DRAINAGE IMPROVEMENT BENEFIT ASSESSMENT METHODS AND
SUBSURFACE DRAINAGE PRACTICES IN OHIO

A Thesis
Presented in Partial Fulfillment of the Requirements for
the Degree Master of Science in the
Graduate School of The Ohio State University

* * * * *

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ABSTRACT

Mail surveys were conducted to investigate group drainage activity and assessment methods used in Ohio, and characteristics and practices of Ohio subsurface drainage contractors. A computer program was developed to evaluate drain spacings for 53 Ohio soils using steady-state equations.

Agencies in 37 counties reported the construction of 342 new group drainage improvements costing over $9.5 million from 1994 to 1996, including 192.4 miles (309.6 km) of open ditches benefiting 144,127 ac (58,276 ha) of land. Total 1996 maintenance expenditures of $2,810,437.03 were reported for 47 county ditch maintenance programs which benefit an estimated 3.1 million acres (1.25 million ha) of land. Seventeen formulae are used by Ohio county engineers and SWCDs to distribute the costs of group drainage projects among the benefiting parcels of land. Agencies in general do not determine benefits when making assessment calculations.

A FORTRAN computer program was written to calculate drain spacing values for 53 Ohio soils using steady-state drain spacing equations, and the permeability values found in the Soil Interpretation Record (SIR) of the State Soil Survey Database. Proper estimation of the saturated hydraulic conductivity, especially below drain depth, is relatively more important than the correct estimation of the depth to the restrictive layer or the design drainage rate when using these steady-state drain spacing equations.
Fifty-nine mainline and 34 sideline Ohio contractors installed nearly 90 million feet of drain pipe from 1995 through 1997, with the mainline contractors responsible for 89% of the total. The amount of drain pipe installed increased each year. Drain pipe is typically installed from 30 to 36 in deep. Drain spacings range from 18 ft to 100 ft and are typically installed at spacings greater than spacings calculated using the Hooghoudt equation with permeability data from the SIR records. Drainage contractors make little use of soil surveys, the Ohio Drainage Guide, or hydraulic conductivity tests when designing a subsurface drainage system, relying primarily on experience and a topographic map.
Dedicated to my father

ACKNOWLEDGMENTS

I first wish to express my appreciation and admiration for my wife, Rosemary, who, while whole-heartedly supporting me in this endeavor, realized a life-long dream by completing her own bachelor's degree.

I thank my advisor, Larry C. Brown, for providing the opportunity to work on these projects, and the intellectual support and encouragement for this research.

I am extremely grateful to the personnel in the county engineers’ offices and soil and water conservation districts, and the drainage contractors who used some of their valuable time to complete the surveys and provide the information contained in this thesis. It was rewarding to receive many supportive and encouraging comments from these people during the course of this work.

Sarah Roby Huffman was instrumental in entering the data from these studies into computer databases, and also prepared the appendices to this thesis. Thank you, Sarah.

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CHAPTER 1

INTRODUCTION

Much of the northwest Ohio was not occupied by humans until it was drained in the nineteenth century, and a large area was known as the Great Black Swamp. Travelers in the early 1800s reported that the area east of Fort Wayne, Indiana, contained few areas that could be settled because of wet conditions, and that there were immense swarms of mosquitoes and horse flies that bothered the animals as well as humans (Wooten and Jones, 1955). In order to facilitate conversion of the land to farmland in these areas, the federal government, through the Swamp Land Acts of 1849, 1850 and 1860, transferred about 64 million acres of swamp and overflow land to 15 states (Wooten and Jones, 1955). The period of time following these grants saw tremendous investment and progress in agricultural drainage.

The expansion of agricultural drainage was often enhanced by the cooperation of groups of landowners having a common interest in the removal of excess water. Individual landowners often had problems removing excess water because of insufficient outlets downstream (Sandretto, 1987). However, cooperative efforts, especially in larger projects, had limitations. In addition to the inherent weaknesses of groups to achieve a common goal, they did not possess the power to compel all landowners who benefited from the project to pay their fair share of the costs, nor could they compel an
uncooperative landowner to allow construction across his property. A third limitation was that often a project was not properly maintained following its construction. This led to legislation giving public officials or authorized public organizations (drainage districts) certain powers to overcome these difficulties.

