Eldorado	0.0067	B	0.0471	0.14	0.8866
Qlit*SoilType Waben	0.0000	B	.	.	.
Qlit*SoilType Carytown	-0.0054	B	0.0344	-0.16	0.8758
Qlit*SoilType Doniphan	-0.0186	B	0.0229	-0.81	0.4165
Qlit*SoilType Peridge	-0.0195	B	0.0236	-0.83	0.4078
Qlit*SoilType Jay	-0.0230	B	0.0247	-0.93	0.3531
Qlit*SoilType Newtonia	-0.0281	B	0.0236	-1.19	0.2340
Qlit*SoilType Cherokee	-0.0296	B	0.0406	-0.73	0.4658
Qlit*SoilType Linker	-0.0480	B	0.0368	-1.30	0.1926
Qlit*SoilType Healing	**-0.0496**	**B**	**0.0262**	**-1.90**	**0.0578**
Qlit*SoilType Secesh	**-0.0882**	**B**	**0.0252**	**-3.50**	**0.0005**
Qlit*SoilType Captina	**-0.1036**	**B**	**0.0227**	**-4.57**	**<.0001**
Qlit*SoilType Stigler	-0.1339	B	0.0254	-5.28	<.0001

Table 6 is also a continuation of Table 4 and Table 5 (the regression results, Phosphorus loss as a function of soil type, land use, quantity of litter applied, RKLS, quantity of litter and RKLS, quantity of litter and soil type).

In Table 6, the highlighted parameter variables significantly (Pr>│F│ ~ <.05) contribute positively to Phosphorus loss in the Eucha Spavinaw watershed.

Note that the combination of the quantity of litter applied and Captina soil type leads to a significant (Pr>│F│ ~ <.0001) negative contribution ~-0.01 (Table 6). Captina Soil type individually however has a significant (Pr>│F│ ~ <.0001) estimate of ~1.5 (Table 5). These seem distorted. Nonetheless the important factor to consider is the soil type acreage (Table 3) (Figure 15). With 5150.5 hectares of Captain Soil type in the watershed Captina has more effect on the total phosphorus loss. It is also noted that in developing Table 4, 5 and 6 the phosphorus loss means were not weighted by area unlike in Figure 15. When considered in terms of magnitude of change in phosphorus loss with increase in poultry litter application (Figure 14), for Captina soil type, phosphorus loss begins to increase less rapidly with higher levels of litter application than Waben soil. This could be due to the increase in the vegetation cover. It can be concluded that Captina soil type contributes less to phosphorus loss as illustrated in Figure 15 and Table 5.

On the other hand the Universal Soil Loss equation variable RKLS indicates that Phosphorus loss increases significantly with slope, slope length, and the soil K factor as expected.

The significantly positive interaction terms between soil type and litter application indicate the soils where the amount that phosphorous loss tends to increase significantly more rapidly than the Waben*Qlit. The other significantly positively soils include Hector, Nixa, Taloka, Britwater, Tonti, Noark, and Macedonia.

The soils where the phosporus loss increased significantly less rapidly than the mean were Healing, Secesh, and Captina.

4.3 WATERSHED LEVEL TARGET MOTAD LINEAR PROGRAMMING MODEL

Following the SWAT runs MOTAD linear programming was used to determine the most efficient feasible management practices. The LP model outlined under sub topic Target MOTAD 3.3 contained over 13,000 activities and 1978 constraints.

While much larger than the model used by Ancev (2003), the GAMS –MINOS (Brook et al 1988) was able to solve the model in less than 30 seconds on a 2.60GHz Pentium© 4 processor.

The main objective of the research was to estimate the economic cost and the probabilities of meeting weather related margins of safety for alternative TMDLs when only poultry litter applications were varied. The TMDLs (Annual Average Phosphorus Load) considered were 40Mg, 35Mg, 30Mg, 27.5Mg and 25Mg (Table 7, Figure 16). The process was to first run the TMDL representing average annual phosphorus loss with no attempt to constrain the annual deviations above this average.

Then with the TMDL target held constant, an upper bound on deviations above the target was parametrically reduced and additional solutions were obtained. When it became clear the only method of further reducing the deviations above the tentative TMDL was to reduce the TMDL itself, the TMDL was reduced by 500 or 250 kg and the process repeated. The linear programming problem became infeasible when the total annual phosphorus loss was constrained to be less than 25Mg per year. The watershed level results are summarized below in Table 7 and Figure 16.

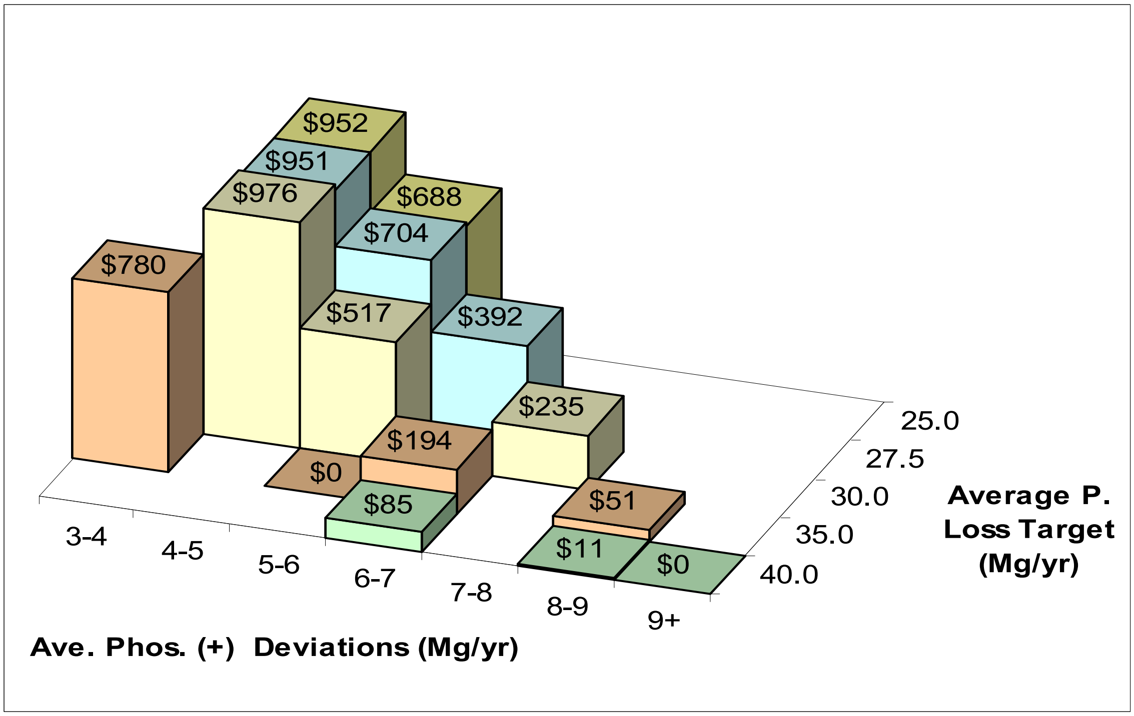

Figure 16: Annual Cost (thousands) of Reducing Mean and Deviation of Phosphorus Loss (thousands)

Figure 16 shows that if the annual deviation loss were maintained at 40Mg, the average deviations above 40Mg could be reduced from over 9Mg/ha to 8Mg/ha for $11,000 per year but that it would cost $85,000 to reduce the average deviation to 6-7Mg per year.

The average annual phosphorus loss could be reduced to 30Mg per year with an annual deviation between 7-8 Mg. Reducing these deviations to 5Mg would cost $517,000 per year.

In Table 7 for each possible TMDL and level of deviations, the objective value (expected returns) and the shadow price are given. The base solution is taken to be the 40Mg limit as this is only slightly lower (shadow price of $.37 per kg) than a solution with no restriction on annual P loss. The objective function value of $1.5 million is taken as the baseline income against which lower TMDL targets are measured. This value is net of any costs of loading, hauling, and unloading poultry litter on fields or hauling to a potential "Litter to Energy" plant at Jay, Oklahoma.

Table 7: Maximum Expected Income from Pasture and Litter Use with Alternative Limits on both the Average and the Variability of Phosphorus Runoff from the Watershed.

Maximum Average P Loss (Kg)	Actual Phosphorus Loss (Kg)	Shadow Price[a] (US$)	Deviation Above Average (Kg)	Objective Value Value (US$/Yr)	Treatment Cost Cost(US$)	Shipped To Electric Plant (Kg)
40000	40000	0.37	9356	1501205	0.00	37
40000	38056		8000	1490445	10760	493
40000	34524		6000	1415871	85334	17345
35000	35000	24.81	8361	1449855	51349	11632
35000	31580		6000	1307196	194009	24771
35000	29721		5000	1198894	302310	32265
35000	26032		3250	720729	780476	44574
35000	25786		3177	565574	935631	44574
30000	30000	52.79	7261	1265972	235233	29515
30000	26898		5000	984184	517021	39001
30000	25549		4145	525149	976056	44574
27500	27500	73.79	6660	1109525	391680	34728
27500	25709		5000	797398	703807	44048
27500	25574		4900	733892	767312	44574
27500	25324		4773	550592	950613	44574
25000	25000	241.06	5907	813321	687884	44574
25000	25000	161.03	5529	549612	951593	44574

[a]Shadow prices are only applicable when the maximum average Phosphorus loss equals the actual Phosphorus loss.

In row 1 of Table 7 an annual average phosphorus loss of 40Mg has an average deviation above this target of 9.4Mg P loss per year. The shadow price column in Table 7 shows the cost of reducing the average annual phosphorus loss by one kilogram. The “treatment cost” for each scenario is equal to the producer income for the base scenario minus the producer income of each specific scenario. The treatment cost for each scenario measures the loss in agricultural income and the increased transportation cost to transport the poultry litter from each centroid to the receiving sub-basin or the potential electric plant at Jay, Oklahoma. The actual cost of converting the litter to energy is assumed to be equal to the value of electricity and fertilizer nutrients recovered (Chala 2005). It is assumed any fertilizer nutrients recovered are transported out of the basin.

In the first row (Table 7) if we allowed one more kg of phosphorus runoff from the watershed the expected returns from the watershed would increase by US$0.37.

Similarly if the level of allowable phosphorus runoff from the watershed were 25Mg, then income from the watershed would increase by US$241 if the annual average phosphorus runoff was limited to 25Mg and no restrictions were placed on the average allowable deviation above this target. All 59Mg of litter had to either be applied or hauled to a potential “Litter to Energy” plant assumed to be built in Jay, Oklahoma.

The shipment pattern from the chicken centroids to either land application or for electricity generation is shown in Figure 17. The movement is from east to west.

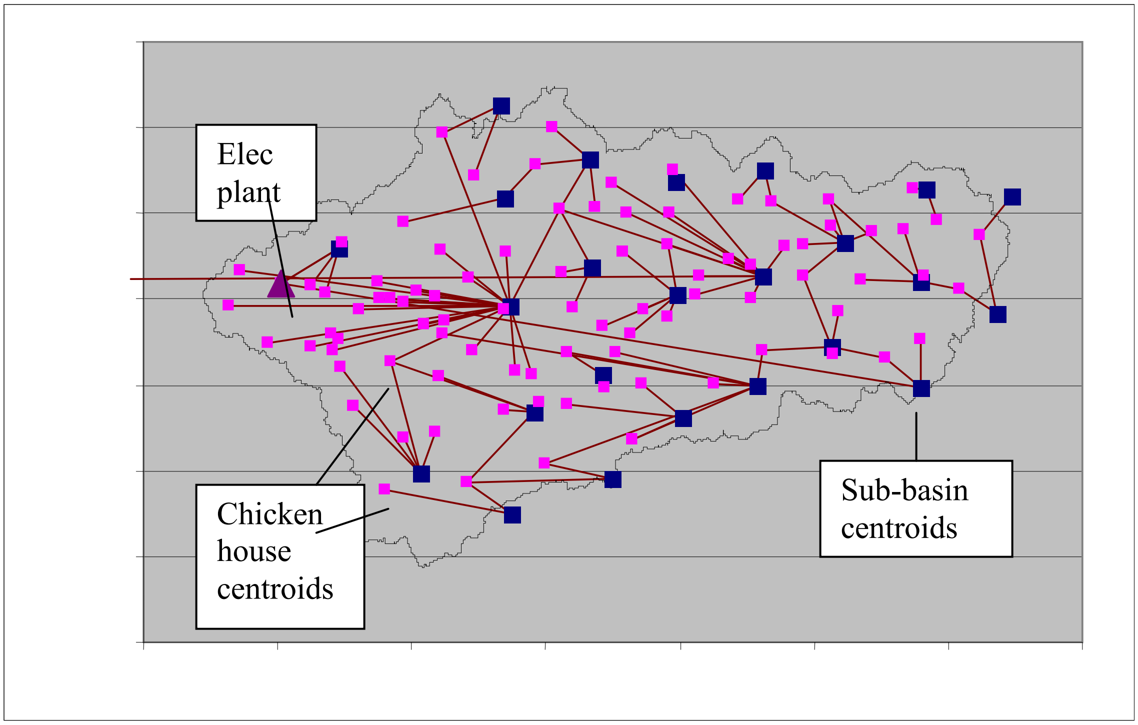

Figure 17: Poultry Litter Transportation when Maximum Annual Average Phosphorus Loss was 40Mg

As expected as the potential TMDLs were reduced and/or the deviations above these TMDLs were reduced the cost of meeting the TMDLs increased. The cost is measured by the difference between the maximum income that could be obtained with a given TMDL and the base income in row 1 of Table 7.

From Table 7 it is also noted that the quantity of litter shipped to the electric plant did not exceed 44,574 tons. This is because the remainder of the poultry litter is needed for fertilizer.

This might change if producers had been allowed to replace litter with commercial nitrogen. In addition, as shown earlier, there is actually more P loss with zero fertilization because of Phosphorus associated with erosion on some soils.

The results in Table 7 show that reducing the TMDL does reduce the unrestricted absolute deviations above the TMDL. However in most cases the actual average deviations are less than the target mean. This means that it was less costly to just reduce the target than to reduce the deviations around a given target. For example in the second scenario in Table 7 when maximum annual deviations were restricted from 9.4Mg to 8Mg per year, the mean annual phosphorus loss was reduced from 40Mg to 38Mg.

4.4 ANALYSIS OF DIFFERENCES IN PHOSPHORUS ABATEMENT AMONG SOIL TYPES.

In Figure 18 the annual average phosphorus loss was set at 35Mg, 30Mg, 27Mg and 25Mg the bar graphs indicate the quantity of litter applied and the corresponding average Phosphorus loss. Note that in as much as Captina has the highest phosphorus loss it was also more optimal to apply more litter on this soil type because the soil type is more suitable for agriculture hence more income. When the annual phosphorus loss target was 35 Mg It was optimal to apply over 35 tons of litter which generates nearly 1.5 kg of phosphorus loss. For the Nixa soil type, at a maximum annual phosphorus runoff load of 35 Mg, it would be optimal to apply 1Mg of litter per ha and the average phosphorus loss would be 1 kg/ha. When the maximum phosphorus loss was limited to 25 Mg, no poultry litter was applied and the average phosphorus loss from Nixa soils was type of up to 0.8kg/ha.

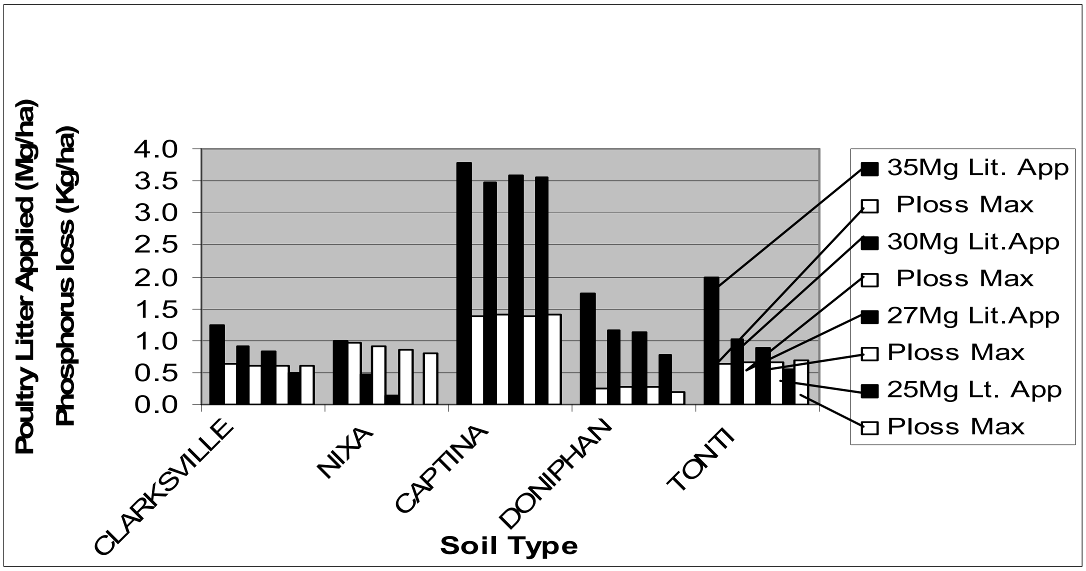

Figure 18: Average Phosphorus Loss Compared to the Quantity of Litter Applied with Respect to the Average Phosphorus Load

In Figure 18, therefore, it would be advisable not to put poultry manure on Nixa at all as one decreases the amount of annual phosphorus loss from 35Mg to 25Mg. Considerable amounts of poultry litter can still be applied on Captina for all levels of annual phosphorus loads simulated. Note that Captina soil is mainly good for hay and pasture. Alternatively, as the total phosphorus load was reduced from 35 to 25 Mg, the litter application rate actually increased slightly. The increase in the litter application rate on some soils as the total phosphorus load is reduced comes from a greater spreading of the litter.

Table 8: Summary of Annual Phosphorus Loads

	Target Ploss 35Mg			Target Ploss 30Mg		
	Ave. Dev Kg	Obj. Val US$	Elec Kg	Ave. Dev Kg	OBJ Val US$	Elec Kg
	8361	1449856	11632	7261	1265972	29515

Soil Type	Area Ha	Qlitter Mg/ha	Yld tons	AvPloss kg/ha	Rent/Ha US$/ha	T.Ploss Kg/ha	Qlitter Mg/ha	Yld tons	AvPloss Kg/ha	Rent/Ha US$/ha	T.Ploss Kg/ha
CLARKSVILL	5932	1.2	1.4	0.6	14.9	3755.3	0.9	1.4	0.6	2.5	3675.0
NIXA	5752	1.0	1.0	1.0	3.8	5582.5	0.5	1.0	0.9	-7.8	5193.0
CAPTINA	5150	3.8	1.6	1.4	1.5	7150.6	3.5	1.6	1.4	-34.1	7180.0
DONIPHAN	4353	1.7	1.6	0.3	25.3	1111.6	1.2	1.6	0.3	19.3	1166.0
TONTI	3039	2.0	1.5	0.6	22.5	1892.2	1.0	1.6	0.7	11.5	2038.0

	Target Ploss 27.5Mg			Target Ploss 25Mg		
	Ave. Dev Kg	Obj Val US$	Elec Kg	Ave.Dev Kg	OBJ Val US$	Elec Kg
	6660	1109525	34728	5907	813321	44574

Soil Type	Area Ha	Qlitter Mg/ha	Yld tons	AvPloss Kg/ha	Rent/Ha US$/ha	T.Ploss Kg/ha	Qlitter Mg/ha	Yld tons	AvPloss Kg/ha	Rent/Ha US$/ha	T.Ploss Kg/ha
CLARKSVILL	5932	0.8	1.4	0.6	-6.4	3594.3	0.5	1.4	0.6	-56.3	3307.0
NIXA	5752	0.1	1.0	0.9	-13.4	4946.3	0.0	0.9	0.8	-39.8	4880.1
CAPTINA	5150	3.6	1.6	1.4	-49.3	7166.6	3.6	1.6	1.4	-80.5	7123.0
DONIPHAN	4353	1.1	1.6	0.3	15.1	1159.9	0.8	1.6	0.2	-9.7	1024.2
TONTI	3039	0.9	1.6	0.7	3.7	2028.4	0.6	1.5	0.7	-55.1	2041.6

Table 8 is a summary of the annual phosphorus loads that were simulated for five major soils. For example in order to have an annual phosphorus load target of 25Mg and maximize income, the deviation above this target would be as high as 5.9Mg per year, the expected income would be US$ 813,321 from the watershed, 44,574kgs of poultry litter would be shipped to the electric plant. The quantity of litter to be applied, the expected yield, and the average phosphorus runoff are given. The negative values for land rent occur because the model required all land to be used. The possibility of just leaving it ungrazed was not considered.

The results in Table 8 and Figure 18 can be used to explain why targeting for phosphorus loss should not be based solely on the amount of phosphorus loss per hectare alone. In Table 8, the litter application on all Captina soils when the average phosphorus loss for the watershed was 30 Mg, was 3.8 tons of litter and the average phosphorus loss was 1.4 kg per hectare. In the same case, the average litter application rate on the Nixa soil was only 0.5 tons of litter with a loss of only 0.9 kg. of phosphorus per hectare. The reason that more litter (and consequently more phosphorus loss) occurs on the Captina than the Nixa soil is because of the amount of consumed forage that is given up per unit of phosphorus runoff prevented when litter applications are reduced. Consider the data in Table 9 below that compares the average biomass consumed and phosphorus runoff in the watershed from the Captina and Nixa soils.

Table 9: Comparison of Forage Consumptions Forgone per Unit of Phosphorus Loss Prevented by Reducing Litter Applications on Captina and Nixa Soils in the Eucha Watershed.

Captina soils						Nixa Soils				
Litter Mg/ha	P Loss Kg/ha	ΔP Loss Kg/ha	Forage Kg/ha	Δ Forage	Δ Forage / Δ ploss	P Loss Kg/ha	ΔP Loss Kg/ha	Forage Kg/ha	Δ Forage	Δ Forage / Δ ploss
4.0	1.7		1555.0			1.1		1057.0		
3.0	1.5	0.1	1486.0	69.0	492.9	0.9	0.2	971.0	86.0	452.6
2.0	1.4	0.2	1357.0	129.0	860.0	0.7	0.2	836.0	135.0	675.0
1.0	1.4	0.0	1171.0	186.0	9300.0	0.5	0.2	629.0	207.0	985.7
0.0	2.0	-0.7	801.0	370.0	-560.6	0.2	0.3	32.0	597.0	1990.0

(Δ) represents changes or the difference in phosphorus loss or forage consumed as the application of litter is changed.

In the above table, consider a reduction of litter application from 4 to 3 Mg per ha, on both the Captina and Nixa soils. On the Captina soil, forage yields are reduced by

492.9kg per kg of phosphorus loss prevented whereas that only 452.6kg of forage yield is lost per kg of phosphorus abated on the Nixa Soil. When the attempt is made to reduce the litter application from 3 to 2 tons, 860kg of forage consumption is given up for each kg of phosphorus loss abated on the Captina soil as compared to 675kg of forage per kg of phosphorus loss abated on the Nixa soil. Thus the programming model finds is cheaper to abate or prevent phosphorus loss on the Nixa rather than the Captina soils. Note that phosphorus loss at first decreases with increasing litter application on the Captina soil.

Because further reductions of litter on the Captina soil require increasing amounts of forage consumption to be given up (and even increase phosphorus loss if less than a ton is applied), the litter application rate remains high relative to other soils for all phosphorus targets considered.

4.5 COST OF REDUCING DEVIATIONS AROUND A POTENTIAL TMDL.

The probability of exceeding the TMDLs is given in Figure 19. To interpret Figure 19, select a deviation above a TMDL such 400 kg. Reading vertically upward, the diagram shows that only about 87 percent of the deviations are less than 400 kg when the TMDL is 40 Mg per year. Nearly 95 percent of the deviations are less than 400 kg above the TMDL when the TMDL is set at 30 Mg or less. However from Table 8 we know that for the TMDL to be feasible this deviation would be as high as 7,261 kg if the average phosphorus is set high for example 40Mg tons therefore chances of exceeding it.

However, setting the average phosphorus low, for example at 25Mg, increases the chances of exceeding the stated average phosphorus.

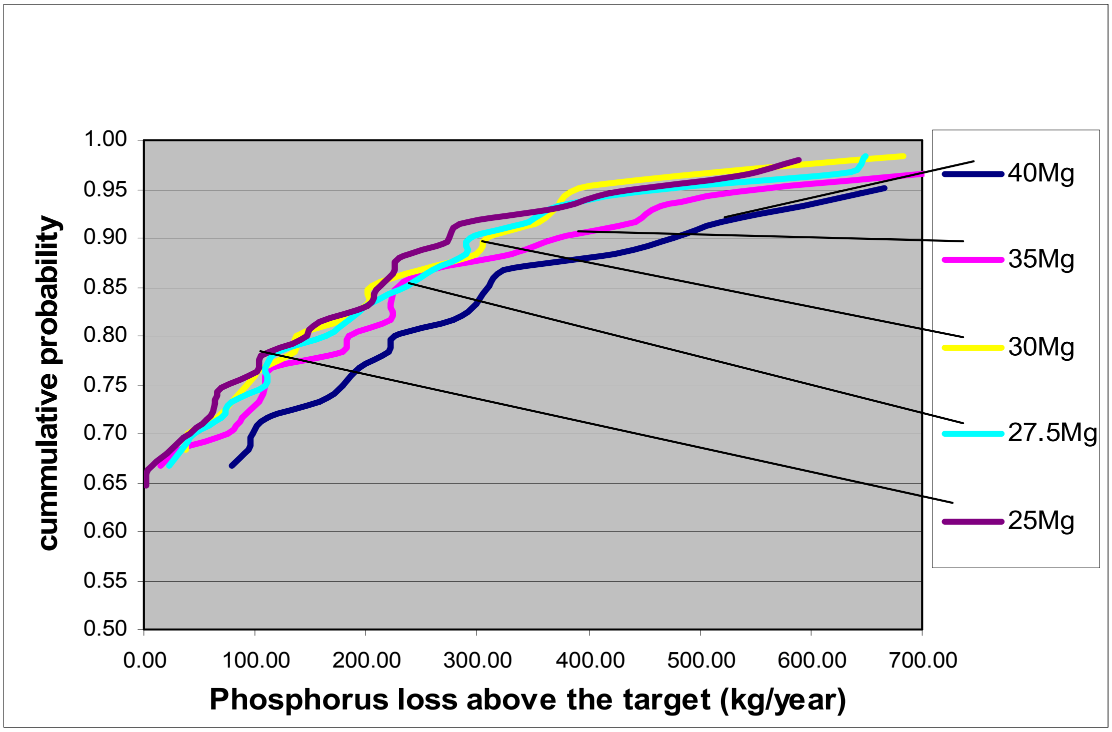

Figure 19: Cumulative Probability of Exceeding the Target Phosphorus Runoff.

4.6 SUMMARY

To be able to solve the problem of phosphorus pollution in the Eucha Spavinaw watershed, There are a number of factors to take into consideration;

a) The amount of Phosphorus getting into the watershed lakes needs to be reduced and an important way of reducing this phosphorus runoff is by reducing litter application in the watershed. However the least cost method of meeting the runoff target would be non-uniform rates of litter application.

b) Based on these initial findings, it appears that the program to reduce phosphorus runoff, at least cost could proceed by first selecting those soils where phosphorus abatement can be obtained at least cost.

c) The previous study by Ancev (2003) found that the inclusion of additional management practices could lower the overall cost of meeting runoff targets. Pasture management and conservation practices such as improving land cover and riparian areas should be analysed.

d) Soil types; Captina, Nixa and Tonti have the highest phosphorus runoff based on the number of hectares in the watershed. Soil types Peridge, Razort, and Newtonia have the lowest phosphorus runoff per hectare. Since the objective incorporates maximizing income from the watershed litter applications levels should be according to the soil type (Table 8).

e) Extreme weather conditions whether it is drought or flooding, contribute to phosphorus runoff. Note that extreme dry conditions lead to loss of land cover and destruction of vegetation, factors that contribute to more erosion and phosphorus runoff. Best management practices are important in this case.

f) Currently the suggestion has been to apply manure based on STP (Soil Test Phosphorus) which is how much phosphorus there is on or near the surface of the soil. However, the major finding in this research is that it might be more important to consider deviations in poultry manure application based on soil type. However more research needs to be done in this area.

g) It is important to note that if the objective is to maximize income from the watershed then in addition to taking into consideration STP values other factors such as income per hectare, slope, land cover, soil type and levels of litter application need to be considered. An integrated holistic watershed plan would be important. Target MOTAD enables the planners to be realistic in their projections.

4.7 CONCLUSION

This study was exploratory, it did not take into consideration all possible best management practices in the watershed and determine the role they play. It would be important to take these into consideration as they play a major role in land use and land cover. Based on the findings of this and other research, cost effective HRU or sub-basin specific management practices can be formulated.

As far as it is known this study is the first to develop a Target MOTAD directly from SWAT outputs to a watershed with this level of spatial detail. The process demonstrates that it is feasible to develop optimization models directly from the SWAT models being used by researchers in many states who are trying to develop TMDLs. The process of setting up models, running the models, and developing summaries of the results needs to become more computerized.

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APPENDIXES

APPENDIX 1 - Management Operations for each Pasture and Range Type

Management Operations	
HPAS 6 Modified 05/06/2006 HPAS Filegen 1.0 for SWAT 2000 1 1 0 12 0.00 00.0 0.00 1000.00 0.11 82.00 1.00 1 1 0.000 15000.000 12 0.000 0.000 0.000 0.000 3 1 0.000 3 1.000 52 **6000**. 3 1 0.000 3 1.000 01001 3 1 0.000 9 7.468 270 7.468 2.409 45	**LPAS** 6 Modified 05/06/2006 LPAS Filegen 1.0 for SWAT 2000 1 1 0 12 0.00 00.0 0.00 1000.00 0.11 82.00 1.00 1 1 0.000 15000.000 12 0.000 0.000 0.000 0.00 0. 3 1 0.000 3 1.000 52 **6000**. 3 1 0.000 3 1.000 01001 3 1 0.000 9 7.468 270 7.468 2.409 45
LHPA 6 Modified 05/06/2006 LHPA Filegen 1.0 for SWAT 2000 1 1 0 12 0.00 00.0 0.00 1000.00 0.11 82.00 1.00 1 1 0.000 15000.000 12 0.00 0.00 0.000 0.000 0.0 3 1 0.000 3 1.000 52 **6000**. 3 1 0.000 3 1.000 01001 3 1 0.000 9 7.468 270 7.468 2.409 45	**MPAS** 6 Modified 05/06/2006 MPAS Filegen 1.0 for SWAT 2000 1 1 0 12 0.00 00.0 0.00 1000.00 0.11 82.00 1.00 1 1 0.000 15000.000 12 0.000 0.000 0.000 0.00 0. 3 1 0.000 3 1.000 52 **6000**. 3 1 0.000 3 1.000 01001 3 1 0.000 9 7.468 270 7.468 2.409 45
LLPA 6 Modified 05/06/2006 LLPA Filegen 1.0 for SWAT 2000 1 1 0 12 0.00 00.0 0.00 1000.00 0.11 82.00 1.00 1 1 0.000 15000.000 12 0.000 0.000 0.000 0.000 3 1 0.000 3 1.000 52 **6000**. 3 1 0.000 3 1.000 01001 3 1 0.000 9 7.468 270 7.468 2.409 45	**RNGB** 6 Modified 05/06/2006 RNGB Filegen 1.0 for SWAT 2000 1 1 0 16 0.20 20.00 1800.00 1148.00 0.11 54.00 1.0 1 1 0.000 11800.000 16 0.000 0.000 0.00 0.00 0.0 3 1 0.000 9 7.468 270 7.468 2.409 45
LMPA 6 Modified 05/06/2006 LMPA Filegen 1.0 for SWAT 2000 1 1 0 12 0.00 00.0 0.00 1000.00 0.11 82.00 1.00 1 1 0.000 15000.000 12 0.000 0.00 0.00 0.000 0.000 3 1 0.000 3 1.000 52 **6000**. 3 1 0.000 3 1.000 01001 3 1 0.000 9 7.468 270 7.468 2.409 45	

HPAS- High biomass pasture

LPAS- Low biomass pasture

LHPA- Litter high biomass pasture

MPAS- Medium biomass pasture

LLPA- Litter Low biomass

RNGB- Range brush

LMPA- Litter medium biomass pasture

APPENDIX 2 - Low, Medium, and High Biomass Pasture Management

Activity/date	LPAS	MPAS	HPAS	LLPA	LMPA	LHPA
Crop Planted (1/1)	Tall Fescue	Tall Fescue	Tall Fescue	Tall Fescue	Tall Fescue	Tall Fescue
Fertilizer (3/1)	None	None	Broiler fresh manure	Broiler fresh manure	Broiler fresh manure	Broiler fresh manure
Grazing (3/1)	270 days	270 days	270 days	270 days	270 days	270 days
BIO-MIN (kg/ha/day)	1000	1000	1000	1000	1000	1000
BMEAT (kg/ha/day)	7.468	7.468	7.468	7.468	7.468	7.468
BMTRMP (kg/ha/day)	7.468	7.468	7.468	7.468	7.468	7.468
WMANURE (kg/ha/day)	2.409	2.409	2.409	2.409	2.409	2.409

BIO_MIN- Minimum plant biomass for grazing

BMEAT- Dry weight of biomass consumed daily (kg/ha/day)

BMTRMP-Dry weight of biomass trampled daily (kg/ha/day)

WMANURE-Dry weight of manure deposited daily (kg/ha/day)

APPENDIX 3 - Agricultural land Management File Low, Medium, and High Biomass Pasture Management

AGRL 14	**Graze-out Green Bean and winter Wheat Rotation system**	
Modified 05/06/2006 AGRL Filegen 1.0 for SWAT 2000	**AGL (Agricultural Land generic)**	
1 1 0 28 0.20 20.0 2000 1000.00 0.11 80.00 1.00	**Date**	**Activity**
2 15 0.000 9 13.950 75 13.950 4.500 45	15-Feb	Grazing (75 days),
3 1 0.000 3 1.000 5200**6000**.	1-Mar	Apply poutry manure
5 1 0.000 5 0.000	1-May	Harvest and killwinter wheat
5 4 0.000 6 2 0.000	4-May	Tillage operation
5 5 0.000 3 1.000 0100000.3	5-May	Apply commercial fertilizer N 0.3Kg/ha
5 15 0.000 11200.000 84 0.000 0.00 0.000 0.00 0.	15-May	Plant green beans
8 1 0.000 5 0.000	1-Aug	Harvest and Kill green beans
8 5 0.000 3 1.000 0100000.7	5-Aug	Apply commercial fertilizer N 0.7Kg/ha
8 10 0.000 6 2 0.000	10-Aug	Tillage operation
9 1 0.000 11500.000 28 0.000 0.00 0.000 0.00 0.0	1-Sep	Plant winter wheat
11 15 0.000 9 13.950 45 13.950 4.500 45	15-Nov	Grazing (45 days),

APPENDIX 4.1 - 60 Year Summary by Soil Type when average Annual Phosphorus was constrained to Less than 35 Mg

Annual Average Ploss	SP	LmdMx	Obj Val	Elec
35000.0	($)	(Kg)	($)	(Kg)
(Kg)	24.8	8361.3	1449855.5	11632.1

Hgrp	Soil Type	Area (Ha)	CurveNo	RKLS	Qlitter (Kg/ha)	TotN (Kg/ha)	Yld Ton/ha	Ploss (Kg/ha)	Rent $/Ha	T.Ploss (Kg/ha)		Cum. Freq	Dev Kg/ha
B	RKSVILLE	5932.4	55.3	35.9	1.2	37.3	1.4	0.6	14.9	3755.3	Y29	0.67	14.9
C	NIXA	5752.4	67.1	38.7	1.0	36.2	1.0	1.0	3.8	5582.5			
C	CAPTINA	5150.5	67.2	40.1	3.8	113.1	1.6	1.4	1.5	7150.6	Y13	0.70	74.7
B	DONIPHAN	4352.8	56.7	25.2	1.7	51.8	1.6	0.3	25.3	1111.6	Y11	0.95	562.0
C	TONTI	3039.2	67.2	40.8	2.0	53.3	1.5	0.6	22.5	1892.2	Y10	0.92	443.1
B	EWTONIA	2223.8	54.0	25.0	2.1	64.1	1.5	0.3	24.6	749.3	Y37	0.72	88.4
D	TALOKA	1948.2	72.9	30.6	1.0	25.5	1.6	1.4	9.9	2746.0	Y2	0.97	712.8
B	ACEDONIA	1460.1	54.4	32.9	1.6	47.2	1.6	0.7	17.7	1078.5	Y59	0.82	221.5
B	PERIDGE	1338.6	53.4	42.0	2.7	79.8	1.5	0.3	23.0	464.7			
B	RAZORT	1118.4	53.1	38.3	1.3	39.5	1.4	0.6	14.3	640.4	Y55	0.80	184.0
B	RITWATER	1111.3	53.1	48.4	1.1	33.8	1.5	1.0	11.0	1125.1	Y39	0.85	229.5
C	JAY	984.8	66.8	22.0	2.0	56.8	1.5	1.2	8.4	1145.8	Y33	0.87	258.0
B	NOARK	393.6	52.7	33.5	1.9	57.7	1.1	0.5	13.2	212.8	Y32	0.68	32.7
D	STIGLER	367.5	75.6	39.4	2.0	67.9	1.7	0.8	13.5	292.7	Y22	0.93	464.4
B	SECESH	209.8	52.8	41.3	4.7	141.3	1.6	0.3	25.4	62.6	Y12	0.83	222.5
B	HEALING	174.9	51.1	36.1	2.4	73.3	1.4	0.6	10.0	100.7			
D	ARYTOWN	127.3	71.7	23.0	2.0	47.3	1.5	1.4	5.1	176.4	Y26	0.88	331.0
B	ELSAH	85.2	52.2	32.9	2.1	64.2	0.9	0.3	-0.8	27.8	Y54	0.77	115.5
B	LINKER	44.0	57.1	26.3	4.8	143.9	1.4	0.3	28.4	12.5	Y8	0.98	790.2
B	WABEN	44.0	53.5	33.4	2.1	61.9	1.2	0.2	20.0	9.3	Y28	0.75	109.8
B	LDORADO	26.1	55.0	40.7	1.9	56.3	1.5	1.1	3.2	28.2	Y49	0.78	178.8
D	HEROKEE	19.5	73.2	64.9	4.0	127.5	1.6	2.9	-38.3	55.8	Y60	0.90	372.7
D	HECTOR	6.2	82.0	17.5	0.0	0.0	0.0	8.9	-36.0	55.5	Y56	0.73	103.6
D	TAINBURG	0.7	77.0	9.3	3.0	90.0	0.0	0.3	-32.2	0.2	Y47	1.00	
	Total or wtave	35911.0	61.2		1.9	56.2	1.5	0.8	13.4	28477.0			

Sp=shadow price
Hgrp=Hydrology group

APPENDIX 4.2 - 60 Year Summary by Soil Type when average Annual Phosphorus was constrained to Less than 30Mg

Annual Average Ploss	SP	LmdMx	Obj Val	Elec
30000.0	($)	(Kg)	($)	(Kg)
(Kg)	52.8	7261.3	1265971.9	29515.0

Hgrp	Soil Type	Area (Ha)	CurveNo	RKLS	Qlitter (Kg/ha)	TotN (Kg/ha)	Yld Ton/ha	Ploss (Kg/ha)	Rent $/Ha	T.Ploss (Kg/ha)		Dev Kg/ha	Cum. Freq
B	ARKSVILLE	5932.4	55.3	36.0	0.9	27.4	1.4	0.6	2.5	3675.0	Y32	37.6	0.68
C	NIXA	5752.4	67.1	39.0	0.5	14.5	1.0	0.9	-7.8	5193.0			
C	CAPTINA	5150.5	67.2	40.0	3.5	104.5	1.6	1.4	-34.1	7180.0	Y28	65.7	0.70
B	DONIPHAN	4352.8	56.7	25.0	1.2	35.1	1.6	0.3	19.3	1166.0	Y11	516.5	0.72
C	TONTI	3039.2	67.2	41.0	1.0	30.6	1.6	0.7	11.5	2038.0	Y60	372.7	0.73
B	NEWTONIA	2223.8	54.0	25.0	2.0	58.4	1.6	0.4	16.7	797.0	Y37	78.2	0.75
D	TALOKA	1948.2	72.9	31.0	0.6	16.9	1.6	1.5	-11.9	2879.0	Y2	683.4	0.77
B	ACEDONIA	1460.1	54.4	33.0	1.2	34.4	1.6	0.7	4.2	1085.0	Y12	200.9	0.78
B	PERIDGE	1338.6	53.5	42.0	2.3	67.5	1.5	0.4	9.8	481.0			0.80
B	RAZORT	1118.4	53.1	38.0	1.2	35.8	1.4	0.6	1.1	652.0	Y59	178.1	0.82
B	RITWATER	1111.3	53.1	48.0	0.7	20.2	1.5	1.0	-8.9	1114.0	Y33	248.2	0.83
C	JAY	984.8	66.8	22.0	1.5	45.1	1.5	1.3	-16.0	1232.0	Y60	299.2	0.85
B	NOARK	393.6	52.8	33.0	1.0	31.1	1.1	0.5	4.5	214.0	Y13	39.7	0.87
D	STIGLER	367.5	75.6	39.0	2.9	88.1	1.7	1.0	-9.7	362.0	Y22	392.0	0.88
B	SECESH	209.8	52.8	41.0	5.3	159.6	1.7	0.3	11.9	66.0	Y39	204.7	0.90
B	HEALING	174.9	51.1	36.0	2.5	75.3	1.5	0.6	-12.7	104.0			0.92
D	ARYTOWN	127.3	71.7	23.0	1.0	30.0	1.5	1.5	-22.3	190.0	Y26	309.5	0.93
B	ELSAH	85.2	52.2	33.0	1.8	54.1	1.0	0.4	-23.7	32.0	Y55	134.9	0.95
B	LINKER	44.0	57.1	26.0	4.5	135.8	1.5	0.2	23.5	10.0	Y8	702.6	0.97
B	WABEN	44.0	53.5	33.0	1.9	58.1	1.2	0.2	12.8	10.0	Y56	107.4	0.98
B	ELDORADO	26.1	55.0	41.0	1.0	30.0	1.5	1.2	-23.9	32.0	Y49	136.5	1.00
D	CHEROKEE	19.5	73.2	65.0	2.0	60.0	1.5	3.6	-119.8	70.0	Y10	354.8	
D	HECTOR	6.2	82.0	17.0	0.0	0.0	0.0	8.9	-76.6	55.0	Y54	92.4	
D	TAINBURG	0.7	77.0	9.0	3.0	90.0	0.0	0.3	-59.3	0.0	Y47		
	Total or wtave	35911.0	61.2		1.4	43.2	1.5	0.8	-2.4	28635.0			

Sp=shadow price
Hgrp=Hydrology group

APPENDIX 4.3 - 60 Year Summary by Soil Type when average Annual Phosphorus was constrained to Less than 27Mg

Annual Average Ploss (Kg)	SP ($)	LmdMx (Kg)	Obj Val ($)	Elec (Kg)
27000.0	**73.8**	**6659.5**	**1109524.8**	**34728.5**

Hgrp	Soil Type	Area (Ha)	CurveNo	RKLS	Qlitter (Kg/ha)	TotN (Kg/ha)	Yld Ton/ha	Ploss (Kg/ha)	Rent $/Ha	T.Ploss (Kg/ha)		Dev Kg/ha	Cum. Freq
B	ARKSVILLE	5932.4	55.3	35.9	0.8	24.6	1.4	0.6	-6.4	3594.3	Y13	21.9	0.67
B	NIXA	5752.4	67.1	38.7	0.1	4.2	1.0	0.9	-13.4	4946.3			
B	CAPTINA	5150.5	67.2	40.1	3.6	107.3	1.6	1.4	-49.3	7166.6	Y32	44.7	0.70
B	DONIPHAN	4352.8	56.7	25.2	1.1	33.7	1.6	0.3	15.1	1159.9	Y11	475.9	0.95
B	TONTI	3039.2	67.2	40.8	0.9	26.4	1.6	0.7	3.7	2028.4	Y22	346.3	0.92
B	NEWTONIA	2223.8	54.0	25.0	1.9	56.7	1.6	0.4	11.2	797.0	Y37	69.3	0.72
B	TALOKA	1948.2	72.9	30.6	0.5	16.3	1.6	1.5	-19.3	2889.3	Y2	635.6	0.97
B	ACEDONIA	1460.1	54.4	32.9	1.1	32.9	1.6	0.7	-5.6	1084.6	Y12	184.9	0.82
B	PERIDGE	1338.7	53.5	42.0	1.9	57.6	1.5	0.4	0.3	501.4			
B	RAZORT	1118.4	53.1	38.3	1.0	31.2	1.4	0.6	-8.6	658.4	Y59	163.7	0.80
B	RITWATER	1111.3	53.1	48.4	0.7	19.9	1.5	1.0	-23.5	1114.0	Y33	236.3	0.85
B	JAY	984.8	66.8	22.0	1.4	41.6	1.5	1.2	-33.9	1223.0	Y60	259.4	0.87
B	NOARK	393.6	52.8	33.5	0.9	27.9	1.1	0.5	-1.2	211.5	Y28	34.6	0.68
B	STIGLER	367.5	75.6	39.4	4.1	124.1	1.7	1.0	-25.2	372.9	Y60	372.7	0.93
C	SECESH	209.8	52.8	41.3	5.3	160.1	1.7	0.3	0.7	65.9	Y39	203.5	0.83
C	HEALING	174.9	51.1	36.1	2.6	78.9	1.5	0.6	-29.3	105.1			
C	ARYTOWN	127.3	71.7	23.0	1.0	30.0	1.5	1.5	-42.4	190.5	Y26	290.6	0.88
C	ELSAH	85.2	52.2	32.9	1.6	47.4	1.0	0.4	-40.5	31.2	Y56	109.7	0.77
D	LINKER	44.0	57.1	26.4	4.3	127.7	1.5	0.2	19.2	10.7	Y8	649.9	0.98
D	WABEN	44.0	53.5	33.4	1.8	53.4	1.2	0.2	7.3	10.4	Y49	108.2	0.75
D	ELDORADO	26.1	55.0	40.7	1.0	30.0	1.5	1.2	-44.2	31.8	Y55	120.7	0.78
D	CHEROKEE	19.5	73.2	64.9	2.0	60.0	1.5	3.6	-180.6	70.2	Y10	293.4	0.90
D	HECTOR	6.2	82.0	17.5	0.0	0.0	0.0	8.9	-107.0	55.5	Y54	78.2	0.73
D	TAINBURG	0.7	77.0	9.3	3.0	90.0	0.0	0.3	-79.0	0.2	Y47	2319	1.00
	Total or wtave	35911.0	61.2		1.4	40.4	1.4	0.8	-11.4	28319.0			

Sp=shadow price
Hgrp=Hydrology group

APPENDIX 4.4 - 60 Year Summary by Soil Type when average Annual Phosphorus was constrained to Less than 25Mg

Annual Average Ploss (Kg)	SP ($)	LmdMx (Kg)	Obj Val ($)	Elec (Kg)
25000.0	241.1	5906.7	813321.1	44574.0