Ohio's first drainage laws were passed in 1841 (Frost and Nichols, 1985). These first laws were followed in 1859 by drainage laws (58 Ohio Laws 491, cited in Frost and Nichols, 1985) which provided for a system of public ditches, with the legal authority vested in the boards of county commissioners. Following a petition by one or more landowners, and subsequent hearings, the commissioners could authorize the construction of a drainage ditch, which was paid for by special assessment on the benefiting land (Frost and Nichols, 1985). One of the first large cooperative efforts was the "Jackson Cut Off" in Wood County. This project drained 30,000 acres in the upper Portage River watershed and diverted the water to the Maumee River at a cost of $110,000 in 1879 (Frost and Nichols, 1985). By 1884, it was reported by the Ohio Society of Engineers and Surveyors that 20,000 miles of public ditches benefiting over 11 million acres of land had been constructed (Wooten and Jones, 1955).

The special assessments through which these multi-landowner, or group, drainage projects are funded, by law are to be proportional to the benefits derived from the project (Glown, 1988). As with any assessment, these drainage assessments are often controversial. They often appear to be based on a formula, with no direct estimation of

1 Legal citations take the form of volume, publication, page number. For example, 58 Ohio Laws 49 refers to Volume 58, page 49 of the publication Ohio Laws.
the benefits resulting from the drainage project. Although these formulae provide a relatively consistent means to calculate and distribute drainage assessments, they are often difficult for people to understand.

The author's experiences with the Huron Soil and Water Conservation District (SWCD) provided the impetus to the first of the studies reported in this thesis. The Indian Creek 121 SB-160 project was subject to controversy and ultimately a lawsuit over the assessments. The Huron SWCD Board of Supervisors, in January 1978, held a hearing on the project and submitted assessments to the commissioners based on a formula developed by the Preble SWCD. This is a complicated formula and one of its components is a factor for elevation. The original formula assigned values of 10, 7, 4, 1 to parcels of land based on the elevation, in 10 ft increments, of the property above the ditch bank. A hearing on the assessments was held before the Board of Huron County Commissioners, and a few landowners felt the assessments were unfair. The Board subsequently reviewed the formula, felt that the 10, 7, 4, 1 values did not make sense, and directed the SWCD to change them to equal increments, such as 10, 8, 6, 4, 2. The SWCD complied with this request and new proposed assessments were mailed to the landowners. However, a new group of landowners appealed, as their assessments were now higher than they would have been under the original assessments. In spite of this, the Board of Commissioners approved the new assessments, and a group of the landowners appealed the Board's decision to the Court of Common Pleas, as provided in Section 1515.24 of the Ohio Revised Code.

This suit languished in the courts until 1987, when the Common Pleas Court of Huron County found that the assessments were not based on benefits. New assessments
were calculated based on the formula developed by Moran (1983). These assessments were approved by the Board of Commissioners for the plaintiffs and were not appealed. The result is that this project has maintenance assessments calculated by two different methods, depending on which parcel is being assessed.

The above situation has led to much consternation among the landowners and the public officials involved, and prompted the author's interest in formulae and methods used to distribute drainage assessments. Chapter 2 is an outcome of that interest, and the author hopes that others will benefit from it. There are two main objectives to this study: 1) To estimate the scope of group drainage activity performed annually in Ohio; and 2) to identify the methods used by the agencies in various Ohio counties to distribute costs of group drainage projects among the benefiting parcels of land.

In order to investigate group project activity and assessment methods used by county agencies in Ohio, a survey of county engineers and SWCDs in Ohio was undertaken in November 1997. This survey had four major components: 1) estimating demand for new group project assistance and construction activity; 2) estimating the number of group drainage projects being maintained under county programs and the annual costs of this maintenance; 3) evaluating how benefits are determined and identifying how the costs are structured for individual projects; 4) identifying assessment methods and formulae used by each agency and its attitude towards the process. A modified Diliman (1978) approach was used to conduct the survey. The results of this survey are presented in Chapters 2 and 3.

The second part of the work reported here is an outgrowth of work on the proposed Ohio Agricultural Water Management Guide. Although eventually the guide
will contain information about all phases of agricultural water management, initial work
is focused on updating the Ohio Drainage Guide (SCS, 1976). The last edition of the
Ohio Drainage Guide contained, in part, drain spacing estimates for Ohio soils. Each soil
was placed in one of 22 drainage groups along with other soils having similar
characteristics. For each soil drainage group, trench depth and drain spacing ranges were
provided.