Hgrp	Soil Type	Area (Ha)	CurveNo	RKLS	Qlitter (Kg/ha)	TotN (Kg/ha)	Yld Ton/ha	Ploss (Kg/ha)	Rent $/Ha	T.Ploss (Kg/ha)		Dev Kg/ha	Cum. Freq
B	RKSVILLE	5932.4	55.3	35.9	0.5	15.0	1.4	0.6	-56.3	3307.0	Y13	2.3	0.65
C	NIXA	5752.4	67.1	38.7	0.0	0.2	0.9	0.8	-39.8	4880.1	Y22	3.8	0.66
C	CAPTINA	5150.5	67.2	40.1	3.6	107.2	1.6	1.4	-80.5	7123.0	Y32	35.4	0.70
B	DONIPHAN	4352.8	56.7	25.2	0.8	22.7	1.6	0.2	-9.7	1024.2	Y11	426.1	0.95
C	TONTI	3039.2	67.2	40.8	0.6	16.7	1.5	0.7	-55.1	2041.6	Y26	283.4	0.91
B	EWTONIA	2223.8	54.0	25.0	1.9	56.5	1.6	0.4	-28.5	790.8	Y54	56.4	0.71
D	TALOKA	1948.2	72.9	30.6	0.4	11.1	1.5	1.5	-60.3	2968.8	Y2	534.5	0.96
B	ACEDONIA	1460.1	54.4	32.9	0.8	24.0	1.6	0.7	-61.2	1061.4	Y12	157.9	0.81
B	PERIDGE	1338.7	53.5	42.0	1.7	51.4	1.6	0.4	-52.2	518.4			
B	RAZORT	1118.4	53.1	38.3	1.1	34.0	1.4	0.5	-72.3	602.0	Y59	141.3	0.80
B	RITWATER	1111.3	53.1	48.4	0.6	19.2	1.5	1.0	-125.5	1109.2	Y10	208.6	0.85
C	JAY	984.8	66.8	22.0	1.2	37.3	1.5	1.3	-66.6	1234.4	Y60	223.8	0.86
B	NOARK	393.6	52.8	33.5	0.1	1.8	1.0	0.5	-28.3	185.1	Y28	21.6	0.68
D	STIGLER	367.5	75.6	39.4	5.0	150.9	1.7	1.0	-108.1	378.5	Y60	372.7	0.93
B	SECESH	209.8	52.8	41.3	5.6	169.0	1.7	0.3	-78.1	70.0	Y39	200.6	0.83
B	HEALING	174.9	51.1	36.1	3.6	108.0	1.6	0.6	-154.9	106.7			
D	ARYTOWN	127.3	71.7	23.0	1.0	30.0	1.5	1.5	-104.1	190.5	Y33	229.6	0.88
B	ELSAH	85.2	52.2	32.9	1.1	31.4	1.0	0.4	-165.1	30.6	Y55	101.4	0.76
B	LINKER	44.0	57.1	26.4	4.2	125.4	1.5	0.2	-7.2	10.8	Y8	588.1	0.98
B	WABEN	44.0	53.5	33.4	0.9	27.8	1.3	0.3	-31.2	11.3	Y37	69.0	0.75
B	LDORADO	26.1	55.0	40.7	1.0	30.0	1.5	1.2	-202.7	31.8	Y56	106.1	0.78
D	HEROKEE	19.5	73.2	64.9	2.0	60.0	1.5	3.6	-660.7	70.2	Y22	272.8	0.90
D	HECTOR	6.2	82.0	17.5	0.0	0.0	0.0	8.9	-349.5	55.5	Y49	64.1	0.73
D	TAINBURG	0.7	77.0	9.3	3.0	90.0	0.0	0.3	-231.9	0.2	Y47	2172	1.00
	Total or wtave	35911.0	61.2		1.2	35.2	1.4	0.8	-54.5	27802.0			

Sp=shadow price

Hgrp=Hydrology group

APPENDIX 5 - Management by Hydrologic soil class and HRU when Total phosphorus Loss was constrained to less than 35Mg

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subasin	Soil Type	OpAct	Area	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent $/ha
B	3	1	DONIPHAN	62	49.09	72	18.23	2	1.66	0.36	27.49
B	8	1	MACEDONIA	42	10.86	62	24.57	2	1.57	0.62	21.68
B	18	1	DONIPHAN	72	222.33	48	18.23	2	1.64	0.21	28.92
B	19	1	DONIPHAN	52	33.27	54	18.23	2	1.62	0.12	30.10
B	20	1	MACEDONIA	52	31.03	54	24.57	2	1.56	0.44	23.32
B	29	1	RAZORT	22	13.02	54	20.61	2	1.41	0.14	24.06
B	30	1	CLARKSVILLE	22	9.53	54	18.23	2	1.44	0.25	22.64
B	32	1	DONIPHAN	22	15.47	54	18.23	2	1.62	0.13	29.85
B	34	1	DONIPHAN	34	2.06	54	18.23	4	1.48	0.09	26.55
B	37	2	CLARKSVILLE	61	11.19	72	16.98	1	1.46	0.66	19.54
B	40	2	DONIPHAN	62	9.56	72	16.98	2	1.66	0.36	27.08
B	41	2	MACEDONIA	61	12.60	72	22.89	1	1.55	0.95	18.18
B	49	2	DONIPHAN	42	18.98	62	16.98	2	1.62	0.20	29.44
B	53	2	CLARKSVILLE	71	33.21	48	16.98	1	1.46	0.45	20.95
B	56	2	DONIPHAN	72	57.56	48	16.98	2	1.62	0.22	28.83
B	57	2	MACEDONIA	72	33.43	48	22.89	2	1.57	0.73	20.84
B	60	2	DONIPHAN	52	28.11	54	16.98	2	1.61	0.12	30.20
B	70	2	CLARKSVILLE	26	0.71	54	16.98	6	1.61	0.40	-263.03
B	72	2	DONIPHAN	22	1.89	54	16.98	2	1.61	0.12	30.37
B	74	2	DONIPHAN	34	0.99	54	16.98	4	1.48	0.08	-239.76
B	76	3	CLARKSVILLE	61	45.06	72	37.01	1	1.46	0.94	16.32
B	77	3	CLARKSVILLE	61	34.19	72	37.01	1	1.33	0.72	17.34
B	80	3	DONIPHAN	62	58.74	72	37.01	2	1.63	0.43	24.90
B	87	3	MACEDONIA	40	7.66	62	49.88	0	1.52	0.96	17.27
B	92	3	RAZORT	71	54.56	48	41.83	1	1.42	0.62	16.76
B	93	3	CLARKSVILLE	71	88.61	48	37.01	1	1.45	0.66	17.66
B	95	3	DONIPHAN	72	57.56	48	37.01	2	1.60	0.27	26.25
B	97	3	MACEDONIA	51	7.16	54	49.88	1	1.53	0.67	18.69
B	106	3	DONIPHAN	23	8.33	54	37.01	3	1.26	0.11	25.25
B	108	3	MACEDONIA	30	0.09	54	49.88	0	1.51	0.25	-1597.16
B	109	4	CLARKSVILLE	61	68.16	72	41.13	1	1.45	1.20	12.26
B	110	4	CLARKSVILLE	61	30.16	72	41.13	1	1.32	0.88	15.22
B	111	4	DONIPHAN	62	24.24	72	41.13	2	1.63	0.51	24.23
B	112	4	MACEDONIA	60	24.65	72	55.43	0	1.53	1.92	6.91
B	118	4	DONIPHAN	42	6.25	62	41.13	2	1.60	0.27	28.01
B	123	4	RAZORT	71	65.59	48	46.49	1	1.43	0.75	15.67
B	124	4	CLARKSVILLE	71	154.59	48	41.13	1	1.44	0.75	16.87
B	125	4	BRITWATER	72	69.36	48	55.43	2	1.56	1.33	11.14
B	126	4	CLARKSVILLE	52	12.63	54	41.13	2	1.40	0.38	20.11
B	127	4	CLARKSVILLE	51	17.93	54	41.13	1	1.33	0.43	19.06
B	129	4	DONIPHAN	52	17.83	54	41.13	2	1.59	0.16	29.44
B	130	4	MACEDONIA	52	20.14	54	55.43	2	1.58	0.80	18.05
B	137	4	RAZORT	23	3.28	54	46.49	3	1.14	0.13	21.38
B	138	4	CLARKSVILLE	22	9.40	54	41.13	2	1.40	0.42	18.53
B	140	4	BRITWATER	22	4.75	54	55.43	2	1.55	0.69	17.53

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	141	4	CLARKSVILLE	33	1.57	54	41.13	3	1.15	0.18	20.27
B	143	4	BRITWATER	32	2.24	54	55.43	2	1.55	0.60	19.21
B	144	4	DONIPHAN	31	2.24	54	41.13	1	1.53	0.23	10.02
B	153	5	NEWTONIA	42	13.02	62	20.46	2	1.56	0.33	26.58
B	168	5	NEWTONIA	72	141.45	48	20.46	2	1.56	0.37	25.78
B	170	5	PERIDGE	72	126.24	48	20.46	2	1.60	0.47	23.29
B	173	5	PERIDGE	52	47.26	54	20.46	2	1.59	0.27	26.37
B	181	5	NEWTONIA	23	89.88	54	20.46	3	1.23	0.15	25.55
B	183	5	PERIDGE	22	41.47	54	20.46	2	1.59	0.28	26.09
B	186	5	PERIDGE	32	23.68	54	20.46	2	1.59	0.27	25.94
B	187	6	NEWTONIA	62	13.33	72	26.32	2	1.56	0.63	22.84
B	193	6	NEWTONIA	72	39.62	48	26.32	2	1.55	0.37	25.94
B	194	6	RAZORT	55	2.08	54	22.07	5	1.41	0.09	21.28
B	195	6	BRITWATER	50	1.04	54	26.32	0	1.41	0.30	21.76
B	200	6	RAZORT	23	2.95	54	22.07	3	1.15	0.06	25.56
B	201	6	NEWTONIA	23	8.05	54	26.32	3	1.25	0.12	27.17
B	202	6	RAZORT	32	1.55	54	22.07	2	1.33	0.11	25.13
B	203	6	BRITWATER	32	1.46	54	26.32	2	1.51	0.37	25.47
B	204	6	NEWTONIA	30	0.59	54	26.32	0	1.45	0.06	-506.86
B	205	7	RAZORT	60	0.09	72	69.66	0	1.33	0.35	-4928.53
B	206	7	CLARKSVILLE	66	0.19	72	61.62	6	1.63	0.87	-1807.55
B	209	7	CLARKSVILLE	71	1.43	48	61.62	1	1.46	0.55	19.30
B	212	7	CLARKSVILLE	20	0.19	54	61.62	0	1.37	0.16	-3725.88
B	214	8	NEWTONIA	62	60.71	72	15.19	2	1.56	0.37	26.31
B	219	8	NEWTONIA	43	9.36	62	15.19	3	1.25	0.09	27.93
B	220	8	ELDORADO	41	3.20	62	15.19	1	1.48	0.62	21.15
B	229	8	NEWTONIA	72	140.75	48	15.19	2	1.55	0.18	28.56
B	232	8	NEWTONIA	53	109.64	54	15.19	3	1.25	0.07	29.50
B	241	8	NEWTONIA	23	19.89	54	15.19	3	1.25	0.07	29.29
B	245	8	NEWTONIA	33	35.96	54	15.19	3	1.25	0.07	29.30
B	247	9	NEWTONIA	62	19.91	72	19.79	2	1.58	0.51	24.40
B	264	9	NEWTONIA	72	74.58	48	19.79	2	1.56	0.34	27.19
B	270	9	NEWTONIA	53	77.83	54	19.79	3	1.23	0.09	29.09
B	278	9	NEWTONIA	23	17.97	54	19.79	3	1.23	0.10	28.99
B	279	9	PERIDGE	24	21.47	54	19.79	4	1.42	0.16	26.60
B	287	10	PERIDGE	61	5.93	72	20.62	1	1.62	0.72	22.17
B	293	10	LINKER	42	1.87	62	15.30	2	1.36	0.18	26.46
B	304	10	PERIDGE	72	76.84	48	20.62	2	1.60	0.43	24.49
B	307	10	NEWTONIA	53	25.11	54	20.62	3	1.23	0.11	28.38
B	315	10	NEWTONIA	22	4.91	54	20.62	2	1.56	0.24	28.68
B	316	10	PERIDGE	23	7.74	54	20.62	3	1.24	0.12	27.68
B	320	10	NEWTONIA	33	8.84	54	20.62	3	1.23	0.10	27.46
B	345	11	SECESH	26	1.39	54	32.43	6	1.74	0.23	31.93
B	349	11	NOARK	32	11.02	54	28.69	2	1.08	0.43	16.70
B	351	12	BRITWATER	62	2.53	72	53.43	2	1.59	1.39	12.37
B	352	12	SECESH	65	2.10	72	44.81	5	1.61	0.61	25.15
B	362	12	BRITWATER	72	10.22	48	53.43	2	1.55	1.13	17.38

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	basin	Soil Type	OpAct	rea (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	363	12	SECESH	75	3.07	48	44.81	5	1.61	0.30	32.15
B	368	12	BRITWATER	26	0.29	54	53.43	6	1.71	0.61	-1498.44
B	369	12	ELSAH	20	0.20	54	34.47	0	1.00	0.12	-1712.59
B	389	13	NOARK	72	73.74	48	25.44	2	1.02	0.55	13.08
B	393	13	NOARK	52	7.06	54	25.44	2	1.02	0.38	15.12
B	405	13	NOARK	32	5.34	54	25.44	2	1.02	0.37	15.85
B	427	14	LINKER	56	26.99	54	23.17	6	1.61	0.19	31.40
B	439	14	SECESH	25	10.24	54	26.19	5	1.58	0.13	36.56
B	446	15	NOARK	61	6.89	72	33.63	1	1.16	0.82	11.61
B	459	15	NOARK	72	47.61	48	33.63	2	1.08	0.61	13.61
B	461	15	SECESH	55	16.20	54	38.01	5	1.60	0.21	35.10
B	462	15	NOARK	52	36.28	54	33.63	2	1.07	0.43	15.95
B	469	15	SECESH	25	29.87	54	38.01	5	1.60	0.22	34.95
B	471	15	NOARK	22	16.81	54	33.63	2	1.07	0.43	15.97
B	474	15	SECESH	34	4.62	54	38.01	4	1.50	0.15	33.75
B	475	15	NOARK	32	12.42	54	33.63	2	1.07	0.43	16.03
B	485	16	CLARKSVILLE	53	32.18	54	42.37	3	1.13	0.24	22.69
B	491	16	CLARKSVILLE	23	3.06	54	42.37	3	1.13	0.22	23.40
B	492	16	ELSAH	23	3.17	54	36.84	3	0.55	0.09	19.74
B	494	16	NOARK	22	3.17	54	42.37	2	1.07	0.41	17.02
B	506	17	NOARK	42	3.04	62	35.30	2	1.08	0.59	11.90
B	518	17	NOARK	52	37.67	54	35.30	2	1.05	0.45	13.25
B	524	17	PERIDGE	23	3.14	54	47.57	3	1.24	0.22	25.98
B	528	17	NOARK	32	11.48	54	35.30	2	1.05	0.49	11.95
B	532	18	NOARK	61	2.35	72	33.63	1	1.13	0.92	9.95
B	543	18	SECESH	75	10.83	48	38.01	5	1.59	0.35	28.81
B	545	18	NOARK	72	6.61	48	33.63	2	1.08	0.65	11.85
B	546	18	PERIDGE	72	8.55	48	45.32	2	1.60	0.69	21.48
B	550	18	NOARK	52	8.66	54	33.63	2	1.05	0.47	14.01
B	556	18	SECESH	25	3.93	54	38.01	5	1.59	0.23	32.74
B	569	19	CLARKSVILLE	72	77.18	48	46.13	2	1.19	0.74	15.81
B	579	19	SECESH	25	23.14	54	52.15	5	1.59	0.32	30.82
B	580	19	CLARKSVILLE	32	4.30	54	46.13	2	1.19	0.51	18.75
B	583	20	CLARKSVILLE	61	23.21	72	42.37	1	1.40	0.83	16.41
B	593	20	CLARKSVILLE	72	22.98	48	42.37	2	1.22	0.59	19.48
B	594	20	BRITWATER	72	23.44	48	57.10	2	1.51	1.43	13.35
B	596	20	SECESH	75	22.40	48	47.89	5	1.59	0.46	29.67
B	598	20	BRITWATER	53	21.42	54	57.10	3	1.22	0.39	20.72
B	601	20	PERIDGE	55	40.40	54	57.10	5	1.55	0.35	27.52
B	605	20	BRITWATER	23	13.04	54	57.10	3	1.22	0.38	21.11
B	606	20	SECESH	25	22.78	54	47.89	5	1.59	0.23	34.86
B	608	20	BRITWATER	33	14.42	54	57.10	3	1.22	0.39	21.02
B	610	20	WABEN	33	9.72	54	42.37	3	1.09	0.09	26.31

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	612	21	CLARKSVILLE	61	58.96	72	32.81	1	1.46	0.92	15.01
B	613	21	DONIPHAN	62	54.88	72	32.81	2	1.66	0.41	25.25
B	614	21	NEWTONIA	62	74.76	72	44.22	2	1.59	1.04	15.11
B	619	21	RAZORT	41	9.83	62	37.08	1	1.44	0.46	19.80
B	620	21	CLARKSVILLE	41	15.29	62	32.81	1	1.46	0.55	19.65
B	621	21	CLARKSVILLE	41	9.30	62	32.81	1	1.36	0.46	19.58
B	622	21	DONIPHAN	42	12.19	62	32.81	2	1.63	0.22	28.40
B	623	21	MACEDONIA	42	8.45	62	44.22	2	1.58	0.88	17.96
B	624	21	NEWTONIA	42	17.53	62	44.22	2	1.58	0.56	21.52
B	630	21	RAZORT	71	129.85	48	37.08	1	1.44	0.54	17.57
B	631	21	CLARKSVILLE	71	165.16	48	32.81	1	1.46	0.63	17.54
B	632	21	CLARKSVILLE	71	114.98	48	32.81	1	1.36	0.53	17.85
B	633	21	DONIPHAN	72	130.83	48	32.81	2	1.63	0.25	27.20
B	634	21	NEWTONIA	72	153.34	48	44.22	2	1.58	0.60	20.39
B	635	21	RAZORT	52	144.46	54	37.08	2	1.44	0.20	22.27
B	636	21	CLARKSVILLE	52	200.32	54	32.81	2	1.47	0.30	20.68
B	637	21	DONIPHAN	52	111.54	54	32.81	2	1.62	0.14	29.08
B	644	21	RAZORT	22	35.07	54	37.08	2	1.44	0.20	22.18
B	645	21	CLARKSVILLE	23	16.85	54	32.81	3	1.17	0.19	19.72
B	646	21	CLARKSVILLE	21	31.27	54	32.81	1	1.35	0.37	19.57
B	647	21	HEALING	22	15.36	54	44.22	2	1.53	0.36	21.45
B	648	21	RAZORT	32	17.67	54	37.08	2	1.44	0.19	22.36
B	649	21	CLARKSVILLE	32	31.13	54	32.81	2	1.47	0.31	20.42
B	650	21	CLARKSVILLE	31	17.33	54	32.81	1	1.35	0.37	19.65
B	651	21	MACEDONIA	32	22.35	54	44.22	2	1.57	0.63	19.69
B	652	21	NEWTONIA	32	15.96	54	44.22	2	1.58	0.36	23.42
B	653	21	ELDORADO	32	22.92	54	44.22	2	1.47	1.14	0.63
B	654	22	MACEDONIA	61	18.40	72	18.16	1	1.56	0.93	18.57
B	656	22	NEWTONIA	62	31.56	72	18.16	2	1.60	0.58	22.45
B	662	22	DONIPHAN	42	10.99	62	13.47	2	1.64	0.21	28.95
B	663	22	MACEDONIA	42	20.64	62	18.16	2	1.59	0.60	21.89
B	666	22	MACEDONIA	72	82.02	48	18.16	2	1.59	0.59	21.99
B	668	22	NEWTONIA	72	192.62	48	18.16	2	1.59	0.28	26.47
B	669	22	MACEDONIA	52	40.25	54	18.16	2	1.57	0.40	24.23
B	678	22	MACEDONIA	21	5.98	54	18.16	1	1.54	0.43	22.98
B	679	22	NEWTONIA	23	6.44	54	18.16	3	1.24	0.10	26.10
B	680	22	CLARKSVILLE	32	2.07	54	13.47	2	1.47	0.22	23.53
B	681	22	DONIPHAN	32	5.37	54	13.47	2	1.63	0.12	30.08
B	682	22	MACEDONIA	32	4.03	54	18.16	2	1.57	0.38	24.43
B	683	22	NEWTONIA	33	2.37	54	18.16	3	1.24	0.09	27.18
B	686	23	PERIDGE	62	5.71	72	43.12	2	1.62	1.15	13.41
B	691	23	CLARKSVILLE	46	0.56	62	31.99	6	1.43	0.75	-13.84
B	692	23	SECESH	46	0.56	62	36.17	6	1.73	0.36	-516.35
B	694	23	NOARK	46	0.56	62	31.99	6	1.31	0.97	-65.39
B	695	23	PERIDGE	46	0.56	62	43.12	6	1.74	0.74	-101.09

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygr	HRU	basin	Soil Type	OpAct	rea (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	702	23	HEALING	76	13.50	48	43.12	6	1.66	0.79	13.92
B	703	23	SECESH	74	9.82	48	36.17	4	1.48	0.36	27.61
B	705	23	NOARK	72	11.71	48	31.99	2	1.07	0.64	11.53
B	706	23	PERIDGE	73	11.83	48	43.12	3	1.25	0.39	20.73
B	709	23	PERIDGE	53	15.76	54	43.12	3	1.24	0.23	26.75
B	718	23	SECESH	34	3.15	54	36.17	4	1.48	0.22	32.09
B	720	23	NOARK	32	3.72	54	31.99	2	1.06	0.48	12.85
B	722	24	BRITWATER	61	2.00	72	47.57	1	1.57	1.25	13.24
B	724	24	PERIDGE	62	6.96	72	47.57	2	1.62	1.19	12.75
B	729	24	CLARKSVILLE	45	0.93	62	35.30	5	1.35	0.33	16.25
B	732	24	SECESH	45	0.93	62	39.90	5	1.59	0.22	-84.49
B	733	24	PERIDGE	43	2.79	62	47.57	3	1.25	0.29	24.17
B	739	24	BRITWATER	72	6.82	48	47.57	2	1.49	1.26	15.20
B	741	24	SECESH	75	8.92	48	39.90	5	1.59	0.40	27.59
B	744	24	PERIDGE	53	91.89	54	47.57	3	1.24	0.21	27.72
B	749	24	CLARKSVILLE	22	3.54	54	35.30	2	1.20	0.33	22.63
B	750	24	BRITWATER	22	4.08	54	47.57	2	1.48	0.69	23.06
B	751	24	SECESH	24	8.37	54	39.90	4	1.48	0.15	33.58
B	752	24	PERIDGE	23	10.51	54	47.57	3	1.24	0.21	27.55
B	753	24	CLARKSVILLE	32	6.18	54	35.30	2	1.20	0.34	22.43
B	755	24	BRITWATER	32	8.03	54	47.57	2	1.48	0.75	22.27
B	758	24	PERIDGE	33	9.54	54	47.57	3	1.24	0.20	27.23
B	770	25	NOARK	42	5.61	62	33.63	2	1.08	0.61	11.20
B	778	25	NOARK	72	21.19	48	33.63	2	1.08	0.67	9.56
B	779	25	CLARKSVILLE	52	25.00	54	33.63	2	1.19	0.44	18.95
B	789	25	ELSAH	22	5.27	54	29.24	2	0.81	0.27	12.11
B	792	25	CLARKSVILLE	32	7.50	54	33.63	2	1.19	0.51	16.71
B	796	25	NOARK	32	7.17	54	33.63	2	1.05	0.51	10.87
B	815	26	CLARKSVILLE	52	19.01	54	34.46	2	1.20	0.39	21.23
B	827	26	HEALING	23	8.68	54	46.44	3	1.20	0.37	24.74
B	828	26	SECESH	24	5.47	54	38.95	4	1.48	0.20	32.53
B	833	26	PERIDGE	33	9.37	54	46.44	3	1.24	0.26	25.72
B	834	27	CLARKSVILLE	61	2.19	72	39.67	1	1.36	1.02	10.29
B	841	27	BRITWATER	42	1.06	62	53.47	2	1.51	0.95	18.57
B	842	27	SECESH	44	0.59	62	44.85	4	1.49	0.28	-276.67
B	843	27	PERIDGE	43	1.29	62	53.47	3	1.25	0.35	23.34
B	848	27	CLARKSVILLE	72	2.24	48	39.67	2	1.17	0.59	17.52
B	849	27	BRITWATER	72	2.24	48	53.47	2	1.51	1.18	15.98
B	851	27	PERIDGE	73	8.41	48	53.47	3	1.25	0.50	19.02
B	852	27	CLARKSVILLE	52	7.66	54	39.67	2	1.17	0.43	20.12
B	855	27	HEALING	56	5.44	54	53.47	6	1.66	0.49	25.58
B	856	27	PERIDGE	53	8.16	54	53.47	3	1.24	0.29	25.42
B	862	27	BRITWATER	32	7.84	54	53.47	2	1.48	0.87	19.98
B	864	27	WABEN	33	3.27	54	39.67	3	1.07	0.12	24.36

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	865	27	PERIDGE	33	12.85	54	53.47	3	1.24	0.29	25.94
B	868	28	SECESH	65	3.70	72	40.86	5	1.59	0.92	15.98
B	880	28	CLARKSVILLE	72	5.06	48	36.15	2	1.18	0.62	16.78
B	884	28	CLARKSVILLE	52	26.34	54	36.15	2	1.17	0.43	19.67
B	893	28	CLARKSVILLE	24	1.09	54	36.15	4	1.25	0.29	18.48
B	896	28	CLARKSVILLE	32	17.09	54	36.15	2	1.17	0.46	18.88
B	900	29	CLARKSVILLE	61	48.12	72	35.30	1	1.45	1.05	14.28
B	901	29	CLARKSVILLE	61	19.82	72	35.30	1	1.36	0.79	16.66
B	902	29	DONIPHAN	62	21.64	72	35.30	2	1.64	0.47	25.43
B	903	29	MACEDONIA	61	23.33	72	47.57	1	1.55	1.42	9.28
B	908	29	CLARKSVILLE	41	5.44	62	35.30	1	1.44	0.60	19.75
B	909	29	CLARKSVILLE	41	8.16	62	35.30	1	1.35	0.51	19.11
B	911	29	MACEDONIA	42	6.18	62	47.57	2	1.59	0.92	17.30
B	916	29	CLARKSVILLE	71	72.58	48	35.30	1	1.44	0.81	14.74
B	917	29	CLARKSVILLE	71	78.16	48	35.30	1	1.35	0.64	16.09
B	918	29	MACEDONIA	72	99.96	48	47.57	2	1.59	1.12	12.97
B	919	29	NEWTONIA	72	41.25	48	47.57	2	1.58	0.50	19.11
B	920	29	CLARKSVILLE	52	40.65	54	35.30	2	1.25	0.37	18.27
B	921	29	DONIPHAN	52	44.38	54	35.30	2	1.60	0.18	29.03
B	922	29	MACEDONIA	52	77.69	54	47.57	2	1.58	0.71	18.09
B	923	29	NEWTONIA	53	38.29	54	47.57	3	1.23	0.30	22.57
B	929	29	RAZORT	22	4.39	54	39.90	2	1.38	0.24	22.25
B	930	29	CLARKSVILLE	22	7.80	54	35.30	2	1.44	0.38	19.93
B	931	29	MACEDONIA	21	6.22	54	47.57	1	1.54	0.67	18.03
B	932	29	NEWTONIA	22	3.66	54	47.57	2	1.58	0.30	24.47
B	933	29	CLARKSVILLE	32	5.32	54	35.30	2	1.25	0.34	18.95
B	934	29	MACEDONIA	32	12.90	54	47.57	2	1.58	0.66	19.21
B	935	29	NEWTONIA	32	9.67	54	47.57	2	1.58	0.35	23.54
B	936	30	CLARKSVILLE	61	11.98	72	32.81	1	1.45	0.93	16.46
B	939	30	DONIPHAN	62	5.61	72	32.81	2	1.64	0.44	26.84
B	940	30	MACEDONIA	61	5.72	72	44.22	1	1.55	1.25	13.52
B	946	30	MACEDONIA	42	5.16	62	44.22	2	1.59	0.84	19.16
B	947	30	NEWTONIA	43	4.27	62	44.22	3	1.24	0.24	23.59
B	953	30	RAZORT	72	18.75	48	37.08	2	1.41	0.56	17.32
B	954	30	CLARKSVILLE	72	23.30	48	32.81	2	1.46	0.62	17.32
B	955	30	DONIPHAN	72	42.39	48	32.81	2	1.61	0.28	27.99
B	956	30	MACEDONIA	72	36.29	48	44.22	2	1.59	0.98	16.22
B	958	30	DONIPHAN	52	9.42	54	32.81	2	1.60	0.16	30.19
B	959	30	MACEDONIA	52	43.10	54	44.22	2	1.58	0.62	20.67
B	966	30	RAZORT	23	3.18	54	37.08	3	1.14	0.09	23.63
B	967	30	CLARKSVILLE	21	6.46	54	32.81	1	1.44	0.47	20.19
B	968	30	DONIPHAN	22	5.57	54	32.81	2	1.60	0.17	30.05
B	969	30	MACEDONIA	22	1.79	54	44.22	2	1.58	0.47	22.98
B	970	30	MACEDONIA	32	11.37	54	44.22	2	1.58	0.61	20.75
B	971	31	RAZORT	61	3.17	72	90.67	1	1.57	1.47	5.64
B	972	31	CLARKSVILLE	60	15.34	72	80.21	0	1.49	1.28	8.61
B	973	31	CLARKSVILLE	61	3.36	72	80.21	1	1.48	0.89	15.93
B	974	31	BRITWATER	60	2.57	72	108.11	0	1.62	1.89	7.23
B	977	31	CLARKSVILLE	45	0.38	62	80.21	5	1.52	0.24	-529.38

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	985	31	RAZORT	71	25.35	48	90.67	1	1.54	1.03	8.52
B	986	31	CLARKSVILLE	71	49.21	48	80.21	1	1.58	1.02	9.23
B	987	31	CLARKSVILLE	51	5.34	54	80.21	1	1.57	0.58	16.60
B	990	31	RAZORT	21	2.10	54	90.67	1	1.53	0.41	19.23
B	991	31	CLARKSVILLE	21	7.45	54	80.21	1	1.57	0.66	13.96
B	992	31	CLARKSVILLE	23	2.10	54	80.21	3	1.13	0.21	12.07
B	993	31	CLARKSVILLE	35	0.38	54	80.21	5	1.51	0.19	-1132.72
B	994	32	CLARKSVILLE	60	5.41	72	22.32	0	1.37	0.48	19.20
B	995	32	DONIPHAN	61	5.52	72	22.32	1	1.69	0.35	24.86
B	1008	32	RAZORT	71	6.63	48	25.24	1	1.53	0.36	20.57
B	1009	32	CLARKSVILLE	71	10.59	48	22.32	1	1.56	0.44	20.61
B	1010	32	DONIPHAN	71	7.49	48	22.32	1	1.67	0.22	25.48
B	1013	32	RAZORT	20	0.09	54	25.24	0	1.47	0.09	-959.67
B	1014	32	CLARKSVILLE	20	0.09	54	22.32	0	1.48	0.16	-2738.12
B	1025	33	NOARK	41	4.05	62	25.04	1	1.10	0.61	8.15
B	1043	33	SECESH	22	10.40	54	28.31	2	1.68	0.27	20.73
B	1044	33	PERIDGE	22	15.25	54	33.75	2	1.59	0.36	17.11
B	1051	34	CLARKSVILLE	42	2.48	62	28.00	2	1.18	0.51	18.40
B	1052	34	BRITWATER	42	4.09	62	37.74	2	1.51	1.07	17.15
B	1054	34	WABEN	42	2.36	62	28.00	2	1.15	0.35	20.64
B	1059	34	CLARKSVILLE	72	6.24	48	28.00	2	1.18	0.54	18.07
B	1061	34	HEALING	73	5.79	48	37.74	3	1.21	0.61	17.61
B	1062	34	CLARKSVILLE	52	17.84	54	28.00	2	1.17	0.38	20.61
B	1064	34	BRITWATER	52	13.03	54	37.74	2	1.48	0.74	21.18
B	1066	34	HEALING	53	12.61	54	37.74	3	1.20	0.33	24.81
B	1069	34	CLARKSVILLE	26	0.87	54	28.00	6	1.45	0.65	-78.94
B	1071	34	HEALING	25	0.54	54	37.74	5	1.50	0.14	-937.38
B	1072	34	SECESH	26	0.43	54	31.65	6	1.74	0.23	-1451.10
B	1074	34	BRITWATER	32	24.78	54	37.74	2	1.48	0.81	19.67
B	1075	34	HEALING	33	25.02	54	37.74	3	1.20	0.41	23.14
B	1076	34	PERIDGE	33	12.26	54	37.74	3	1.24	0.25	25.50
B	1077	35	CLARKSVILLE	61	13.91	72	34.89	1	1.45	0.91	16.88
B	1078	35	CLARKSVILLE	61	16.38	72	34.89	1	1.33	0.72	17.71
B	1082	35	RAZORT	71	6.46	48	39.44	1	1.43	0.56	17.74
B	1083	35	CLARKSVILLE	71	24.16	48	34.89	1	1.44	0.66	17.83
B	1084	35	CLARKSVILLE	71	14.48	48	34.89	1	1.35	0.53	17.90
B	1087	35	RAZORT	20	0.38	54	39.44	0	1.30	0.10	-1764.99
B	1088	35	CLARKSVILLE	26	0.29	54	34.89	6	1.59	0.52	-1337.14
B	1089	35	BRITWATER	25	0.47	54	47.03	5	1.52	0.65	-480.62
B	1090	36	RAZORT	61	10.00	72	38.70	1	1.43	1.12	11.68
B	1091	36	CLARKSVILLE	61	30.37	72	34.23	1	1.45	0.99	15.13
B	1092	36	BRITWATER	60	16.83	72	46.14	0	1.52	1.75	10.74
B	1096	36	DONIPHAN	46	0.94	62	34.23	6	1.71	0.35	-56.59
B	1097	36	MACEDONIA	44	1.06	62	46.14	4	1.43	0.59	11.55
B	1102	36	RAZORT	71	16.63	48	38.70	1	1.43	0.65	15.57
B	1103	36	CLARKSVILLE	71	36.81	48	34.23	1	1.44	0.73	15.90
B	1104	36	BRITWATER	72	22.73	48	46.14	2	1.58	1.25	11.90
B	1105	36	MACEDONIA	72	16.85	48	46.14	2	1.59	1.03	13.33

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1106	36	CLARKSVILLE	56	1.35	54	34.23	6	1.59	0.60	9.64
B	1107	36	CLARKSVILLE	52	1.94	54	34.23	2	1.25	0.31	18.79
B	1108	36	DONIPHAN	52	3.48	54	34.23	2	1.60	0.16	28.88
B	1109	36	MACEDONIA	56	0.87	54	46.14	6	1.69	0.79	-52.80
B	1113	36	CLARKSVILLE	22	2.94	54	34.23	2	1.43	0.36	19.41
B	1114	36	BRITWATER	22	1.20	54	46.14	2	1.56	0.52	20.63
B	1115	36	MACEDONIA	21	5.22	54	46.14	1	1.54	0.67	16.87
B	1116	36	CLARKSVILLE	30	0.09	54	34.23	0	1.33	0.18	-2237.56
B	1117	36	DONIPHAN	30	0.20	54	34.23	0	1.48	0.12	-3198.12
B	1118	36	MACEDONIA	36	0.29	54	46.14	6	1.69	0.69	-1281.92
B	1119	37	NEWTONIA	63	10.34	72	59.62	3	1.24	0.58	16.06
B	1121	37	NOARK	61	4.66	72	44.23	1	1.15	0.87	11.79
B	1122	37	PERIDGE	62	5.94	72	59.62	2	1.62	1.21	10.62
B	1126	37	NOARK	42	1.81	62	44.23	2	1.09	0.56	14.87
B	1127	37	PERIDGE	43	2.86	62	59.62	3	1.24	0.36	23.06
B	1134	37	CLARKSVILLE	72	10.89	48	44.23	2	1.22	0.64	16.93
B	1135	37	BRITWATER	72	6.93	48	59.62	2	1.51	1.35	12.23
B	1137	37	SECESH	75	6.93	48	50.00	5	1.59	0.51	26.82
B	1138	37	NOARK	72	7.26	48	44.23	2	1.09	0.67	12.30
B	1139	37	PERIDGE	73	11.92	48	59.62	3	1.24	0.56	18.32
B	1141	37	NOARK	52	13.40	54	44.23	2	1.07	0.49	14.59
B	1142	37	PERIDGE	54	17.99	54	59.62	4	1.42	0.34	25.59
B	1147	37	WABEN	23	6.83	54	44.23	3	1.09	0.11	24.56
B	1148	37	NOARK	22	7.41	54	44.23	2	1.07	0.48	14.63
B	1149	37	PERIDGE	24	19.33	54	59.62	4	1.42	0.34	25.46
B	1150	37	NEWTONIA	36	15.09	54	59.62	6	1.72	0.55	26.48
B	1152	37	PERIDGE	34	55.21	54	59.62	4	1.42	0.32	25.83
B	1153	38	CLARKSVILLE	62	5.91	72	47.73	2	1.25	0.85	14.91
B	1155	38	PERIDGE	65	6.31	72	64.33	5	1.58	0.86	11.52
B	1159	38	CLARKSVILLE	43	3.98	62	47.73	3	1.14	0.30	20.94
B	1161	38	LINKER	43	3.26	62	47.73	3	1.19	0.35	26.18
B	1167	38	CLARKSVILLE	73	31.32	48	47.73	3	1.14	0.37	18.62
B	1168	38	ELSAH	73	17.71	48	41.50	3	0.72	0.20	16.52
B	1170	38	CLARKSVILLE	53	27.55	54	47.73	3	1.13	0.24	22.81
B	1172	38	PERIDGE	55	35.78	54	64.33	5	1.55	0.29	29.76
B	1178	38	CLARKSVILLE	23	14.74	54	47.73	3	1.13	0.21	23.62
B	1181	38	PERIDGE	25	25.70	54	64.33	5	1.55	0.28	30.13
B	1182	38	CLARKSVILLE	33	10.67	54	47.73	3	1.13	0.21	23.73
B	1184	38	PERIDGE	35	37.40	54	64.33	5	1.55	0.28	30.07
B	1185	39	CLARKSVILLE	61	2.00	72	25.64	1	1.34	0.68	15.62
B	1188	39	PERIDGE	61	0.88	72	34.56	1	1.61	0.73	19.59
B	1201	39	BRITWATER	71	3.36	48	34.56	1	1.55	0.84	12.47
B	1202	39	PERIDGE	72	18.18	48	34.56	2	1.60	0.61	14.96
B	1203	39	CLARKSVILLE	54	0.95	54	25.64	4	1.25	1.82	-12.36
B	1209	39	HEALING	26	1.33	54	34.56	6	1.66	0.28	13.39
B	1210	39	PERIDGE	24	0.92	54	34.56	4	1.44	1.33	-175.87

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	basin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1211	39	CLARKSVILLE	36	0.19	54	25.64	6	1.46	0.54	-4346.78
B	1221	40	PERIDGE	42	9.07	62	51.05	2	1.61	0.52	15.95
B	1227	40	CLARKSVILLE	71	44.19	48	37.88	1	1.39	0.54	14.44
B	1232	40	PERIDGE	52	122.23	54	51.05	2	1.59	0.25	21.33
B	1237	40	CLARKSVILLE	21	36.88	54	37.88	1	1.38	0.41	15.78
B	1239	40	PERIDGE	22	28.96	54	51.05	2	1.59	0.31	19.59
B	1240	40	CLARKSVILLE	31	41.88	54	37.88	1	1.38	0.41	15.13
B	1242	40	PERIDGE	32	148.01	54	51.05	2	1.59	0.25	20.60
B	1250	41	CLARKSVILLE	76	0.38	48	146.09	6	1.60	0.88	-599.81
B	1251	41	BRITWATER	71	0.57	48	196.91	1	1.53	1.13	-12.17
B	1253	42	BRITWATER	61	2.04	72	33.79	1	1.54	1.13	14.45
B	1261	42	BRITWATER	70	1.07	48	33.79	0	1.51	0.62	11.63
B	1264	43	CLARKSVILLE	66	0.20	72	68.83	6	1.64	0.84	-1767.36
B	1265	43	BRITWATER	60	0.09	72	92.77	0	1.62	0.64	-1620.15
B	1272	43	CLARKSVILLE	71	7.16	48	68.83	1	1.58	0.78	13.53
B	1273	43	BRITWATER	70	1.92	48	92.77	0	1.60	0.93	6.70
B	1274	43	CLARKSVILLE	56	0.29	54	68.83	6	1.62	0.44	-2073.86
B	1277	43	RAZORT	20	0.20	54	77.81	0	1.47	0.11	-939.19
B	1278	43	CLARKSVILLE	25	0.96	54	68.83	5	1.51	0.54	-152.42
B	1279	43	CLARKSVILLE	31	1.53	54	68.83	1	1.57	0.49	18.19
B	1284	44	CLARKSVILLE	42	5.22	62	41.45	2	1.25	0.56	10.79
B	1293	44	CLARKSVILLE	52	57.37	54	41.45	2	1.25	0.39	14.04
B	1301	44	CLARKSVILLE	32	29.15	54	41.45	2	1.25	0.40	13.60
B	1304	45	CLARKSVILLE	60	3.56	72	28.57	0	1.50	0.54	17.84
B	1311	45	CLARKSVILLE	70	3.66	48	28.57	0	1.49	0.30	18.94
B	1314	46	CLARKSVILLE	61	5.78	72	52.10	1	1.36	0.95	6.22
B	1316	46	NOARK	61	8.07	72	52.10	1	1.16	0.93	5.28
B	1327	46	CLARKSVILLE	71	21.02	48	52.10	1	1.35	0.68	9.21
B	1328	46	ELSAH	72	19.04	48	45.30	2	1.00	0.49	5.82
B	1330	46	CLARKSVILLE	52	8.38	54	52.10	2	1.24	0.47	13.83
B	1338	46	CLARKSVILLE	22	15.64	54	52.10	2	1.24	0.47	13.64
B	1339	46	ELSAH	22	9.67	54	45.30	2	0.99	0.24	10.60
B	1341	46	NOARK	21	6.86	54	52.10	1	1.13	0.47	10.30
B	1342	46	CLARKSVILLE	32	22.10	54	52.10	2	1.24	0.48	13.51
B	1345	47	CLARKSVILLE	61	4.16	72	20.24	1	1.45	0.71	18.47
B	1346	47	CLARKSVILLE	61	4.77	72	20.24	1	1.33	0.63	17.39
B	1347	47	HEALING	61	1.72	72	27.27	1	1.50	0.87	14.37
B	1351	47	CLARKSVILLE	71	9.84	48	20.24	1	1.44	0.50	18.87
B	1352	47	ELSAH	72	7.16	48	17.60	2	1.02	0.29	10.24
B	1353	47	HEALING	71	16.11	48	27.27	1	1.49	0.65	15.84
B	1357	47	RAZORT	22	0.64	54	22.87	2	1.38	0.15	19.22
B	1358	47	CLARKSVILLE	21	1.83	54	20.24	1	1.44	0.39	18.16
B	1359	47	ELSAH	26	0.54	54	17.60	6	1.23	0.24	-1080.58
B	1360	48	RAZORT	61	2.08	72	21.77	1	1.44	0.66	17.31
B	1361	48	CLARKSVILLE	61	5.82	72	19.26	1	1.45	0.70	18.17
B	1362	48	CLARKSVILLE	61	2.91	72	19.26	1	1.36	0.62	17.74
B	1363	48	DONIPHAN	61	6.55	72	19.26	1	1.57	0.40	24.72
B	1370	48	RAZORT	71	15.81	48	21.77	1	1.43	0.43	18.23

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1371	48	CLARKSVILLE	71	17.40	48	19.26	1	1.45	0.51	18.52
B	1372	48	HEALING	71	45.95	48	25.96	1	1.49	0.66	13.46
B	1376	48	CLARKSVILLE	21	2.08	54	19.26	1	1.44	0.36	19.44
B	1377	48	HEALING	24	4.15	54	25.96	4	1.40	0.91	11.12
B	1378	49	CLARKSVILLE	61	15.92	72	68.83	1	1.45	1.35	9.69
B	1379	49	CLARKSVILLE	61	5.14	72	68.83	1	1.33	0.86	14.84
B	1380	49	BRITWATER	60	8.65	72	92.77	0	1.53	2.56	6.30
B	1388	49	CLARKSVILLE	71	9.64	48	68.83	1	1.44	0.80	15.81
B	1389	49	BRITWATER	70	9.42	48	92.77	0	1.51	1.46	8.84
B	1393	49	CLARKSVILLE	20	0.09	54	68.83	0	1.32	0.18	-1947.05
B	1394	49	BRITWATER	20	0.20	54	92.77	0	1.51	0.27	-804.44
B	1400	51	RAZORT	61	19.35	72	20.76	1	1.44	0.75	15.32
B	1401	51	BRITWATER	60	5.58	72	24.75	0	1.51	1.14	18.39
B	1402	51	ELSAH	61	6.03	72	15.97	1	1.05	0.56	10.41
B	1405	51	CLARKSVILLE	46	0.38	62	18.37	6	1.59	0.54	-880.24
B	1406	51	CLARKSVILLE	46	0.38	62	18.37	6	1.47	0.60	-597.30
B	1407	51	MACEDONIA	46	0.38	62	24.75	6	1.70	0.86	-323.15
B	1414	51	RAZORT	71	73.64	48	20.76	1	1.43	0.44	16.91
B	1415	51	BRITWATER	71	37.12	48	24.75	1	1.53	0.76	15.53
B	1416	51	CLARKSVILLE	51	4.74	54	18.37	1	1.44	0.34	19.15
B	1417	51	CLARKSVILLE	52	6.46	54	18.37	2	1.26	0.26	13.85
B	1418	51	MACEDONIA	52	3.23	54	24.75	2	1.58	0.39	19.10
B	1422	51	RAZORT	21	7.63	54	20.76	1	1.42	0.24	18.93
B	1423	51	CLARKSVILLE	21	1.68	54	18.37	1	1.33	0.37	15.97
B	1424	51	ELSAH	22	1.88	54	15.97	2	1.03	0.15	11.29
B	1425	51	CLARKSVILLE	36	0.54	54	18.37	6	1.58	0.45	-548.32
B	1426	51	CLARKSVILLE	31	1.95	54	18.37	1	1.33	0.38	15.92
B	1427	52	RAZORT	66	0.67	72	12.74	6	1.56	0.69	-62.59
B	1428	52	ELSAH	61	2.29	72	9.80	1	1.05	0.50	11.81
B	1433	52	RAZORT	75	1.05	48	12.74	5	1.41	0.82	3.87
B	1434	52	ELSAH	71	3.82	48	9.80	1	1.04	0.31	11.50
B	1436	52	ELSAH	20	0.09	54	9.80	0	1.02	0.12	-1042.04
B	1437	53	CLARKSVILLE	61	7.22	72	22.32	1	1.34	0.65	16.22
B	1442	53	CLARKSVILLE	45	0.87	62	22.32	5	1.46	1.52	-17.58
B	1445	53	PERIDGE	41	1.19	62	30.09	1	1.59	0.40	23.06
B	1451	53	RAZORT	71	4.74	48	25.24	1	1.46	0.42	18.44
B	1452	53	CLARKSVILLE	71	6.22	48	22.32	1	1.33	0.47	16.55
B	1453	53	BRITWATER	71	11.85	48	30.09	1	1.55	0.75	15.87
B	1454	53	HEALING	72	7.11	48	30.09	2	1.48	0.52	15.47
B	1458	53	PERIDGE	52	11.30	54	30.09	2	1.59	0.28	22.26
B	1463	53	RAZORT	22	3.22	54	25.24	2	1.34	0.17	20.13
B	1469	53	PERIDGE	32	6.95	54	30.09	2	1.59	0.28	22.04
B	1478	54	PERIDGE	42	16.05	62	39.68	2	1.59	0.55	22.42
B	1479	54	LINKER	43	11.91	62	29.44	3	1.09	0.50	22.59
B	1496	54	CLARKSVILLE	22	33.92	54	29.44	2	1.14	0.29	20.12
B	1502	54	PERIDGE	32	47.84	54	39.68	2	1.56	0.30	25.34
B	1508	56	RAZORT	60	0.09	72	80.11	0	1.48	0.28	-1262.31
B	1513	57	RAZORT	61	2.69	72	35.50	1	1.47	0.77	17.38
B	1514	57	CLARKSVILLE	61	2.05	72	31.40	1	1.36	0.61	19.62