For the updated drainage guide, drain spacing estimates will be provided for all
soils based on computer simulations (Atherton et al., 1998). To provide a limited number
of soils for testing, a set of 53 soils, called the benchmark soils, was compiled to
represent the more than 475 soils currently mapped in Ohio. The objective of this latter
study is to evaluate the applicability of using steady-state drain spacing equations to
predict drain spacing for Ohio soils using readily available soil data from the Soil
Interpretation Record of the State Soil Survey Database.

A computer simulation was undertaken to estimate drain spacing values for 53
soils in Ohio. Four implementations of steady-state drain spacing equations were coded
in a FORTRAN program, which was used to calculate drain spacing estimates for each of
the 53 soils at four drain depths. The results of this study are presented in Chapter 4.

During the drain spacing study, the following question arose: How well do the
estimates of drain spacing provided by the steady-state drain spacing equations match
installation practices of Ohio drainage contractors? This question led to the final
objective reported in this thesis: to estimate the scope of subsurface drain installation in
Ohio and the practices used by drainage contractors to design subsurface drainage
systems.
In order to obtain the data needed for this study, a mail survey of drainage contractors was conducted in early 1998. A list of nearly 400 possible drainage contractors was compiled from information provided by soil and water conservation districts (SWCDs), the Ohio Land Improvement Contractor’s Association, and the Overholt Drainage Research and Education Program. The survey instrument was developed to gather data on the drainage design practices used, the depth and spacing values used by soil series, and other information related to the installation of subsurface drains. A modified Dillman (1978) was used to conduct the survey. The results of this study are presented in Chapter 5.

1.1 References


CHAPTER 2

SCOPE AND IMPORTANCE OF GROUP DRAINAGE PROJECT ACTIVITY IN OHIO

2.1 Introduction

Much of northwest Ohio was uninhabitable by humans until it was drained during the nineteenth century. Settlement lagged in these areas because of the wetness and the presence of mosquitoes and disease but individual landowners often had problems removing excess water because of insufficient outlets downstream (Sandretto, 1987). Thus, the expansion of agricultural drainage was often enhanced by the cooperation of groups of landowners having a common interest in the removal of excess water. However, cooperative efforts, especially in larger projects, had limitations. In addition to the inherent weaknesses of groups to achieve a common goal, they did not possess the power to compel all landowners who benefited from the endeavor to pay their fair share of the costs, nor could they compel an uncooperative landowner to allow construction across his property. A third limitation was that often a project was not maintained.

Since the drainage of land for agriculture was recognized as beneficial to the public welfare because excess water was seen to influence public health, farm production, farm income, and real estate values (Sandretto, 1987), laws were enacted giving public officials or authorized public organizations (drainage districts) certain powers to
overcome these difficulties. Ohio\textsuperscript{2} passed its first drainage laws March 26, 1841 (39 Ohio Laws 122) (Frost and Nichols, 1985). Under the provisions of this law, the courts of common pleas were empowered to appoint persons for "clearing and removing the banks and obstructions of the passages of the water in rivers, brooks, streams or ponds, which occasion the overflowing and drowning of meadows, swamps and lowlands..."

(Schwartz, 1955). In 1859, in 56 Ohio Laws 58, the legislature gave control of the construction of drainage projects to the boards of county commissioners. Landowners that needed improved drainage were required to petition the board of county commissioners in their county to begin the process by which a group drainage project was constructed. By 1884, the Ohio Society of Engineers and Surveyors reported that 20,000 miles of public ditches benefiting over 11 million acres of land had been constructed (Wooten and Jones, 1955).

While this would seem to indicate that much of the large drainage projects had been accomplished by the end of the 19\textsuperscript{th} century, in fact, group drainage projects continue to be constructed. There are two main reasons for this. First, group drainage projects often were not effectively maintained after construction, and consequently many projects were petitioned for improvement more than one time. For example, in a study of county petition projects in Franklin County, Pierce (1996) reported finding 439 separate drainage systems resulting from over 1000 petitions. Second, drainage needs and standards have changed over time, with the result that projects no longer provided the

\textsuperscript{2} Ohio is one of 10 states identified in the 1950 Census of Drainage as "county drain" states. These are states where the county serves as the predominant drainage organization.
drainage capacity needed for optimum agricultural production, infrastructure needs, or flood control.