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1515	57	BRITWATER	60	1.92	72	42.33	0	1.46	1.28	15.78
B	1516	57	DONIPHAN	62	1.67	72	31.40	2	1.64	0.34	27.68
B	1526	57	RAZORT	72	16.58	48	35.50	2	1.35	0.38	20.33
B	1527	57	CLARKSVILLE	71	12.88	48	31.40	1	1.34	0.46	19.73
B	1528	57	BRITWATER	72	12.88	48	42.33	2	1.57	0.95	16.13
B	1535	57	RAZORT	22	5.07	54	35.50	2	1.35	0.16	24.13
B	1536	57	CLARKSVILLE	21	6.24	54	31.40	1	1.34	0.33	20.84
B	1537	57	BRITWATER	22	7.28	54	42.33	2	1.55	0.61	20.76
B	1538	58	CLARKSVILLE	61	5.17	72	28.69	1	1.47	0.84	12.40
B	1539	58	CLARKSVILLE	61	7.54	72	28.69	1	1.36	0.72	12.13
B	1546	58	CLARKSVILLE	41	1.94	62	28.69	1	1.46	0.45	17.37
B	1547	58	CLARKSVILLE	42	5.81	62	28.69	2	1.13	0.41	13.70
B	1553	58	CLARKSVILLE	71	28.73	48	28.69	1	1.35	0.47	14.59
B	1555	58	BRITWATER	71	17.10	48	38.66	1	1.53	0.78	12.35
B	1557	58	CLARKSVILLE	51	27.66	54	28.69	1	1.33	0.33	15.36
B	1565	58	RAZORT	21	7.27	54	32.43	1	1.43	0.25	17.06
B	1567	58	DONIPHAN	22	11.73	54	28.69	2	1.62	0.15	23.80
B	1570	59	RAZORT	61	5.04	72	38.73	1	1.45	1.03	11.28
B	1571	59	CLARKSVILLE	61	3.52	72	34.26	1	1.34	0.72	14.96
B	1572	59	BRITWATER	61	10.57	72	46.18	1	1.56	1.40	10.16
B	1576	59	RAZORT	42	1.49	62	38.73	2	1.32	0.28	20.29
B	1577	59	CLARKSVILLE	41	1.99	62	34.26	1	1.34	0.44	17.61
B	1578	59	BRITWATER	41	2.74	62	46.18	1	1.54	0.75	18.76
B	1581	59	RAZORT	71	11.30	48	38.73	1	1.43	0.59	16.45
B	1582	59	BRITWATER	71	6.49	48	46.18	1	1.54	0.86	15.66
B	1583	59	HEALING	72	8.42	48	46.18	2	1.44	0.59	11.90
B	1584	59	RAZORT	52	12.39	54	38.73	2	1.31	0.19	21.18
B	1585	59	BRITWATER	51	16.02	54	46.18	1	1.53	0.59	19.05
B	1594	59	BRITWATER	26	0.80	54	46.18	6	1.72	0.60	-94.36
B	1595	59	HEALING	20	0.34	54	46.18	0	1.32	0.04	-727.83
B	1596	59	RAZORT	32	3.74	54	38.73	2	1.31	0.15	21.60
B	1597	59	BRITWATER	32	3.21	54	46.18	2	1.47	0.58	20.16
B	1598	59	ELSAH	32	3.86	54	29.79	2	0.80	0.14	11.85
B	1599	60	CLARKSVILLE	61	6.71	72	28.67	1	1.47	0.90	14.85
B	1600	60	DONIPHAN	62	7.85	72	28.67	2	1.64	0.42	23.95
B	1606	60	CLARKSVILLE	41	2.35	62	28.67	1	1.47	0.49	20.03
B	1607	60	CLARKSVILLE	42	3.21	62	28.67	2	1.19	0.38	17.57
B	1608	60	DONIPHAN	42	8.41	62	28.67	2	1.62	0.22	27.46
B	1609	60	MACEDONIA	41	3.34	62	38.64	1	1.57	0.67	19.69
B	1613	60	CLARKSVILLE	71	49.99	48	28.67	1	1.47	0.55	19.02
B	1614	60	CLARKSVILLE	72	22.19	48	28.67	2	1.19	0.40	17.34
B	1616	60	DONIPHAN	72	30.41	48	28.67	2	1.62	0.21	27.63
B	1617	60	CLARKSVILLE	52	20.07	54	28.67	2	1.38	0.26	21.51
B	1618	60	DONIPHAN	52	29.12	54	28.67	2	1.61	0.11	29.30
B	1625	60	CLARKSVILLE	22	3.83	54	28.67	2	1.18	0.25	19.15
B	1626	60	DONIPHAN	24	13.98	54	28.67	4	1.39	0.26	27.58
B	1627	60	CLARKSVILLE	32	3.74	54	28.67	2	1.38	0.24	20.89

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	basin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1628	60	DONIPHAN	32	10.61	54	28.67	2	1.61	0.12	28.97
B	1629	61	CLARKSVILLE	61	6.26	72	27.97	1	1.47	0.76	17.61
B	1630	61	CLARKSVILLE	61	6.02	72	27.97	1	1.36	0.63	18.24
B	1631	61	BRITWATER	60	13.35	72	37.70	0	1.53	1.20	12.60
B	1639	61	CLARKSVILLE	71	19.10	48	27.97	1	1.46	0.67	14.05
B	1640	61	CLARKSVILLE	71	18.09	48	27.97	1	1.35	0.58	14.97
B	1641	61	BRITWATER	72	97.03	48	37.70	2	1.57	0.91	10.96
B	1645	61	BRITWATER	22	8.89	54	37.70	2	1.56	0.54	13.33
B	1647	62	RAZORT	61	7.99	72	28.02	1	1.45	0.76	16.19
B	1648	62	CLARKSVILLE	61	13.17	72	24.78	1	1.47	0.71	18.52
B	1649	62	CLARKSVILLE	61	13.38	72	24.78	1	1.35	0.61	17.26
B	1650	62	BRITWATER	61	9.50	72	33.40	1	1.57	1.11	16.45
B	1651	62	DONIPHAN	62	14.46	72	24.78	2	1.64	0.32	25.65
B	1652	62	MACEDONIA	61	8.86	72	33.40	1	1.60	1.00	17.59
B	1657	62	RAZORT	41	2.22	62	28.02	1	1.44	0.32	21.37
B	1658	62	DONIPHAN	42	8.39	62	24.78	2	1.62	0.16	27.65
B	1659	62	MACEDONIA	41	5.71	62	33.40	1	1.58	0.61	21.66
B	1665	62	RAZORT	71	39.25	48	28.02	1	1.44	0.50	16.37
B	1666	62	CLARKSVILLE	71	37.77	48	24.78	1	1.46	0.57	16.40
B	1667	62	CLARKSVILLE	71	29.60	48	24.78	1	1.33	0.51	14.83
B	1668	62	BRITWATER	71	42.01	48	33.40	1	1.54	0.77	16.51
B	1669	62	DONIPHAN	72	50.50	48	24.78	2	1.62	0.23	24.54
B	1670	62	MACEDONIA	71	41.48	48	33.40	1	1.58	0.70	17.84
B	1671	62	RAZORT	51	9.53	54	28.02	1	1.43	0.24	19.97
B	1672	62	CLARKSVILLE	51	13.99	54	24.78	1	1.46	0.37	19.03
B	1673	62	DONIPHAN	52	23.02	54	24.78	2	1.61	0.12	26.50
B	1674	62	MACEDONIA	51	32.25	54	33.40	1	1.57	0.49	20.35
B	1681	62	RAZORT	21	14.19	54	28.02	1	1.43	0.25	19.53
B	1682	62	CLARKSVILLE	21	14.30	54	24.78	1	1.46	0.38	18.61
B	1683	62	CLARKSVILLE	22	12.73	54	24.78	2	1.13	0.26	16.24
B	1684	62	BRITWATER	21	9.91	54	33.40	1	1.53	0.51	19.36
B	1685	62	CLARKSVILLE	31	8.15	54	24.78	1	1.46	0.37	18.82
B	1686	62	DONIPHAN	32	14.29	54	24.78	2	1.61	0.13	26.25
B	1687	62	MACEDONIA	31	9.71	54	33.40	1	1.57	0.48	20.55
B	1689	63	NEWTONIA	62	96.73	72	23.30	2	1.60	0.60	22.28
B	1694	63	DONIPHAN	42	6.07	62	17.29	2	1.64	0.19	29.42
B	1695	63	MACEDONIA	42	26.27	62	23.30	2	1.58	0.66	21.22
B	1702	63	CLARKSVILLE	71	53.29	48	17.29	1	1.46	0.49	20.63
B	1703	63	CLARKSVILLE	71	53.95	48	17.29	1	1.36	0.47	19.31
B	1704	63	DONIPHAN	72	62.18	48	17.29	2	1.64	0.22	28.35
B	1705	63	MACEDONIA	72	107.46	48	23.30	2	1.58	0.64	20.97
B	1707	63	NEWTONIA	72	101.79	48	23.30	2	1.59	0.34	25.08
B	1708	63	DONIPHAN	52	49.69	54	17.29	2	1.63	0.12	29.94
B	1709	63	MACEDONIA	52	28.55	54	23.30	2	1.57	0.45	23.03
B	1711	63	NEWTONIA	52	66.16	54	23.30	2	1.58	0.22	26.52
B	1721	63	NEWTONIA	22	36.58	54	23.30	2	1.58	0.23	26.37

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1722	63	DONIPHAN	32	4.84	54	17.29	2	1.63	0.12	29.95
B	1723	63	MACEDONIA	32	3.81	54	23.30	2	1.57	0.41	23.63
B	1725	63	NEWTONIA	33	2.37	54	23.30	3	1.24	0.10	26.37
B	1726	64	CLARKSVILLE	61	9.20	72	23.65	1	1.37	0.58	18.51
B	1728	64	DONIPHAN	61	10.30	72	23.65	1	1.62	0.37	25.23
B	1729	64	MACEDONIA	60	12.49	72	31.87	0	1.51	1.14	15.60
B	1734	64	CLARKSVILLE	41	0.88	62	23.65	1	1.50	0.34	22.42
B	1737	64	DONIPHAN	43	1.87	62	23.65	3	1.28	0.42	25.40
B	1738	64	MACEDONIA	41	2.46	62	31.87	1	1.60	0.55	19.03
B	1744	64	CLARKSVILLE	71	17.13	48	23.65	1	1.36	0.45	17.67
B	1747	64	DONIPHAN	72	19.16	48	23.65	2	1.65	0.19	25.17
B	1748	64	MACEDONIA	71	38.77	48	31.87	1	1.60	0.64	14.31
B	1749	64	CLARKSVILLE	51	11.83	54	23.65	1	1.50	0.33	20.11
B	1751	64	BRITWATER	51	8.90	54	31.87	1	1.57	0.45	18.50
B	1752	64	DONIPHAN	52	18.74	54	23.65	2	1.64	0.11	26.73
B	1753	64	MACEDONIA	52	19.67	54	31.87	2	1.59	0.42	17.54
B	1760	64	CLARKSVILLE	21	5.47	54	23.65	1	1.50	0.36	18.86
B	1761	64	CLARKSVILLE	21	4.82	54	23.65	1	1.36	0.34	17.97
B	1763	64	MACEDONIA	21	3.00	54	31.87	1	1.59	0.43	15.70
B	1766	64	BRITWATER	31	4.94	54	31.87	1	1.57	0.46	17.71
B	1767	64	MACEDONIA	32	9.53	54	31.87	2	1.59	0.42	16.93
B	1768	65	RAZORT	61	5.04	72	25.24	1	1.44	0.79	13.85
B	1769	65	CLARKSVILLE	61	8.29	72	22.32	1	1.46	0.77	15.57
B	1770	65	CLARKSVILLE	61	8.39	72	22.32	1	1.35	0.68	15.67
B	1772	65	BRITWATER	60	9.54	72	30.09	0	1.51	1.37	13.51
B	1773	65	MACEDONIA	60	5.56	72	30.09	0	1.54	1.20	16.00
B	1779	65	CLARKSVILLE	42	4.15	62	22.32	2	1.46	0.38	16.81
B	1780	65	CLARKSVILLE	41	4.58	62	22.32	1	1.35	0.44	17.43
B	1788	65	CLARKSVILLE	71	21.58	48	22.32	1	1.45	0.49	18.43
B	1789	65	CLARKSVILLE	71	13.38	48	22.32	1	1.35	0.45	17.46
B	1790	65	BRITWATER	70	49.94	48	30.09	0	1.50	0.80	16.25
B	1791	65	CLARKSVILLE	51	16.91	54	22.32	1	1.44	0.33	20.26
B	1792	65	MACEDONIA	51	37.09	54	30.09	1	1.54	0.53	18.92
B	1798	65	CLARKSVILLE	21	1.07	54	22.32	1	1.44	0.35	9.62
B	1799	65	BRITWATER	21	4.07	54	30.09	1	1.52	0.54	17.24
B	1800	65	MACEDONIA	21	3.64	54	30.09	1	1.54	0.54	17.64
B	1801	65	RAZORT	36	0.74	54	25.24	6	1.55	0.19	-449.16
B	1802	65	BRITWATER	36	0.53	54	30.09	6	1.68	0.63	-328.83
B	1803	65	DONIPHAN	32	1.37	54	22.32	2	1.61	0.13	24.06
B	1804	65	MACEDONIA	31	1.37	54	30.09	1	1.54	0.50	19.28
B	1805	66	RAZORT	61	6.69	72	30.29	1	1.49	0.94	13.99
B	1806	66	CLARKSVILLE	61	12.45	72	26.80	1	1.33	0.70	16.46
B	1807	66	DONIPHAN	61	15.68	72	26.80	1	1.63	0.44	24.14
B	1808	66	MACEDONIA	60	20.63	72	36.12	0	1.48	1.46	14.61
B	1814	66	CLARKSVILLE	41	1.27	62	26.80	1	1.49	0.44	20.81
B	1815	66	CLARKSVILLE	42	1.37	62	26.80	2	1.25	0.30	16.12

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1817	66	DONIPHAN	44	1.80	62	26.80	4	1.48	0.72	19.88
B	1818	66	MACEDONIA	40	2.53	62	36.12	0	1.48	0.66	16.80
B	1823	66	RAZORT	71	11.55	48	30.29	1	1.47	0.52	18.46
B	1824	66	CLARKSVILLE	71	14.11	48	26.80	1	1.49	0.55	18.76
B	1825	66	CLARKSVILLE	71	23.59	48	26.80	1	1.32	0.48	17.75
B	1826	66	DONIPHAN	72	25.07	48	26.80	2	1.63	0.19	25.47
B	1827	66	MACEDONIA	70	23.59	48	36.12	0	1.48	0.85	15.81
B	1828	66	RAZORT	51	12.28	54	30.29	1	1.47	0.28	21.16
B	1829	66	CLARKSVILLE	51	14.18	54	26.80	1	1.49	0.37	20.59
B	1830	66	CLARKSVILLE	51	8.18	54	26.80	1	1.29	0.34	18.91
B	1831	66	DONIPHAN	51	15.68	54	26.80	1	1.60	0.17	26.26
B	1832	66	MACEDONIA	50	23.67	54	36.12	0	1.47	0.52	17.22
B	1837	66	CLARKSVILLE	21	3.25	54	26.80	1	1.49	0.49	15.78
B	1838	66	DONIPHAN	25	1.34	54	26.80	5	1.56	1.51	14.04
B	1839	66	CLARKSVILLE	31	6.03	54	26.80	1	1.49	0.50	15.27
B	1840	66	CLARKSVILLE	31	2.01	54	26.80	1	1.29	0.45	6.34
B	1841	66	DONIPHAN	32	6.78	54	26.80	2	1.62	0.14	22.64
B	1842	66	MACEDONIA	32	2.86	54	36.12	2	1.56	0.55	13.98
B	1843	67	DONIPHAN	61	731.55	72	22.29	1	1.62	0.36	25.89
B	1847	67	CLARKSVILLE	41	3.18	62	22.29	1	1.49	0.46	21.25
B	1848	67	CLARKSVILLE	41	6.24	62	22.29	1	1.29	0.44	19.06
B	1849	67	DONIPHAN	41	15.09	62	22.29	1	1.61	0.24	26.33
B	1857	67	CLARKSVILLE	71	295.97	48	22.29	1	1.29	0.55	14.96
B	1858	67	DONIPHAN	72	1003.00	48	22.29	2	1.63	0.21	23.34
B	1860	67	DONIPHAN	52	73.29	54	22.29	2	1.62	0.12	24.29
B	1871	67	DONIPHAN	22	47.45	54	22.29	2	1.62	0.13	22.99
B	1873	67	CLARKSVILLE	32	2.14	54	22.29	2	1.23	0.25	13.20
B	1874	67	DONIPHAN	32	7.79	54	22.29	2	1.62	0.13	23.15
B	1875	67	MACEDONIA	32	2.34	54	30.05	2	1.56	0.45	16.06
B	1877	68	CLARKSVILLE	61	5.66	72	34.23	1	1.50	1.03	13.85
B	1878	68	CLARKSVILLE	61	4.62	72	34.23	1	1.30	0.84	14.52
B	1879	68	DONIPHAN	61	20.24	72	34.23	1	1.62	0.55	21.73
B	1883	68	CLARKSVILLE	42	0.57	62	34.23	2	1.47	0.27	18.19
B	1884	68	CLARKSVILLE	45	0.86	62	34.23	5	1.29	0.93	-30.12
B	1885	68	DONIPHAN	41	3.34	62	34.23	1	1.61	0.31	24.70
B	1888	68	CLARKSVILLE	71	11.94	48	34.23	1	1.49	0.77	14.52
B	1889	68	CLARKSVILLE	71	7.38	48	34.23	1	1.28	0.65	14.82
B	1890	68	BRITWATER	71	8.90	48	46.14	1	1.58	1.03	8.04
B	1891	68	DONIPHAN	72	18.81	48	34.23	2	1.63	0.24	22.56
B	1892	68	CLARKSVILLE	52	4.68	54	34.23	2	1.44	0.25	16.23
B	1893	68	CLARKSVILLE	51	8.77	54	34.23	1	1.27	0.47	16.51
B	1896	68	CLARKSVILLE	21	2.23	54	34.23	1	1.48	0.49	18.31
B	1897	68	BRITWATER	21	4.92	54	46.14	1	1.57	0.69	12.80
B	1898	68	CLARKSVILLE	35	0.84	54	34.23	5	1.29	0.96	-113.13
B	1899	68	DONIPHAN	32	0.21	54	34.23	2	1.62	0.10	-3439.70
B	1900	69	CLARKSVILLE	61	25.62	72	48.59	1	1.57	1.23	11.60
B	1901	69	CLARKSVILLE	61	26.66	72	48.59	1	1.47	0.90	16.15

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygr	HRU	basin	Soil Type	OpAct	rea (ha)	urveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1902	69	BRITWATER	60	11.98	72	65.49	0	1.61	2.08	4.02
B	1903	69	DONIPHAN	62	21.98	72	48.59	2	1.66	0.37	22.56
B	1908	69	CLARKSVILLE	41	7.85	62	48.59	1	1.56	0.75	17.37
B	1909	69	CLARKSVILLE	41	20.64	62	48.59	1	1.47	0.61	18.80
B	1913	69	CLARKSVILLE	71	38.59	48	48.59	1	1.56	0.84	15.04
B	1914	69	CLARKSVILLE	71	29.86	48	48.59	1	1.47	0.64	17.85
B	1915	69	BRITWATER	70	19.18	48	65.49	0	1.61	1.38	4.36
B	1916	69	DONIPHAN	72	31.58	48	48.59	2	1.65	0.22	24.87
B	1917	69	RAZORT	51	5.27	54	54.93	1	1.53	0.45	19.59
B	1918	69	CLARKSVILLE	51	20.32	54	48.59	1	1.56	0.58	18.30
B	1919	69	CLARKSVILLE	51	19.54	54	48.59	1	1.46	0.46	19.47
B	1924	69	CLARKSVILLE	21	3.38	54	48.59	1	1.56	0.58	17.34
B	1925	69	CLARKSVILLE	21	2.64	54	48.59	1	1.46	0.47	18.50
B	1926	69	DONIPHAN	22	6.22	54	48.59	2	1.65	0.13	25.77
B	1927	69	CLARKSVILLE	31	2.38	54	48.59	1	1.56	0.56	17.86
B	1928	69	DONIPHAN	30	1.25	54	48.59	0	1.60	0.10	20.69
B	1929	70	RAZORT	61	71.37	72	52.99	1	1.47	1.61	4.88
B	1930	70	CLARKSVILLE	61	116.34	72	46.88	1	1.50	1.24	11.92
B	1931	70	CLARKSVILLE	61	43.47	72	46.88	1	1.30	0.92	14.34
B	1932	70	DONIPHAN	61	39.48	72	46.88	1	1.62	0.53	22.97
B	1943	70	RAZORT	71	55.54	48	52.99	1	1.46	1.06	8.20
B	1944	70	CLARKSVILLE	71	210.83	48	46.88	1	1.49	0.95	10.71
B	1945	70	CLARKSVILLE	71	62.87	48	46.88	1	1.29	0.76	12.46
B	1946	70	DONIPHAN	71	47.98	48	46.88	1	1.61	0.43	21.56
B	1948	70	DONIPHAN	51	3.49	54	46.88	1	1.61	0.24	24.38
B	1954	70	CLARKSVILLE	21	22.36	54	46.88	1	1.48	0.69	13.28
B	1955	70	BRITWATER	22	8.37	54	63.18	2	1.55	0.83	6.59
B	1956	70	DONIPHAN	22	8.86	54	46.88	2	1.62	0.14	23.54
B	1957	70	CLARKSVILLE	30	0.09	54	46.88	0	1.30	0.15	-2488.11
B	1959	71	DONIPHAN	62	64.21	72	20.19	2	1.67	0.33	26.48
B	1960	71	MACEDONIA	60	45.51	72	27.21	0	1.51	1.20	16.98
B	1964	71	DONIPHAN	42	12.55	62	20.19	2	1.66	0.17	28.65
B	1965	71	MACEDONIA	41	26.28	62	27.21	1	1.60	0.64	18.86
B	1970	71	DONIPHAN	72	129.31	48	20.19	2	1.66	0.22	26.15
B	1971	71	MACEDONIA	72	134.80	48	27.21	2	1.61	0.64	16.45
B	1972	71	RAZORT	52	24.43	54	22.82	2	1.41	0.16	19.32
B	1973	71	CLARKSVILLE	51	28.57	54	20.19	1	1.49	0.38	20.30
B	1974	71	DONIPHAN	52	69.41	54	20.19	2	1.65	0.12	27.87
B	1975	71	MACEDONIA	52	28.08	54	27.21	2	1.59	0.44	19.32
B	1976	71	NEWTONIA	52	33.19	54	27.21	2	1.60	0.24	18.54
B	1984	71	DONIPHAN	22	18.31	54	20.19	2	1.65	0.14	27.08
B	1985	71	MACEDONIA	22	17.95	54	27.21	2	1.59	0.45	18.70
B	1986	71	NEWTONIA	22	8.98	54	27.21	2	1.60	0.22	21.82
B	1987	71	CLARKSVILLE	31	6.07	54	20.19	1	1.35	0.39	18.62
B	1988	71	DONIPHAN	33	9.27	54	20.19	3	1.27	0.53	25.97

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	1989	71	MACEDONIA	32	13.80	54	27.21	2	1.59	0.44	18.86
B	1991	71	NEWTONIA	32	14.14	54	27.21	2	1.60	0.23	18.89
B	1992	72	CLARKSVILLE	61	18.40	72	17.88	1	1.47	0.68	18.39
B	1998	72	CLARKSVILLE	41	8.57	62	17.88	1	1.45	0.41	21.32
B	1999	72	CLARKSVILLE	42	9.70	62	17.88	2	1.13	0.36	18.49
B	2009	72	CLARKSVILLE	71	71.34	48	17.88	1	1.45	0.43	20.56
B	2012	72	CLARKSVILLE	52	117.22	54	17.88	2	1.36	0.21	22.24
B	2014	72	DONIPHAN	52	69.03	54	17.88	2	1.63	0.11	29.12
B	2024	72	CLARKSVILLE	32	35.90	54	17.88	2	1.36	0.26	19.19
B	2030	73	CLARKSVILLE	61	48.98	72	46.25	1	1.45	1.26	10.87
B	2031	73	CLARKSVILLE	61	32.79	72	46.25	1	1.31	0.86	13.65
B	2036	73	CLARKSVILLE	45	0.57	62	46.25	5	1.44	0.49	3.98
B	2037	73	CLARKSVILLE	46	0.95	62	46.25	6	1.45	0.72	-23.89
B	2045	73	RAZORT	71	23.93	48	52.28	1	1.41	0.95	9.17
B	2046	73	CLARKSVILLE	71	105.82	48	46.25	1	1.44	0.97	10.31
B	2047	73	CLARKSVILLE	71	28.48	48	46.25	1	1.30	0.69	12.52
B	2048	73	DONIPHAN	72	26.48	48	46.25	2	1.58	0.35	22.42
B	2049	73	CLARKSVILLE	51	3.54	54	46.25	1	1.43	0.56	16.49
B	2050	73	CLARKSVILLE	51	2.53	54	46.25	1	1.28	0.45	15.73
B	2055	73	RAZORT	23	1.74	54	52.28	3	1.13	0.35	14.44
B	2056	73	CLARKSVILLE	21	9.56	54	46.25	1	1.43	0.64	14.38
B	2057	73	BRITWATER	21	1.96	54	62.33	1	1.51	0.78	13.96
B	2058	73	CLARKSVILLE	35	0.29	54	46.25	5	1.28	0.47	-1354.40
B	2060	74	CLARKSVILLE	61	89.84	72	52.50	1	1.45	1.14	10.61
B	2061	74	CLARKSVILLE	61	68.10	72	52.50	1	1.33	0.82	13.19
B	2062	74	DONIPHAN	61	23.29	72	52.50	1	1.57	0.52	21.87
B	2069	74	CLARKSVILLE	71	166.60	48	52.50	1	1.44	0.71	14.63
B	2070	74	CLARKSVILLE	71	56.33	48	52.50	1	1.32	0.56	14.79
B	2071	74	BRITWATER	70	63.43	48	70.76	0	1.51	1.21	10.11
B	2072	74	DONIPHAN	71	45.75	48	52.50	1	1.54	0.31	22.95
B	2076	74	RAZORT	21	1.46	54	59.34	1	1.42	0.30	15.82
B	2077	74	CLARKSVILLE	21	2.30	54	52.50	1	1.44	0.52	13.29
B	2078	74	BRITWATER	26	0.62	54	70.76	6	1.69	0.75	-268.81
B	2079	75	CLARKSVILLE	61	18.72	72	27.38	1	1.58	0.79	17.57
B	2080	75	CLARKSVILLE	61	23.66	72	27.38	1	1.49	0.69	18.37
B	2081	75	BRITWATER	60	31.90	72	36.91	0	1.61	1.13	13.24
B	2093	75	CLARKSVILLE	70	11.59	48	27.38	0	1.49	0.34	17.93
B	2094	75	CLARKSVILLE	71	25.33	48	27.38	1	1.48	0.48	19.59
B	2095	75	BRITWATER	70	23.82	48	36.91	0	1.60	0.61	14.97
B	2100	75	BRITWATER	25	0.59	54	36.91	5	1.56	1.92	-412.93
B	2101	75	MACEDONIA	22	3.13	54	36.91	2	1.66	0.35	10.95
B	2102	76	RAZORT	66	0.87	72	13.06	6	1.56	0.75	0.35
B	2103	76	BRITWATER	60	0.97	72	15.57	0	1.51	0.77	22.39
B	2109	76	RAZORT	71	7.10	48	13.06	1	1.43	0.36	20.16
B	2110	76	BRITWATER	71	6.25	48	15.57	1	1.53	0.65	19.76

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygr	HRU	basin	Soil Type	OpAct	rea (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	2111	76	ELSAH	72	3.92	48	10.05	2	1.04	0.28	12.92
B	2114	76	RAZORT	20	0.09	54	13.06	0	1.30	0.09	-877.84
B	2115	76	BRITWATER	20	0.09	54	15.57	0	1.50	0.22	-1086.29
B	2117	77	NEWTONIA	61	28.23	72	22.06	1	1.59	0.53	19.09
B	2123	77	CLARKSVILLE	46	0.30	62	16.37	6	1.59	0.56	-1358.06
B	2124	77	NEWTONIA	44	1.61	62	22.06	4	1.43	1.17	15.94
B	2131	77	NEWTONIA	71	159.36	48	22.06	1	1.58	0.29	22.54
B	2132	77	RAZORT	51	9.41	54	18.50	1	1.43	0.20	21.61
B	2133	77	BRITWATER	51	6.35	54	22.06	1	1.54	0.47	21.35
B	2134	77	NEWTONIA	51	15.43	54	22.06	1	1.58	0.24	23.21
B	2141	77	RAZORT	21	2.96	54	18.50	1	1.43	0.22	20.48
B	2142	77	CLARKSVILLE	21	4.79	54	16.37	1	1.47	0.36	19.49
B	2144	77	NEWTONIA	21	12.19	54	22.06	1	1.58	0.25	22.05
B	2145	77	RAZORT	31	4.80	54	18.50	1	1.43	0.22	20.27
B	2146	77	BRITWATER	32	3.04	54	22.06	2	1.48	0.46	18.37
B	2147	77	NEWTONIA	31	6.31	54	22.06	1	1.58	0.25	22.38
B	2148	78	CLARKSVILLE	61	19.91	72	45.38	1	1.58	0.98	13.66
B	2149	78	CLARKSVILLE	61	9.34	72	45.38	1	1.49	0.77	16.45
B	2150	78	BRITWATER	60	4.67	72	61.16	0	1.61	1.59	12.03
B	2151	78	DONIPHAN	61	5.56	72	45.38	1	1.69	0.41	22.89
B	2161	78	RAZORT	71	20.63	48	51.29	1	1.54	0.70	13.68
B	2162	78	CLARKSVILLE	71	19.42	48	45.38	1	1.57	0.70	14.16
B	2163	78	CLARKSVILLE	71	14.24	48	45.38	1	1.48	0.59	15.72
B	2164	78	BRITWATER	70	50.10	48	61.16	0	1.61	1.07	7.07
B	2168	78	RAZORT	26	0.72	54	51.29	6	1.62	0.22	-508.50
B	2169	78	BRITWATER	20	4.06	54	61.16	0	1.59	0.60	8.51
B	2170	79	CLARKSVILLE	61	5.95	72	26.21	1	1.36	0.73	17.27
B	2173	79	PERIDGE	62	9.05	72	35.33	2	1.62	1.00	15.22
B	2179	79	CLARKSVILLE	45	0.29	62	26.21	5	1.34	0.30	-857.62
B	2188	79	BRITWATER	72	13.42	48	35.33	2	1.51	1.15	15.68
B	2189	79	PERIDGE	72	11.74	48	35.33	2	1.60	0.62	20.91
B	2196	79	BRITWATER	24	0.87	54	35.33	4	1.38	0.27	-94.67
B	2197	79	HEALING	24	0.58	54	35.33	4	1.38	0.14	-858.52
B	2198	79	PERIDGE	20	0.20	54	35.33	0	1.46	0.13	-1063.72
B	2199	79	CLARKSVILLE	30	0.09	54	26.21	0	1.15	0.26	-6050.26
B	2200	80	CLARKSVILLE	61	3.54	72	25.64	1	1.34	0.66	16.02
B	2201	80	BRITWATER	60	2.65	72	34.56	0	1.45	1.28	14.96
B	2206	80	CLARKSVILLE	45	0.64	62	25.64	5	1.34	1.53	4.28
B	2208	80	BRITWATER	46	0.86	62	34.56	6	1.71	0.86	-39.60
B	2210	80	WABEN	46	0.96	62	25.64	6	1.43	0.40	-21.10
B	2218	80	CLARKSVILLE	72	6.19	48	25.64	2	1.19	0.53	10.97
B	2219	80	BRITWATER	71	19.92	48	34.56	1	1.55	0.86	11.61
B	2220	80	WABEN	71	8.10	48	25.64	1	1.31	0.39	15.20
B	2221	80	PERIDGE	72	17.10	48	34.56	2	1.60	0.59	14.95
B	2222	80	BRITWATER	52	33.16	54	34.56	2	1.49	0.67	15.81
B	2223	80	PERIDGE	52	26.86	54	34.56	2	1.59	0.32	18.68

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	2230	80	CLARKSVILLE	25	0.79	54	25.64	5	1.34	1.90	-51.86
B	2231	80	BRITWATER	21	1.39	54	34.56	1	1.54	0.47	19.61
B	2233	80	PERIDGE	24	0.39	54	34.56	4	1.44	1.28	-880.31
B	2234	80	BRITWATER	31	4.74	54	34.56	1	1.54	0.54	17.18
B	2235	80	WABEN	31	12.78	54	25.64	1	1.31	0.22	17.68
B	2236	80	PERIDGE	32	17.41	54	34.56	2	1.59	0.32	20.10
B	2237	81	CLARKSVILLE	61	8.15	72	21.63	1	1.37	0.63	19.03
B	2238	81	BRITWATER	61	13.39	72	29.16	1	1.54	1.08	15.12
B	2239	81	DONIPHAN	62	17.86	72	21.63	2	1.66	0.36	27.24
B	2244	81	CLARKSVILLE	41	2.61	62	21.63	1	1.36	0.41	20.92
B	2252	81	CLARKSVILLE	72	53.05	48	21.63	2	1.48	0.41	20.24
B	2253	81	CLARKSVILLE	71	57.13	48	21.63	1	1.36	0.47	19.37
B	2254	81	DONIPHAN	72	56.79	48	21.63	2	1.64	0.21	28.75
B	2255	81	NEWTONIA	72	36.72	48	29.16	2	1.59	0.43	23.31
B	2256	81	CLARKSVILLE	52	17.35	54	21.63	2	1.26	0.25	20.81
B	2259	81	NEWTONIA	52	59.58	54	29.16	2	1.59	0.27	25.41
B	2266	81	CLARKSVILLE	22	5.98	54	21.63	2	1.47	0.25	22.28
B	2267	81	CLARKSVILLE	22	12.10	54	21.63	2	1.26	0.27	20.16
B	2268	81	MACEDONIA	22	6.53	54	29.16	2	1.57	0.47	22.12
B	2269	81	NEWTONIA	22	10.61	54	29.16	2	1.59	0.27	25.17
B	2270	81	CLARKSVILLE	32	3.06	54	21.63	2	1.47	0.24	22.63
B	2271	81	CLARKSVILLE	31	1.28	54	21.63	1	1.34	0.33	20.65
B	2273	81	NEWTONIA	32	5.23	54	29.16	2	1.59	0.25	25.54
B	2274	82	CLARKSVILLE	61	6.27	72	74.42	1	1.45	1.26	11.42
B	2275	82	BRITWATER	60	9.40	72	100.30	0	1.52	2.71	3.94
B	2276	82	HEALING	61	2.27	72	100.30	1	1.50	2.52	-13.88
B	2282	82	CLARKSVILLE	71	23.09	48	74.42	1	1.44	0.86	15.19
B	2283	82	BRITWATER	70	27.38	48	100.30	0	1.51	1.62	6.96
B	2287	82	CLARKSVILLE	26	0.38	54	74.42	6	1.59	0.62	-1053.72
B	2288	82	BRITWATER	20	0.19	54	100.30	0	1.50	0.23	-1251.89
B	2289	83	CLARKSVILLE	61	1.92	72	54.12	1	1.47	0.86	16.18
B	2290	83	BRITWATER	60	3.54	72	72.94	0	1.53	1.47	8.56
B	2291	83	DONIPHAN	62	1.31	72	54.12	2	1.66	0.33	25.44
B	2295	83	RAZORT	40	0.09	62	61.18	0	1.33	0.13	-1079.74
B	2296	83	CLARKSVILLE	40	0.09	62	54.12	0	1.37	0.20	-1281.96
B	2297	83	BRITWATER	40	0.19	62	72.94	0	1.52	0.30	-932.66
B	2302	83	CLARKSVILLE	71	1.96	48	54.12	1	1.35	0.55	15.90
B	2303	83	BRITWATER	76	0.39	48	72.94	6	1.69	0.83	-246.45
B	2304	83	DONIPHAN	72	1.47	48	54.12	2	1.65	0.22	24.88
B	2305	83	RAZORT	53	1.59	54	61.18	3	1.16	0.93	16.64
B	2306	83	CLARKSVILLE	51	1.69	54	54.12	1	1.46	0.42	17.71
B	2307	83	BRITWATER	52	3.29	54	72.94	2	1.56	0.54	13.09
B	2311	83	CLARKSVILLE	33	0.47	54	54.12	3	1.19	0.88	-709.28
B	2312	83	BRITWATER	30	0.09	54	72.94	0	1.51	0.20	-1057.94
B	2313	84	CLARKSVILLE	60	2.68	72	108.83	0	1.49	1.14	9.63
B	2314	84	BRITWATER	60	2.77	72	146.69	0	1.62	2.16	2.84

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	basin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
B	2320	84	CLARKSVILLE	71	5.84	48	108.83	1	1.56	0.95	10.33
B	2321	84	BRITWATER	70	4.68	48	146.69	0	1.59	1.38	-0.70
B	2324	85	CLARKSVILLE	61	4.52	72	24.51	1	1.58	0.65	19.08
B	2325	85	CLARKSVILLE	60	7.56	72	24.51	0	1.39	0.46	19.31
B	2334	85	CLARKSVILLE	71	2.78	48	24.51	1	1.58	0.42	20.58
B	2335	85	CLARKSVILLE	71	3.45	48	24.51	1	1.47	0.41	20.00
B	2336	85	DONIPHAN	72	3.12	48	24.51	2	1.65	0.16	25.50
B	2342	85	DONIPHAN	20	0.19	54	24.51	0	1.61	0.07	-750.52
B	2348	86	CLARKSVILLE	70	0.09	48	164.27	0	1.49	0.22	-1581.06
B	2349	86	BRITWATER	75	0.39	48	221.41	5	1.57	1.82	-306.77
B	2352	87	CLARKSVILLE	61	2.02	72	50.90	1	1.45	0.94	13.93
B	2353	87	CLARKSVILLE	61	3.18	72	50.90	1	1.33	0.76	14.30
B	2361	87	CLARKSVILLE	71	3.86	48	50.90	1	1.44	0.66	15.56
B	2362	87	CLARKSVILLE	71	2.29	48	50.90	1	1.32	0.50	15.85
B	2363	87	BRITWATER	70	1.46	48	68.60	0	1.51	0.81	15.14
B	2365	87	RAZORT	20	0.29	54	57.54	0	1.29	0.09	-576.56
B	2366	87	CLARKSVILLE	20	0.09	54	50.90	0	1.33	0.15	-1053.32
B	2367	87	BRITWATER	20	0.09	54	68.60	0	1.50	0.22	-857.43
B	2368	88	CLARKSVILLE	61	2.19	72	33.58	1	1.45	0.81	16.62
B	2369	88	CLARKSVILLE	64	0.69	72	33.58	4	1.24	1.11	1.31
B	2370	88	DONIPHAN	63	1.15	72	33.58	3	1.32	0.55	20.20
B	2371	88	ELSAH	65	0.58	72	29.20	5	1.14	1.50	-11.14
B	2379	88	CLARKSVILLE	71	6.82	48	33.58	1	1.44	0.58	17.65
B	2380	88	BRITWATER	71	1.23	48	45.26	1	1.53	0.75	17.46
B	2383	88	CLARKSVILLE	20	0.09	54	33.58	0	1.32	0.14	-962.25
B	2384	89	RAZORT	60	2.77	72	50.49	0	1.48	0.70	12.10
B	2385	89	CLARKSVILLE	60	2.38	72	44.67	0	1.50	0.59	16.68
B	2386	89	BRITWATER	60	2.20	72	60.20	0	1.61	1.08	13.45
B	2392	89	RAZORT	72	2.00	48	50.49	2	1.49	0.31	16.99
B	2393	89	CLARKSVILLE	71	5.06	48	44.67	1	1.58	0.57	19.27
B	2394	89	BRITWATER	70	4.00	48	60.20	0	1.60	0.63	15.01
B	2397	90	CLARKSVILLE	61	40.55	72	20.41	1	1.58	0.74	18.04
B	2398	90	CLARKSVILLE	61	118.44	72	20.41	1	1.49	0.66	18.30
B	2399	90	DONIPHAN	61	95.23	72	20.41	1	1.69	0.39	24.22
B	2408	90	CLARKSVILLE	71	31.38	48	20.41	1	1.58	0.48	20.34
B	2409	90	CLARKSVILLE	71	50.78	48	20.41	1	1.48	0.45	19.93
B	2410	90	DONIPHAN	72	58.23	48	20.41	2	1.65	0.17	26.37
B	2415	90	DONIPHAN	22	4.13	54	20.41	2	1.65	0.09	26.72
C	1	1	CAPTINA	61	50.82	79	28.54	1	1.55	1.48	5.26
C	10	1	JAY	42	20.90	72	24.57	2	1.54	1.11	11.82
C	17	1	CAPTINA	72	246.37	63	28.54	2	1.58	0.91	13.01
C	22	1	JAY	52	55.84	67	24.57	2	1.53	0.85	14.16
C	31	1	CAPTINA	22	27.06	67	28.54	2	1.57	1.01	10.92
C	33	1	CAPTINA	32	5.14	67	28.54	2	1.57	0.88	13.40
C	36	1	JAY	32	4.83	67	24.57	2	1.53	0.73	15.34
C	38	2	CAPTINA	61	20.75	79	26.58	1	1.53	1.46	4.27
C	47	2	CAPTINA	42	45.61	72	26.58	2	1.58	1.09	11.45

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Basin	Soil Type	OpAct	rea (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	54	2	CAPTINA	72	60.17	63	26.58	2	1.58	1.15	9.18
C	58	2	CAPTINA	52	49.29	67	26.58	2	1.56	0.97	13.55
C	62	2	JAY	52	47.29	67	22.89	2	1.52	0.86	14.84
C	71	2	CAPTINA	22	2.84	67	26.58	2	1.56	0.77	16.84
C	73	2	CAPTINA	32	2.74	67	26.58	2	1.56	0.77	16.96
C	75	2	JAY	32	3.72	67	22.89	2	1.52	0.73	17.28
C	78	3	CAPTINA	61	48.42	79	57.92	1	1.54	2.99	-11.84
C	85	3	CAPTINA	41	6.34	72	57.92	1	1.52	1.87	2.24
C	94	3	CAPTINA	71	56.98	63	57.92	1	1.52	2.38	-9.32
C	96	3	CAPTINA	51	22.91	67	57.92	1	1.52	1.81	-1.75
C	104	3	CAPTINA	21	15.00	67	57.92	1	1.52	2.15	-14.16
C	107	3	CAPTINA	30	0.09	67	57.92	0	1.47	0.33	-7271.01
C	117	4	CAPTINA	41	14.74	72	64.37	1	1.52	2.74	-14.08
C	128	4	CAPTINA	51	31.06	67	64.37	1	1.52	2.29	-9.74
C	139	4	CAPTINA	22	5.66	67	64.37	2	1.56	1.97	-12.04
C	142	4	CAPTINA	32	6.62	67	64.37	2	1.56	2.01	-12.94
C	145	5	CAPTINA	61	70.95	79	23.76	1	1.56	1.81	2.09
C	147	5	JAY	61	88.89	79	20.46	1	1.54	2.07	1.32
C	148	5	NIXA	61	60.81	79	17.16	1	0.97	1.33	1.88
C	152	5	CAPTINA	42	7.81	72	23.76	2	1.58	1.07	12.13
C	154	5	NIXA	41	12.23	72	17.16	1	0.96	0.93	3.82
C	155	5	TONTI	41	6.45	72	20.46	1	1.62	0.63	24.90
C	165	5	CAPTINA	72	133.30	63	23.76	2	1.58	1.33	5.27
C	167	5	JAY	72	232.14	63	20.46	2	1.51	1.20	7.08
C	169	5	NIXA	71	252.04	63	17.16	1	0.96	0.98	2.51
C	171	5	CAPTINA	52	120.44	67	23.76	2	1.57	0.99	10.58
C	172	5	NIXA	51	116.48	67	17.16	1	0.94	0.80	3.21
C	180	5	JAY	22	76.84	67	20.46	2	1.49	1.01	9.18
C	182	5	NIXA	21	56.99	67	17.16	1	0.94	0.83	2.47
C	184	5	CAPTINA	32	34.62	67	23.76	2	1.57	1.07	7.69
C	185	5	NIXA	31	27.70	67	17.16	1	0.94	0.82	2.55
C	217	8	CAPTINA	41	2.56	72	17.64	1	1.56	0.62	21.50
C	228	8	JAY	72	28.79	63	15.19	2	1.52	0.78	17.53
C	230	8	CAPTINA	52	77.59	67	17.64	2	1.54	0.58	21.30
C	240	8	JAY	22	8.25	67	15.19	2	1.49	0.52	22.11
C	244	8	JAY	32	23.30	67	15.19	2	1.49	0.54	21.74
C	246	9	CAPTINA	61	22.27	79	22.99	1	1.56	1.53	7.70
C	248	9	NIXA	61	16.83	79	16.60	1	1.11	1.27	5.56
C	249	9	TONTI	60	13.15	79	19.79	0	1.46	0.93	23.46
C	254	9	CAPTINA	42	4.94	72	22.99	2	1.59	0.91	16.00
C	256	9	NIXA	41	9.67	72	16.60	1	1.08	0.90	7.55
C	263	9	CAPTINA	72	92.80	63	22.99	2	1.59	1.08	10.31
C	265	9	NIXA	71	73.92	63	16.60	1	1.08	0.97	5.97
C	266	9	TONTI	71	68.85	63	19.79	1	1.62	0.65	24.27
C	268	9	CAPTINA	52	41.53	67	22.99	2	1.57	0.90	13.55
C	271	9	NIXA	51	57.20	67	16.60	1	1.07	0.77	7.17