Although interest by landowner in the construction of drainage projects has remained high, following passage of the Clean Water Act in 1972, federal policy has increasingly limited technical assistance from NRCS and other federal government agencies to individuals and groups wishing to drain wetlands. The Food Security Act of 1985, and subsequent farm bills, denied price support and other farm program benefits to producers who use converted wetlands for producing annual crops.

In 1998, legislation was proposed that would place limits on the environmental review for channels that have been used as ditches for at least 20 years (Edwards, 1998a, 1998b, 1998c). This legislation was reintroduced by Senator Cupp as Senate Bill 20 in 1999. Committee hearings are currently being held.

In 1972, following passage of the Clean Water Act, the Ohio Soil and Water Conservation Commission initiated a study of the economic effects of channel modification for drainage and flood prevention purposes. The final report contained some estimates of group drainage activity from several sources (Channel Modification Task Force, 1972). The report indicated that about 490 miles of stream modification work was done annually by all interests in Ohio; 37 miles of open ditch mains and laterals were constructed by individuals using Soil Conservation Service (SCS) designs during fiscal year 1971; groups of landowners cooperated to construct or reconstruct 111 miles of open ditches during FY 1971; the Ohio Department of Natural Resources (ODNR) was reviewing about 65 plans for petitioned drainage projects each year; 7093
miles of natural and constructed streams and channels were being maintained in 53 counties.

Since that study, several other drainage surveys have been done in Ohio. Nolte (1972b) refers to a 1964 survey which showed an estimated 10,000 miles of county tile and 20,000 miles of county open ditches in 47 Ohio counties\(^3\). In 1971, a drainage survey was mailed to 8 contractors and 12 conservationists in 18 Ohio counties; fifteen questionnaires were returned. From this survey, Nolte (1972) reported that an average of 122 miles of open ditches (12 responses) and 4 miles of subsurface drains (11 responses) per county were on a permanent maintenance program. Eleven respondents estimated that an average of 679 additional miles of open ditches per county were in need of maintenance, construction or reconstruction, while 9 respondents estimated 99 miles of subsurface drains needed similar work. The 15 respondents also estimated the percentage of open ditches and tile that were affected by various problems. The major concerns with the open ditches were 1) the channel was overgrown with brush (affecting 50% of cases), 2) the bottom of the channel was filled (43%) and 3) subsurface drain outlets were submerged (29%). The major problem with subsurface mains was a submerged outlet (affecting 25%) or limited capacity (13%). The respondents estimated that an average of 72% of the inadequate outlets would require group action to resolve.

Nolte (1979) conducted a ditch maintenance survey at the 1979 drainage conferences. He found that ditch maintenance work was being done in 32 counties.

---

\(^3\) The term “county tile” or “county ditch” in common usage refers to group drainage projects that were constructed using the county petition process, found in Chapter 6131 of the Ohio Revised Code.
These 32 counties maintained an average of 114 miles of open ditches while 26 counties maintained an average of 9 miles of subsurface mains.

In an unattributed mimeo, probably by Nolte, it was reported that 3687 miles of open ditch and 323 miles of subsurface drainage mains were under ditch maintenance programs in Ohio in 1980. The average expenditure for counties with over 50 miles under maintenance was $303 per mile, ranging from $92 to $662 per mile.

A 1982 survey found 3827 miles of open ditch and 358 miles of subsurface mains being maintained under the authority of Ohio drainage laws. The 13 counties that had more than 50 miles under maintenance reported an average expenditure of $252 per mile (Nolte, 1985b).

The 1985 ditch maintenance survey found a total of 4200 miles of open ditches and 415 miles of subsurface mains under county ditch maintenance programs in 47 counties. Average costs for the 28 counties that reported more than 50 miles of drainage under maintenance were $328 per mile in 1985 (Ernst, 1985).

Vigh (undated) presented a summary of ditch maintenance programs in Ohio in 1994. The 45 county programs in this publication listed 4966 miles of open ditches, 441.56 miles of subsurface mains, 97.71 miles of grassed waterways along with a few other projects under maintenance. A total of $2,557,750 was reportedly spent to maintain these projects.

The objective of this study is to summarize the extent of group drainage project activity in Ohio. In this chapter we will present the findings of a survey of county engineers and SWCDs conducted in 1997 covering the three year period 1994 – 1996. We will discuss the scope of their group drainage project activities during this period,
including requests for assistance, group drainage project construction, 1996 ditch maintenance program activities, and details of several individual ditch projects constructed during the period 1988 – 1992.

2.2 Methods

A survey instrument was developed to obtain the data needed to meet the objectives of this chapter. A description of the survey instrument, its development and implementation is found in Chapter 3. A copy of the survey instrument is found in Appendix A.

The survey instrument contained four sections. Sections I, II, and III are relevant to this study. Section I was designed to assess the level of recent project activity in Ohio. The agencies were asked to provide information regarding the number of projects and total costs associated with assistance provided for new group project activity during 1994, 1995 and 1996. For projects constructed during this time period, respondents were asked to provide this information by project type - open ditches, subsurface mains, grassed waterways, and other project types - for each of the three organizational authorities - County Petition (CP), Senate Bill 160 (SB), and Mutual Agreement (MA) - provided for by the Ohio Revised Code. The specific agency having responsibility for ditch maintenance in each of the surveyed counties was asked to provide detailed information about its county ditch maintenance program in Section II.

Section II was designed to obtain specific information on the types of projects identified in Section I. The agencies were asked to provide the number of projects, total
length, total benefited acres, total maintenance fund expenditures, and the total of other maintenance expenditures.

The third section was designed to obtain information that would allow the author to summarize how the legal authority for a drainage project was selected, why the project was necessary, the sources of funding for drainage projects, the range in unit costs for these projects, and how costs were allocated among work items. In Section III, each agency was asked to provide detailed information about one ditch project constructed during the time period 1988-1992. This time frame is after the implementation of the Swampbuster provisions of the 1985 Farm Bill, and thus reflects current regulatory conditions. Presumably, few non-cropped areas have been brought back into production by improved drainage since Swampbuster implementation. The agencies were asked about ditch projects only since about 90% of the total length of projects on county maintenance programs were found to be ditches in a previous report (Vigh, undated). Survey recipients were asked to provide costs broken down by as many as 14 categories for each of four sources of funds. Finally, the maintenance expenditures by year were requested in each of five sources of funds.

2.3 Results and Discussion

A mail survey of both County Engineers and Soil and Water Conservation Districts (SWCDs) in 50 Ohio counties was conducted from November 1997 through April 1998. A summary of how quickly the surveys were returned is presented in Chapter 3. The response rate was very good with 79 surveys returned by 34 county engineers and 45 SWCDs. In addition, one county engineer and two SWCDs took the
initiative to either send a letter or phone to indicate their activity, for an overall response rate of 82% (82 agencies). Phone calls were made to the agencies that did not respond to the survey, resulting in partial information obtained from 16 agencies, and site visits were made by the author to two county engineers. Overall, information relating to Section I of the survey was obtained from 80 agencies (80%), while information relating to Section II was obtained from 77 agencies (77%).

Visits were made to two counties to get further information on project construction and maintenance activities. Other counties were contacted by phone to get maintenance expenditures for the entire program. In the end, we were able to obtain total maintenance fund expenditures for all of the ditch maintenance programs. Certain details are missing from several counties because of incomplete data provided by the counties. These data are available in the county records, but it would take some time to collect, and agency personnel cited workload concerns as the main reason they could not provide this data. An effort should be made to collect this information in the future, for once collected, it could be kept current with little extra effort.

2.3.1 Requests for New Group Project Assistance

Fifty-two agencies representing 37 counties reported having new or active group project requests during 1994, 1995 and 1996. From 1994 to 1996, 25 agencies reported assisting with county petition projects, 14 agencies assisted with Senate Bill 160 projects and 29 reported assisting with mutual agreement projects (Table 1). In general, the county engineers assist with county petition (CP) requests, SWCDs assist with SB-160 (SB) requests, and either agency can assist with mutual agreement (MA) requests.
Table 2.1. Summary of the number and fate of requests for group project assistance by year and legal authority, 1994-1996.