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	276	9	CAPTINA	22	21.47	67	22.99	2	1.57	0.89	14.27
C	281	9	CAPTINA	32	20.01	67	22.99	2	1.57	0.89	14.29
C	283	9	NIXA	31	25.32	67	16.60	1	1.07	0.76	7.32
C	285	10	JAY	61	10.81	79	20.62	1	1.54	1.71	8.15
C	286	10	NIXA	61	6.46	79	17.29	1	1.11	1.22	6.06
C	292	10	NIXA	41	2.14	72	17.29	1	1.08	0.85	8.33
C	303	10	JAY	72	80.93	63	20.62	2	1.52	1.30	8.50
C	305	10	CAPTINA	52	27.54	67	23.94	2	1.57	0.97	11.50
C	314	10	JAY	22	24.93	67	20.62	2	1.48	0.93	14.38
C	317	10	CAPTINA	32	4.61	67	23.94	2	1.57	0.83	15.04
C	319	10	JAY	32	4.61	67	20.62	2	1.48	0.83	16.27
C	322	11	CAPTINA	66	17.28	79	44.90	6	1.72	1.78	-4.71
C	323	11	NIXA	61	11.69	79	32.43	1	1.12	1.25	5.94
C	324	11	TONTI	62	17.81	79	38.66	2	1.66	1.04	20.25
C	328	11	NIXA	41	9.67	72	32.43	1	1.10	0.87	9.54
C	329	11	TONTI	42	5.43	72	38.66	2	1.64	0.60	26.74
C	333	11	CAPTINA	76	11.24	63	44.90	6	1.71	1.53	2.26
C	334	11	NIXA	71	31.79	63	32.43	1	1.10	0.99	6.97
C	335	11	TONTI	73	9.59	63	38.66	3	1.26	0.33	24.46
C	336	11	CAPTINA	56	30.76	67	44.90	6	1.70	1.26	8.93
C	337	11	NIXA	52	122.41	67	32.43	2	1.02	0.76	9.61
C	338	11	TONTI	53	117.10	67	38.66	3	1.26	0.23	28.73
C	344	11	NIXA	22	3.75	67	32.43	2	1.02	0.76	9.48
C	346	11	TONTI	23	1.25	67	38.66	3	1.26	0.17	30.09
C	347	11	NIXA	32	25.71	67	32.43	2	1.02	0.80	8.67
C	348	11	TONTI	33	17.42	67	38.66	3	1.26	0.25	28.00
C	350	12	CAPTINA	66	2.64	79	62.05	6	1.71	1.98	-9.61
C	357	12	NIXA	41	1.25	72	44.81	1	1.10	0.88	8.79
C	361	12	CAPTINA	76	2.20	63	62.05	6	1.71	1.47	5.20
C	364	12	NIXA	50	0.09	67	44.81	0	0.96	0.52	-1344.04
C	370	13	CAPTINA	66	50.13	79	39.82	6	1.73	2.15	-13.69
C	371	13	NIXA	61	9.57	79	28.76	1	1.09	1.25	1.89
C	372	13	TONTI	61	15.91	79	34.29	1	1.65	0.95	19.69
C	377	13	CAPTINA	46	5.47	72	39.82	6	1.72	1.42	5.66
C	378	13	NIXA	42	1.12	72	28.76	2	0.98	0.81	7.30
C	379	13	TONTI	42	1.72	72	34.29	2	1.55	0.54	26.23
C	386	13	CAPTINA	76	294.95	63	39.82	6	1.72	1.38	6.72
C	387	13	NIXA	72	140.55	63	28.76	2	0.98	0.92	5.20
C	388	13	TONTI	72	181.03	63	34.29	2	1.55	0.66	24.75
C	390	13	CAPTINA	56	9.95	67	39.82	6	1.71	1.19	9.92
C	391	13	NIXA	52	12.95	67	28.76	2	0.96	0.70	8.14
C	392	13	TONTI	53	16.04	67	34.29	3	1.24	0.19	27.75
C	399	13	CAPTINA	26	113.30	67	39.82	6	1.71	1.21	10.67
C	400	13	NIXA	22	40.22	67	28.76	2	0.96	0.70	8.22
C	401	13	TONTI	23	62.92	67	34.29	3	1.24	0.19	27.75
C	402	13	CAPTINA	36	8.27	67	39.82	6	1.71	1.14	12.53

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	403	13	NIXA	32	11.49	67	28.76	2	0.96	0.69	8.52
C	404	13	TONTI	33	9.27	67	34.29	3	1.24	0.18	28.19
C	406	14	CAPTINA	66	35.14	79	36.26	6	1.72	2.04	-6.95
C	407	14	NIXA	61	13.30	79	26.19	1	1.09	1.22	2.32
C	408	14	TONTI	61	20.92	79	31.23	1	1.65	0.94	19.63
C	413	14	CAPTINA	46	13.95	72	36.26	6	1.72	1.49	6.39
C	414	14	JAY	46	3.45	72	31.23	6	1.69	1.27	8.91
C	415	14	TONTI	42	3.02	72	31.23	2	1.59	0.57	25.78
C	422	14	CAPTINA	76	86.22	63	36.26	6	1.72	1.18	13.88
C	423	14	NIXA	72	90.79	63	26.19	2	0.98	0.80	8.16
C	424	14	TONTI	73	145.10	63	31.23	3	1.38	0.32	27.68
C	425	14	CAPTINA	56	55.80	67	36.26	6	1.71	1.00	18.11
C	426	14	TONTI	53	51.65	67	31.23	3	1.24	0.16	29.68
C	437	14	CAPTINA	26	9.56	67	36.26	6	1.71	1.14	14.64
C	438	14	NIXA	22	13.09	67	26.19	2	0.97	0.67	9.13
C	440	14	TONTI	23	39.04	67	31.23	3	1.24	0.18	28.87
C	441	14	CAPTINA	36	47.07	67	36.26	6	1.71	1.13	14.98
C	442	14	NIXA	32	33.76	67	26.19	2	0.97	0.67	9.16
C	443	14	TONTI	33	56.08	67	31.23	3	1.24	0.18	29.05
C	444	15	NIXA	61	27.32	79	38.01	1	1.12	1.37	3.19
C	445	15	TONTI	61	10.73	79	45.32	1	1.63	1.04	17.86
C	450	15	CAPTINA	46	1.84	72	52.63	6	1.71	1.32	9.23
C	451	15	NIXA	41	10.30	72	38.01	1	1.10	0.93	7.08
C	456	15	CAPTINA	76	42.44	63	52.63	6	1.71	1.75	-3.80
C	457	15	NIXA	71	96.90	63	38.01	1	1.10	0.99	5.62
C	458	15	TONTI	72	58.28	63	45.32	2	1.63	0.80	22.70
C	460	15	NIXA	52	69.15	67	38.01	2	1.02	0.82	7.72
C	468	15	NIXA	22	40.58	67	38.01	2	1.02	0.83	7.54
C	470	15	TONTI	23	43.15	67	45.32	3	1.26	0.30	26.74
C	472	15	CAPTINA	36	9.14	67	52.63	6	1.71	1.35	7.04
C	473	15	NIXA	32	16.27	67	38.01	2	1.02	0.82	7.72
C	476	16	NIXA	61	30.74	79	47.89	1	1.12	1.48	0.25
C	479	16	NIXA	41	17.11	72	47.89	1	1.10	1.04	5.29
C	480	16	TONTI	42	6.94	72	57.10	2	1.64	0.79	22.35
C	484	16	NIXA	71	77.60	63	47.89	1	1.10	0.97	6.71
C	486	16	NIXA	52	115.97	67	47.89	2	1.01	0.78	9.48
C	493	16	NIXA	22	16.95	67	47.89	2	1.01	0.83	8.52
C	495	16	NIXA	32	54.78	67	47.89	2	1.01	0.82	8.85
C	496	16	TONTI	33	18.91	67	57.10	3	1.26	0.29	27.01
C	497	17	CAPTINA	66	10.40	79	55.25	6	1.70	2.06	-21.65
C	498	17	NIXA	61	11.23	79	39.90	1	1.02	1.51	-0.51
C	499	17	TONTI	61	27.66	79	47.57	1	1.63	1.16	17.40
C	503	17	CAPTINA	42	3.52	72	55.25	2	1.60	1.72	-3.77
C	504	17	NIXA	41	6.75	72	39.90	1	1.00	1.05	2.83
C	505	17	TONTI	42	14.58	72	47.57	2	1.62	0.84	22.14
C	512	17	CAPTINA	76	28.80	63	55.25	6	1.70	1.61	-10.88

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygr	HRU	asin	Soil Type	OpAct	rea (ha)	urveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	513	17	NIXA	71	33.64	63	39.90	1	1.00	1.09	2.02
C	514	17	TONTI	72	51.04	63	47.57	2	1.62	0.85	21.85
C	515	17	CAPTINA	56	30.85	67	55.25	6	1.69	1.32	-1.61
C	516	17	NIXA	52	49.54	67	39.90	2	0.98	0.88	3.85
C	517	17	TONTI	52	78.15	67	47.57	2	1.61	0.58	25.38
C	521	17	CAPTINA	26	2.69	67	55.25	6	1.69	1.36	-1.16
C	522	17	NIXA	22	2.24	67	39.90	2	0.98	0.89	2.91
C	523	17	TONTI	22	5.49	67	47.57	2	1.61	0.61	24.14
C	525	17	CAPTINA	36	5.93	67	55.25	6	1.69	1.46	-5.10
C	526	17	NIXA	32	4.48	67	39.90	2	0.98	0.92	2.15
C	527	17	TONTI	32	20.14	67	47.57	2	1.61	0.65	23.43
C	529	18	CAPTINA	62	2.02	79	52.63	2	1.63	2.10	-10.01
C	530	18	NIXA	61	1.39	79	38.01	1	1.02	1.44	2.13
C	531	18	TONTI	61	5.11	79	45.32	1	1.63	1.16	19.11
C	537	18	CAPTINA	46	4.10	72	52.63	6	1.70	1.46	-2.12
C	538	18	TONTI	42	3.50	72	45.32	2	1.62	0.82	23.91
C	544	18	TONTI	72	13.45	63	45.32	2	1.62	0.88	22.55
C	547	18	CAPTINA	56	31.94	67	52.63	6	1.69	1.32	1.98
C	548	18	NIXA	52	13.08	67	38.01	2	0.98	0.92	4.40
C	549	18	TONTI	52	14.24	67	45.32	2	1.61	0.61	25.97
C	554	18	CAPTINA	26	1.04	67	52.63	6	1.69	1.20	9.01
C	555	18	NIXA	22	1.15	67	38.01	2	0.98	0.90	4.37
C	557	18	TONTI	22	1.39	67	45.32	2	1.61	0.55	26.41
C	558	18	CAPTINA	36	0.58	67	52.63	6	1.69	1.03	-6.53
C	559	18	NIXA	32	0.48	67	38.01	2	0.98	0.85	5.74
C	560	18	TONTI	33	0.48	67	45.32	3	1.26	0.18	28.03
C	561	19	NIXA	61	93.07	79	52.15	1	1.02	1.82	-4.74
C	565	19	CAPTINA	42	0.71	72	72.21	2	1.60	1.25	8.62
C	566	19	NIXA	41	3.12	72	52.15	1	1.00	1.16	1.38
C	570	19	NIXA	71	284.97	63	52.15	1	1.00	1.22	0.50
C	571	19	CAPTINA	56	23.53	67	72.21	6	1.69	1.74	-11.92
C	572	19	NIXA	52	16.05	67	52.15	2	0.98	1.04	1.38
C	573	19	TONTI	52	10.15	67	62.18	2	1.61	0.72	23.83
C	578	19	NIXA	22	22.49	67	52.15	2	0.98	1.09	-0.35
C	581	19	CAPTINA	36	4.76	67	72.21	6	1.69	1.69	-9.69
C	582	19	NIXA	32	7.55	67	52.15	2	0.98	1.06	0.59
C	584	20	NIXA	61	48.04	79	47.89	1	1.12	1.52	3.20
C	587	20	NIXA	41	13.88	72	47.89	1	1.10	1.08	6.98
C	588	20	TONTI	42	10.76	72	57.10	2	1.62	0.83	23.24
C	595	20	NIXA	71	70.90	63	47.89	1	1.10	1.13	5.74
C	597	20	TONTI	72	27.83	63	57.10	2	1.62	0.88	21.83
C	599	20	NIXA	51	61.95	67	47.89	1	1.08	0.89	7.82
C	600	20	TONTI	53	32.51	67	57.10	3	1.25	0.28	25.85
C	607	20	TONTI	23	17.01	67	57.10	3	1.25	0.28	26.02
C	609	20	NIXA	31	20.04	67	47.89	1	1.08	0.89	7.83
C	611	20	TONTI	33	14.27	67	57.10	3	1.25	0.27	26.10

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygr|	HRU	›asin	Soil Type	OpAct	.rea (ha)	ЭurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	655	22	JAY	62	11.21	79	18.16	2	1.57	1.45	4.94
C	661	22	CAPTINA	42	5.07	72	21.09	2	1.59	0.80	14.61
C	667	22	JAY	72	59.17	63	18.16	2	1.54	1.08	12.59
C	670	22	JAY	52	23.29	67	18.16	2	1.54	0.71	17.32
C	684	23	NIXA	61	5.34	79	36.17	1	1.03	1.51	1.03
C	685	23	TONTI	61	13.76	79	43.12	1	1.63	1.16	18.43
C	693	23	TONTI	42	1.01	72	43.12	2	1.61	0.65	25.72
C	704	23	TONTI	72	32.03	63	43.12	2	1.61	0.85	21.72
C	707	23	NIXA	52	39.13	67	36.17	2	0.99	0.90	4.28
C	708	23	TONTI	52	46.43	67	43.12	2	1.60	0.59	25.44
C	716	23	TONTI	22	22.33	67	43.12	2	1.60	0.64	23.74
C	717	23	NIXA	32	6.87	67	36.17	2	0.99	0.96	2.37
C	719	23	TONTI	32	5.24	67	43.12	2	1.60	0.61	24.39
C	721	24	CAPTINA	66	3.31	79	55.25	6	1.71	1.80	-11.08
C	723	24	NIXA	61	3.77	79	39.90	1	1.12	1.40	3.76
C	730	24	CAPTINA	46	1.40	72	55.25	6	1.70	1.19	7.27
C	731	24	NIXA	41	1.63	72	39.90	1	1.09	0.95	8.01
C	738	24	CAPTINA	76	14.55	63	55.25	6	1.70	1.63	-7.94
C	740	24	NIXA	71	11.28	63	39.90	1	1.09	1.10	4.88
C	742	24	CAPTINA	56	35.42	67	55.25	6	1.69	1.31	0.95
C	743	24	NIXA	51	39.74	67	39.90	1	1.07	0.87	7.22
C	754	24	CAPTINA	36	10.08	67	55.25	6	1.69	1.16	5.07
C	756	24	NIXA	31	5.09	67	39.90	1	1.07	0.81	8.73
C	757	24	TONTI	32	5.42	67	47.57	2	1.60	0.54	26.58
C	759	25	CAPTINA	66	22.92	79	52.63	6	1.71	2.04	-22.72
C	760	25	NIXA	61	19.30	79	38.01	1	1.02	1.53	-0.28
C	761	25	TONTI	61	49.58	79	45.32	1	1.63	1.16	18.02
C	767	25	CAPTINA	42	6.02	72	52.63	2	1.60	1.74	-3.95
C	768	25	NIXA	41	12.48	72	38.01	1	1.00	1.07	2.79
C	769	25	TONTI	41	6.24	72	45.32	1	1.61	0.73	22.73
C	775	25	CAPTINA	76	21.97	63	52.63	6	1.70	1.72	-15.39
C	776	25	NIXA	71	57.88	63	38.01	1	1.00	1.15	0.52
C	777	25	TONTI	72	78.09	63	45.32	2	1.62	0.87	20.58
C	780	25	CAPTINA	56	41.31	67	52.63	6	1.69	1.41	-5.55
C	781	25	NIXA	52	57.94	67	38.01	2	0.98	0.93	2.12
C	782	25	TONTI	52	40.86	67	45.32	2	1.61	0.62	23.86
C	790	25	NIXA	21	2.03	67	38.01	1	0.97	0.94	1.50
C	791	25	TONTI	22	2.43	67	45.32	2	1.61	0.59	23.76
C	793	25	CAPTINA	36	21.61	67	52.63	6	1.69	1.65	-12.35
C	794	25	NIXA	31	9.45	67	38.01	1	0.97	1.00	-0.03
C	795	25	TONTI	32	11.73	67	45.32	2	1.61	0.66	22.40
C	797	26	CAPTINA	66	52.77	79	53.93	6	1.71	1.98	-16.92
C	798	26	NIXA	61	23.55	79	38.95	1	1.12	1.46	3.20
C	799	26	TONTI	61	38.49	79	46.44	1	1.63	1.14	18.10

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	804	26	CAPTINA	46	3.36	72	53.93	6	1.70	1.30	2.18
C	805	26	NIXA	41	2.28	72	38.95	1	1.09	0.97	7.93
C	806	26	TONTI	42	8.78	72	46.44	2	1.62	0.79	23.35
C	812	26	CAPTINA	76	55.10	63	53.93	6	1.70	1.63	-8.21
C	813	26	NIXA	71	49.52	63	38.95	1	1.09	1.11	4.92
C	814	26	TONTI	72	40.83	63	46.44	2	1.62	0.87	21.33
C	816	26	CAPTINA	56	59.07	67	53.93	6	1.69	1.31	0.99
C	817	26	NIXA	51	31.70	67	38.95	1	1.07	0.88	7.28
C	818	26	TONTI	52	28.98	67	46.44	2	1.60	0.60	25.23
C	825	26	CAPTINA	26	5.47	67	53.93	6	1.69	1.33	1.29
C	826	26	NIXA	21	8.91	67	38.95	1	1.07	0.91	6.60
C	830	26	CAPTINA	36	11.74	67	53.93	6	1.69	1.39	-0.93
C	831	26	NIXA	31	11.60	67	38.95	1	1.07	0.92	6.47
C	832	26	TONTI	32	5.88	67	46.44	2	1.60	0.60	25.08
C	835	27	CAPTINA	66	0.64	79	62.09	6	1.71	1.95	-7.44
C	836	27	NIXA	61	1.28	79	44.85	1	1.11	1.60	-1.21
C	840	27	CAPTINA	46	0.59	72	62.09	6	1.70	1.38	-18.00
C	850	27	NIXA	71	2.13	63	44.85	1	1.09	1.13	3.84
C	853	27	CAPTINA	56	5.93	67	62.09	6	1.69	1.50	-0.56
C	854	27	NIXA	51	7.54	67	44.85	1	1.04	0.94	4.62
C	860	27	CAPTINA	26	3.18	67	62.09	6	1.69	1.41	1.97
C	861	27	NIXA	21	2.47	67	44.85	1	1.04	0.89	5.60
C	863	27	NIXA	31	3.71	67	44.85	1	1.04	0.92	5.23
C	866	28	CAPTINA	66	9.00	79	56.58	6	1.71	2.47	-29.01
C	867	28	NIXA	61	2.54	79	40.86	1	1.11	1.59	-1.07
C	869	28	TONTI	61	3.81	79	48.72	1	1.63	1.21	15.10
C	872	28	CAPTINA	46	10.71	72	56.58	6	1.70	1.86	-12.39
C	873	28	NIXA	41	4.21	72	40.86	1	1.09	1.16	3.10
C	874	28	TONTI	42	5.18	72	48.72	2	1.62	0.84	20.72
C	881	28	CAPTINA	76	11.38	63	56.58	6	1.70	1.84	-11.76
C	882	28	NIXA	71	14.75	63	40.86	1	1.09	1.19	2.52
C	883	28	TONTI	72	8.53	63	48.72	2	1.62	0.86	20.52
C	885	28	CAPTINA	56	72.31	67	56.58	6	1.69	1.50	-2.50
C	886	28	NIXA	51	30.16	67	40.86	1	1.04	0.95	4.33
C	887	28	TONTI	52	46.38	67	48.72	2	1.60	0.63	24.08
C	894	28	CAPTINA	26	1.63	67	56.58	6	1.69	1.31	3.44
C	895	28	NIXA	21	4.56	67	40.86	1	1.04	0.94	4.39
C	897	28	CAPTINA	36	13.86	67	56.58	6	1.69	1.59	-4.77
C	898	28	NIXA	31	37.71	67	40.86	1	1.04	0.98	3.55
C	899	28	TONTI	32	26.57	67	48.72	2	1.60	0.65	23.44
C	937	30	CAPTINA	61	3.88	79	51.35	1	1.53	2.37	-7.13
C	996	32	TONTI	60	4.33	79	30.09	0	1.48	1.14	13.22
C	1011	32	TONTI	70	16.99	63	30.09	0	1.48	0.97	11.21
C	1015	32	TONTI	25	0.29	67	30.09	5	1.49	0.39	-477.79
C	1016	33	CAPTINA	61	34.31	79	39.19	1	1.56	2.60	-21.35

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	1017	33	NIXA	60	34.43	79	28.31	0	0.94	1.31	-3.69
C	1018	33	TONTI	60	14.64	79	33.75	0	1.48	1.16	17.87
C	1022	33	CAPTINA	41	8.75	72	39.19	1	1.55	1.74	-6.23
C	1023	33	NIXA	41	11.31	72	28.31	1	0.99	1.04	-0.64
C	1024	33	TONTI	41	6.51	72	33.75	1	1.62	0.70	21.14
C	1032	33	CAPTINA	71	181.03	63	39.19	1	1.55	1.60	-7.51
C	1033	33	NIXA	71	116.69	63	28.31	1	0.99	1.07	-2.17
C	1034	33	TONTI	71	59.66	63	33.75	1	1.62	0.75	19.49
C	1035	33	CAPTINA	51	115.78	67	39.19	1	1.53	1.39	-4.99
C	1036	33	NIXA	51	75.98	67	28.31	1	0.94	0.87	-1.09
C	1041	33	CAPTINA	22	19.42	67	39.19	2	1.56	1.68	-23.08
C	1042	33	NIXA	21	10.75	67	28.31	1	0.94	0.98	-4.06
C	1045	33	CAPTINA	32	17.09	67	39.19	2	1.56	1.66	-22.69
C	1047	34	CAPTINA	66	17.15	79	43.83	6	1.71	2.14	-21.44
C	1048	34	NIXA	61	8.16	79	31.65	1	1.11	1.54	0.15
C	1053	34	NIXA	41	1.49	72	31.65	1	1.09	1.03	5.58
C	1060	34	NIXA	71	13.66	63	31.65	1	1.09	1.10	4.31
C	1063	34	CAPTINA	56	37.06	67	43.83	6	1.69	1.29	1.34
C	1065	34	NIXA	51	30.12	67	31.65	1	1.04	0.88	5.75
C	1070	34	NIXA	25	0.65	67	31.65	5	1.11	0.61	-2.26
C	1073	34	CAPTINA	36	17.37	67	43.83	6	1.69	1.42	-1.60
C	1120	37	NIXA	61	9.69	79	50.00	1	1.12	1.45	3.47
C	1125	37	NIXA	41	5.83	72	50.00	1	1.10	1.02	7.19
C	1136	37	NIXA	71	11.69	63	50.00	1	1.10	1.16	3.98
C	1140	37	NIXA	51	33.87	67	50.00	1	1.08	0.92	6.21
C	1146	37	NIXA	21	13.08	67	50.00	1	1.08	0.92	6.15
C	1151	37	NIXA	31	16.90	67	50.00	1	1.08	0.93	6.07
C	1154	38	NIXA	61	21.64	79	53.96	1	1.13	1.40	3.22
C	1160	38	NIXA	42	15.19	72	53.96	2	1.03	1.04	7.33
C	1169	38	NIXA	72	62.21	63	53.96	2	1.03	1.08	6.11
C	1171	38	NIXA	52	60.88	67	53.96	2	1.02	0.83	9.40
C	1179	38	NIXA	22	21.67	67	53.96	2	1.02	0.81	10.07
C	1183	38	NIXA	32	18.81	67	53.96	2	1.02	0.81	10.11
C	1186	39	CAPTINA	62	1.67	79	40.13	2	1.62	1.60	-3.74
C	1187	39	NIXA	61	0.88	79	28.99	1	1.13	1.25	4.10
C	1193	39	CAPTINA	42	2.53	72	40.13	2	1.60	1.27	3.62
C	1194	39	NIXA	41	2.43	72	28.99	1	1.10	0.93	5.74
C	1200	39	CAPTINA	72	3.36	63	40.13	2	1.60	1.84	-17.22
C	1204	39	CAPTINA	52	3.70	67	40.13	2	1.57	1.41	-7.24
C	1205	39	NIXA	51	2.32	67	28.99	1	1.09	0.84	3.97
C	1208	39	NIXA	26	0.41	67	28.99	6	1.28	1.11	-18.33
C	1212	39	CAPTINA	35	0.86	67	40.13	5	1.55	2.53	-37.09
C	1213	39	NIXA	36	0.29	67	28.99	6	1.28	1.10	-80.86
C	1214	39	TONTI	33	0.57	67	34.56	3	1.29	0.85	21.00
C	1215	40	CAPTINA	66	18.31	79	59.28	6	1.71	2.13	-33.66
C	1216	40	NIXA	61	52.20	79	42.82	1	1.13	1.41	-0.64

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	1219	40	CAPTINA	46	13.01	72	59.28	6	1.70	1.50	-17.37
C	1220	40	NIXA	41	28.96	72	42.82	1	1.11	0.99	3.52
C	1228	40	CAPTINA	76	35.21	63	59.28	6	1.70	1.48	-16.93
C	1229	40	NIXA	71	180.20	63	42.82	1	1.11	0.91	5.22
C	1230	40	CAPTINA	56	126.06	67	59.28	6	1.70	1.09	-6.23
C	1231	40	NIXA	51	243.70	67	42.82	1	1.09	0.69	7.61
C	1238	40	NIXA	21	91.95	67	42.82	1	1.09	0.78	5.44
C	1241	40	NIXA	31	144.79	67	42.82	1	1.09	0.76	5.92
C	1280	44	NIXA	61	36.27	79	46.86	1	1.10	1.53	-8.55
C	1281	44	TONTI	61	9.63	79	55.87	1	1.65	1.22	9.47
C	1285	44	NIXA	41	20.63	72	46.86	1	1.08	1.08	-3.51
C	1290	44	CAPTINA	76	28.55	63	64.88	6	1.72	2.49	-39.19
C	1291	44	NIXA	71	124.37	63	46.86	1	1.08	1.04	-2.90
C	1292	44	TONTI	71	76.29	63	55.87	1	1.63	0.77	15.61
C	1294	44	NIXA	51	164.59	67	46.86	1	1.08	0.80	-0.55
C	1298	44	CAPTINA	26	22.63	67	64.88	6	1.71	2.03	-29.98
C	1299	44	NIXA	21	45.01	67	46.86	1	1.08	0.85	-1.57
C	1300	44	TONTI	21	71.30	67	55.87	1	1.62	0.55	18.60
C	1302	44	NIXA	31	139.96	67	46.86	1	1.08	0.82	-1.18
C	1303	44	TONTI	31	43.10	67	55.87	1	1.62	0.55	18.55
C	1305	45	TONTI	60	24.78	79	38.51	0	1.49	1.44	6.98
C	1312	45	TONTI	70	1.78	63	38.51	0	1.48	0.76	12.87
C	1315	46	NIXA	61	28.05	79	58.89	1	1.12	1.61	-6.48
C	1321	46	CAPTINA	46	4.61	72	81.54	6	1.70	2.08	-24.76
C	1322	46	NIXA	41	3.59	72	58.89	1	1.09	1.05	0.31
C	1329	46	NIXA	71	65.32	63	58.89	1	1.09	1.15	-2.54
C	1331	46	NIXA	51	43.27	67	58.89	1	1.09	0.91	0.13
C	1332	46	TONTI	52	7.63	67	70.22	2	1.60	0.67	18.69
C	1340	46	NIXA	21	23.74	67	58.89	1	1.09	0.90	0.45
C	1343	46	NIXA	31	60.14	67	58.89	1	1.09	0.90	0.34
C	1344	46	TONTI	32	15.41	67	70.22	2	1.60	0.69	18.19
C	1438	53	CAPTINA	61	5.88	79	34.94	1	1.56	1.79	-5.34
C	1443	53	CAPTINA	41	3.03	72	34.94	1	1.55	1.20	6.30
C	1444	53	NIXA	41	1.62	72	25.24	1	1.10	0.86	6.43
C	1455	53	CAPTINA	52	31.00	67	34.94	2	1.57	1.23	2.36
C	1457	53	NIXA	51	9.03	67	25.24	1	1.09	0.75	5.90
C	1464	53	CAPTINA	22	5.54	67	34.94	2	1.57	1.14	2.74
C	1466	53	TONTI	21	3.99	67	30.09	1	1.47	1.07	6.94
C	1467	53	CAPTINA	32	11.78	67	34.94	2	1.57	1.24	0.75
C	1468	53	NIXA	31	4.23	67	25.24	1	1.09	0.75	5.51
C	1470	54	CAPTINA	66	62.87	79	46.08	6	1.72	1.87	-13.73
C	1471	54	NIXA	61	49.40	79	33.28	1	1.11	1.31	2.73
C	1472	54	TONTI	61	42.76	79	39.68	1	1.63	1.02	19.95
C	1476	54	CAPTINA	46	23.01	72	46.08	6	1.72	1.43	-0.93
C	1477	54	TONTI	41	20.87	72	39.68	1	1.61	0.64	23.74
C	1485	54	CAPTINA	76	263.43	63	46.08	6	1.72	1.34	2.11
C	1486	54	NIXA	71	178.11	63	33.28	1	1.07	0.94	5.40

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	1487	54	TONTI	71	108.55	63	39.68	1	1.61	0.65	23.06
C	1488	54	CAPTINA	56	218.04	67	46.08	6	1.71	1.09	7.92
C	1489	54	NIXA	51	113.20	67	33.28	1	1.05	0.75	6.55
C	1490	54	TONTI	52	185.08	67	39.68	2	1.60	0.39	26.07
C	1497	54	CAPTINA	26	34.48	67	46.08	6	1.71	1.25	3.10
C	1498	54	NIXA	21	83.58	67	33.28	1	1.05	0.77	6.10
C	1499	54	CAPTINA	36	102.40	67	46.08	6	1.71	1.23	3.74
C	1500	54	NIXA	31	53.30	67	33.28	1	1.05	0.78	6.03
C	1501	54	TONTI	32	105.19	67	39.68	2	1.60	0.42	25.40
C	1517	57	NIXA	61	1.54	79	35.50	1	1.14	1.20	7.90
C	1529	57	CAPTINA	52	6.48	67	49.15	2	1.52	1.41	6.86
C	1530	57	TONTI	51	3.58	67	42.33	1	1.47	1.03	11.72
C	1540	58	CAPTINA	61	8.72	79	44.90	1	1.55	2.59	-22.05
C	1541	58	NIXA	61	7.43	79	32.43	1	1.11	1.34	-0.59
C	1542	58	TONTI	60	9.81	79	38.66	0	1.44	1.15	16.96
C	1548	58	CAPTINA	42	2.04	72	44.90	2	1.57	1.26	-0.54
C	1549	58	TONTI	41	2.91	72	38.66	1	1.46	1.23	3.71
C	1550	58	TONTI	41	2.69	72	38.66	1	1.61	0.61	21.35
C	1554	58	CAPTINA	72	19.97	63	44.90	2	1.57	1.92	-11.85
C	1556	58	TONTI	71	36.11	63	38.66	1	1.61	0.67	20.07
C	1558	58	CAPTINA	52	41.54	67	44.90	2	1.52	1.54	-4.16
C	1559	58	TONTI	51	69.68	67	38.66	1	1.60	0.47	22.27
C	1566	58	CAPTINA	22	17.48	67	44.90	2	1.52	1.78	-13.55
C	1568	58	CAPTINA	32	25.95	67	44.90	2	1.52	1.82	-14.38
C	1569	58	TONTI	31	54.65	67	38.66	1	1.60	0.51	20.37
C	1615	60	CAPTINA	71	23.62	63	44.87	1	1.53	1.96	-6.32
C	1710	63	JAY	52	35.82	67	23.30	2	1.54	0.84	14.21
C	1719	63	CAPTINA	22	11.95	67	27.06	2	1.57	0.77	13.38
C	1727	64	CAPTINA	61	5.70	79	37.01	1	1.58	1.54	4.00
C	1735	64	CAPTINA	41	1.77	72	37.01	1	1.57	0.87	13.41
C	1745	64	CAPTINA	71	24.24	63	37.01	1	1.57	1.36	-1.30
C	1750	64	CAPTINA	51	8.55	67	37.01	1	1.56	1.00	5.57
C	1764	64	CAPTINA	31	8.24	67	37.01	1	1.56	1.12	0.65
C	1862	67	JAY	52	54.03	67	30.05	2	1.53	1.04	-0.34
C	1870	67	CAPTINA	22	24.58	67	34.90	2	1.56	1.26	-5.92
C	1876	67	JAY	31	1.66	67	30.05	1	1.53	1.21	6.14
C	1936	70	CAPTINA	41	10.98	72	73.38	1	1.57	2.35	-11.41
C	1937	70	TONTI	41	3.14	72	63.18	1	1.48	1.64	4.65
C	1938	70	JAY	41	2.29	72	63.18	1	1.53	2.20	-4.20
C	1947	70	CAPTINA	51	11.10	67	73.38	1	1.56	2.34	-20.61
C	1949	70	JAY	51	11.35	67	63.18	1	1.53	2.56	-20.92
C	1958	70	JAY	30	0.09	67	63.18	0	1.35	0.23	-5099.39
C	1969	71	CAPTINA	72	49.79	63	31.60	2	1.59	1.70	-2.81
C	1990	71	JAY	32	6.52	67	27.21	2	1.54	1.08	6.15
C	1993	72	CAPTINA	61	33.22	79	27.98	1	1.56	1.64	1.19

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygr	HRU	basin	Soil Type	OpAct	rea (ha)	urveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
C	2000	72	CAPTINA	41	23.83	72	27.98	1	1.54	1.13	8.89
C	2001	72	TONTI	41	8.85	72	24.10	1	1.46	0.93	12.69
C	2010	72	CAPTINA	71	94.60	63	27.98	1	1.54	1.09	8.65
C	2013	72	CAPTINA	52	145.04	67	27.98	2	1.51	0.87	15.28
C	2022	72	CAPTINA	22	60.41	67	27.98	2	1.51	1.27	6.95
C	2025	72	CAPTINA	32	88.93	67	27.98	2	1.51	1.19	8.27
C	2026	72	TONTI	31	37.14	67	24.10	1	1.45	0.98	8.13
C	2028	72	JAY	32	38.28	67	24.10	2	1.45	1.05	9.22
C	2029	72	TONTI	31	41.58	67	24.10	1	1.61	0.46	24.53
C	2038	73	CAPTINA	41	1.15	72	72.39	1	1.52	1.91	2.24
C	2039	73	TONTI	42	0.86	72	62.33	2	1.38	1.20	4.41
C	2051	73	TONTI	51	2.33	67	62.33	1	1.43	1.75	-1.18
C	2059	73	TONTI	35	0.19	67	62.33	5	1.42	0.87	-1726.36
C	2082	75	TONTI	60	18.36	79	36.91	0	1.49	1.41	7.33
C	2096	75	TONTI	70	26.08	63	36.91	0	1.48	1.11	7.28
C	2116	77	CAPTINA	61	3.81	79	25.62	1	1.56	1.55	4.99
C	2143	77	JAY	21	3.31	67	22.06	1	1.50	1.12	9.49
C	2171	79	CAPTINA	62	6.70	79	41.03	2	1.62	2.13	-11.34
C	2172	79	NIXA	61	6.70	79	29.63	1	1.11	1.41	3.09
C	2180	79	CAPTINA	45	0.47	72	41.03	5	1.55	0.58	-84.90
C	2181	79	NIXA	42	0.96	72	29.63	2	1.03	0.95	5.69
C	2187	79	CAPTINA	76	7.16	63	41.03	6	1.70	1.54	-5.34
C	2190	79	CAPTINA	56	8.15	67	41.03	6	1.69	1.25	2.37
C	2195	79	CAPTINA	26	0.20	67	41.03	6	1.69	0.81	-1844.48
C	2202	80	NIXA	61	3.09	79	28.99	1	1.13	1.29	3.27
C	2207	80	CAPTINA	41	0.64	72	40.13	1	1.55	0.83	15.41
C	2209	80	NIXA	41	0.64	72	28.99	1	1.10	0.85	6.75
C	2232	80	NIXA	25	0.49	67	28.99	5	1.12	2.21	-14.12
C	2245	81	TONTI	45	0.54	72	29.16	5	1.44	0.76	-28.63
C	2326	85	TONTI	60	15.12	79	33.04	0	1.50	1.18	10.73
C	2337	85	TONTI	70	9.14	63	33.04	0	1.49	0.86	11.16
C	2343	85	TONTI	25	0.86	67	33.04	5	1.49	1.11	-25.19
C	2411	90	JAY	72	22.24	63	27.51	2	1.59	0.99	3.89
C	2416	90	TONTI	21	2.17	67	27.51	1	1.56	0.81	15.52
D	2	1	STIGLER	62	49.09	82	31.71	2	1.75	0.71	15.84
D	4	1	TALOKA	60	27.70	82	31.71	0	1.54	2.18	10.18
D	9	1	TALOKA	40	58.60	77	31.71	0	1.53	1.62	12.13
D	21	1	TALOKA	51	60.87	73	31.71	1	1.56	1.20	10.82
D	35	1	TALOKA	31	6.68	73	31.71	1	1.56	1.17	11.33
D	39	2	STIGLER	62	13.53	82	29.53	2	1.73	0.75	15.20
D	48	2	STIGLER	42	23.08	77	29.53	2	1.72	0.57	19.45
D	55	2	STIGLER	72	73.99	70	29.53	2	1.72	0.61	17.34
D	59	2	STIGLER	52	26.82	73	29.53	2	1.71	0.50	20.65
D	61	2	TALOKA	51	27.17	73	29.53	1	1.55	1.17	10.93
D	79	3	STIGLER	61	46.86	82	64.36	1	1.66	1.45	1.16
D	86	3	STIGLER	42	3.27	77	64.36	2	1.72	0.80	13.31

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	basin	Soil Type	OpAct	rea (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
D	105	3	STIGLER	25	6.55	73	64.36	5	1.66	1.13	3.04
D	146	5	TALOKA	60	48.35	82	26.40	0	1.47	2.46	9.10
D	166	5	TALOKA	71	117.32	70	26.40	1	1.62	1.56	7.73
D	213	8	TALOKA	60	38.30	82	19.60	0	1.48	1.51	18.62
D	218	8	TALOKA	41	3.20	77	19.60	1	1.61	0.94	20.19
D	227	8	TALOKA	71	40.12	70	19.60	1	1.61	1.06	16.31
D	231	8	TALOKA	51	106.36	73	19.60	1	1.60	0.81	19.90
D	238	8	STIGLER	22	8.49	73	19.60	2	1.70	0.35	26.38
D	239	8	TALOKA	21	14.43	73	19.60	1	1.60	0.84	19.15
D	242	8	CARYTOWN	22	9.58	73	17.64	2	1.39	0.69	17.52
D	243	8	TALOKA	31	58.08	73	19.60	1	1.60	0.83	19.43
D	255	9	TALOKA	41	2.59	77	25.54	1	1.62	1.21	16.59
D	267	9	CARYTOWN	71	53.89	70	22.99	1	1.50	1.69	2.14
D	269	9	TALOKA	51	32.65	73	25.54	1	1.60	1.17	12.86
D	277	9	TALOKA	21	12.91	73	25.54	1	1.60	1.14	13.87
D	280	9	CARYTOWN	22	10.86	73	22.99	2	1.42	1.14	8.62
D	282	9	TALOKA	31	20.81	73	25.54	1	1.60	1.15	13.53
D	284	10	TALOKA	60	13.98	82	26.60	0	1.46	2.21	13.27
D	294	10	OUNTAINBURG	43	0.67	77	9.31	3	0.00	0.26	-32.23
D	302	10	TALOKA	71	94.18	70	26.60	1	1.62	1.39	9.61
D	306	10	TALOKA	51	26.46	73	26.60	1	1.60	1.19	11.47
D	308	10	CARYTOWN	52	39.42	73	23.94	2	1.42	1.27	4.69
D	318	10	TALOKA	31	9.23	73	26.60	1	1.60	1.14	13.25
D	321	10	CARYTOWN	32	13.54	73	23.94	2	1.42	1.21	6.67
D	829	26	CHEROKEE	22	7.49	73	53.93	2	1.45	3.44	-38.69
D	910	29	STIGLER	45	3.33	77	61.39	5	1.66	0.95	11.96
D	938	30	STIGLER	65	4.32	82	57.05	5	1.67	1.18	8.49
D	945	30	STIGLER	45	6.80	77	57.05	5	1.66	0.97	13.27
D	957	30	STIGLER	55	11.56	73	57.05	5	1.65	1.00	12.72
D	1046	33	TALOKA	31	36.15	73	43.55	1	1.60	1.82	-13.94
D	1180	38	CHEROKEE	26	10.96	73	74.71	6	1.64	2.57	-41.74
D	1390	49	TALOKA	70	5.03	70	119.70	0	1.55	4.33	0.10
D	1456	53	TALOKA	51	8.16	73	38.82	1	1.60	1.37	3.36
D	1465	53	STIGLER	25	6.56	73	38.82	5	1.64	2.06	10.32
D	1601	60	HECTOR	60	6.20	82	17.45	0	0.00	8.95	-35.98
D	1646	61	TALOKA	21	5.25	73	48.65	1	1.56	1.71	-11.66
D	1688	63	TALOKA	60	65.74	82	30.07	0	1.54	2.12	9.44
D	1706	63	TALOKA	71	53.40	70	30.07	1	1.57	1.46	8.53
D	1720	63	TALOKA	21	10.33	73	30.07	1	1.56	1.19	11.87
D	1724	63	TALOKA	31	9.78	73	30.07	1	1.56	1.19	11.95
D	1736	64	STIGLER	42	0.88	77	41.13	2	1.73	0.37	23.15
D	1746	64	STIGLER	72	26.60	70	41.13	2	1.73	0.65	7.70
D	1762	64	STIGLER	22	3.11	73	41.13	2	1.72	0.49	11.88
D	1765	64	STIGLER	32	10.83	73	41.13	2	1.72	0.55	8.56
D	1771	65	STIGLER	62	6.29	82	38.82	2	1.73	0.83	6.61
D	1781	65	STIGLER	42	8.53	77	38.82	2	1.71	0.67	11.66
D	1816	66	STIGLER	42	1.16	77	46.60	2	1.73	0.45	18.15

Appendix 5. Continued

Annual Average Ploss (Kg) 35000

Hygrp	HRU	Subbasin	Soil Type	OpAct	Area (ha)	CurveNo	RKLS	Qlitter Kg/ha	Yld ton/ha	Ploss Kg/ha	Rent/Ha $/ha
D	1859	67	TALOKA	71	309.60	70	38.77	1	1.64	1.70	-0.02
D	1861	67	TALOKA	51	30.96	73	38.77	1	1.63	1.58	-0.56
D	1872	67	TALOKA	21	21.84	73	38.77	1	1.63	1.64	-3.78
D	1994	72	TALOKA	60	33.38	82	31.09	0	1.44	2.58	7.20
D	2011	72	TALOKA	71	219.12	70	31.09	1	1.62	1.15	15.68
D	2015	72	TALOKA	51	99.37	73	31.09	1	1.61	1.06	14.67
D	2023	72	TALOKA	21	168.74	73	31.09	1	1.61	1.04	13.81
D	2027	72	TALOKA	31	35.90	73	31.09	1	1.61	1.23	9.26
D	2182	79	CHEROKEE	42	1.05	77	41.03	2	1.47	1.75	-0.46
D	2257	81	STIGLER	53	24.00	73	37.62	3	1.36	0.74	16.81
D	2258	81	TALOKA	51	15.46	73	37.62	1	1.56	1.31	7.47
D	2272	81	STIGLER	33	1.87	73	37.62	3	1.36	0.68	19.33

APPENDIX 6 - Source years for Weather Data

Years Sampled for Weather Data			
Weather set	Year	Weather set	Year
1	1967	4	1952
	1957		1984
	1992		1950
	1965		2003
	1982		1955
	1996		1954
	1997		1964
	1990		1954
	1981		1998
2	1961		1958
	1973	5	2000
	1985		2001
	1950		1994
	1977		2002
	1953		1971
	1980		1979
	1976		1986
	1963		1978
	1962		1995
3	1951		1991
	1959	6	1989
	1974		1960
	1975		1952
	1953		1956
	1966		1968
	2004		1951
	1983		1987
	1970		1988
	1972		1999
4	1969		1993

VITA

Stella Moraa Machooka

Candidate for the Degree of

Master of Science

Thesis: STOCHASTIC RISK ASSESSMENT FOR LAKE EUCHA SPAVINAW WATERSHED

Major Field: Environmental Science

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Graduated from Mbooni girls High school in 1995; received a bachelors degree in environmental studies from Kenyatta University, Nairobi, Kenya in October of 2000; Completed the requirements for the degree of master of science with a major in environmental science at Oklahoma State University, Stillwater U.S.A. April of 2007.

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Name: Stella Machooka Date of Degree: April, 2007

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: STOCHASTIC RISK ASSESSMENT FOR LAKE EUCHA SPAVINAW WATERSHED

Pages in study: 119 Candidate for the Degree of Master of Science

Major Field: Environmental Science

Scope and Methodology of Study:

This study tests the feasibility of developing a risk programming (optimization) model directly from the outputs of a biophysical simulation model to determine the most efficient locations for non-point source abatement in a watershed. The SWAT (Soil Water Assessment Tool) simulation model with 60 years of weather data is used to estimate biomass consumption by cattle and phosphorus runoff from seven levels of litter application. Then a Target MOTAD model with 60 years of phosphorus runoff was used to determine the cost and the management practices that should be used in each area of the watershed so average Phosphorus loadings and the deviations of these loading above alternative phosphorus loss targets (possible TMDLs) are met. The ability to put a limit on deviations above a pollution target provides an estimate of the costs associated with the margin of safety associated with setting a TMDL in a watershed.

Findings and Conclusions:

The feasibility of developing a Target MOTAD optimization model, directly from outputs of a simulation model developed and calibrated by hydrologists that could determine the most efficient management practices, under stochastic conditions for each sub area within a watershed is demonstrated. The cost of reducing phosphorus runoff varies significantly between soil types. It is found that for some soils zero litter applications (no fertilizer) actually increases phosphorus loss through erosion of soil sediments. It is optimal to apply more litter to some soils than to others which implies that policies based on non uniform limitations are the most cost effective. The cost of reducing phosphorus runoff from the watershed increased rapidly as attempts were made to reduce annual loadings by more than 15 Mg per year.

Adviser’s Approval: Dr. Arthur Stoecker