<table>
<thead>
<tr>
<th>Year</th>
<th>Legal Authority Used*</th>
<th>Number of Counties Reporting</th>
<th>Number Filed</th>
<th>Number Approved</th>
<th>Percent Approved</th>
<th>Number Rejected or Withdrawn</th>
<th>Percent Rejected or Withdrawn</th>
<th>Number Active End of year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>CP</td>
<td>21</td>
<td>54</td>
<td>35</td>
<td>65%</td>
<td>14</td>
<td>26%</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>MA</td>
<td>25</td>
<td>69</td>
<td>69</td>
<td>100%</td>
<td>6</td>
<td>7%</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>15</td>
<td>32</td>
<td>28</td>
<td>88%</td>
<td>2</td>
<td>6%</td>
<td>55</td>
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<tr>
<td>Subtotal</td>
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<td>155</td>
<td>132</td>
<td>85%</td>
<td>22</td>
<td>14%</td>
<td>185</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>CP</td>
<td>20</td>
<td>35</td>
<td>32</td>
<td>91%</td>
<td>9</td>
<td>26%</td>
<td>72</td>
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<tr>
<td></td>
<td>MA</td>
<td>20</td>
<td>78</td>
<td>78</td>
<td>100%</td>
<td>11</td>
<td>14%</td>
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<td></td>
<td>SB</td>
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<td>27</td>
<td>87%</td>
<td>2</td>
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<td>Subtotal</td>
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<td>95%</td>
<td>22</td>
<td>15%</td>
<td>220</td>
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<td>1996</td>
<td>CP</td>
<td>23</td>
<td>47</td>
<td>35</td>
<td>74%</td>
<td>13</td>
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<td>24</td>
<td>34%</td>
<td>3</td>
<td>9%</td>
<td>86</td>
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<tr>
<td>Subtotal</td>
<td></td>
<td>153</td>
<td>131</td>
<td>86%</td>
<td>23</td>
<td>15%</td>
<td>234</td>
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<tr>
<td>Three year total</td>
<td></td>
<td>452</td>
<td>400</td>
<td>88%</td>
<td>67</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* CP denotes the county petition process  
MA denotes the mutual agreement process  
SB denotes the SB-160 process  
1 Percentages may not total 100% because of requests carried over from previous years  
2 Active petitions may include those filed but still in the approval process

The number of requests for assistance with group drainage projects remained fairly constant, averaging about 150 requests annually for the counties reporting. Nearly half (48%) of the requests were for projects to be organized under the mutual agreement (MA) process. These requests were almost always approved by the administrative authority, because all or nearly all of the landowners are in agreement. Although the initial approval rate is 100%, apparently some approved requests are later rejected or withdrawn, since 24 requests were reported to suffer this fate. The total number of
requests acted upon totals more than the number of requests submitted because of carry over from previous years. The number of active MA requests at the end of the calendar year increased just over 20% from 57 in 1994 to 69 in 1996. A high number (78) was reported active in 1995, so the number of active projects actually decreased from 1995 to 1996, suggesting that the agencies are able to keep current with the requests for assistance for MA projects.

County petition requests are the second most numerous, with 136 total requests made during 1994 – 1996, 30% of the total number of requests. Only 75% of the requests were approved, with 26% of the total being rejected or withdrawn. The number active at the end of the year increased slightly from 73 requests in 1994 to 79 requests in 1996. The increase in active requests is likely because of a large (34%) increase in requests for 1996 over 1995. These numbers suggest that the agencies are staying fairly current with the CP requests.

SB-160 requests make up 22% of the total. The smaller number of SB requests reflects the smaller number of counties using this process. On an annual basis, there were 2.33 SB requests per county, compared with 2.51 MA requests and 1.81 CP requests per county. This shows that in those counties where it is used, it is a popular process. Overall, the approval rate for SB requests was slightly better than for CP requests, 81% vs. 76%. However, the rejection or withdrawal rate was much less, 9% for SB requests vs. 26% for CP requests. Apparently only about 90% of the requests are being acted upon in a timely fashion (81% approved and 9% rejected or withdrawn), indicating the agencies are not keeping current with these requests. This is probably one reason why
the number of active SB requests at the end of the year increased dramatically from 55 in 1994 to 86 in 1996, an increase of 56%.

This increase in active SB requests occurs in spite of a steady number of new requests, which averaged just under 33 requests annually. Thus, the increase in active requests (31) nearly equals the average number of new requests, indicating that over the three year period, the agencies actually fell behind one year in dealing with the requests. The reasons for this are not known. It could be that the workload exceeded the capability of existing staff. A contributing factor could be that the SB-160 process is not as well laid out as the county petition (CP) process, resulting in less motivation to move requests along in a timely manner. The SB-160 process is relatively new, about 30 years old, whereas the county petition process in its current form is over 75 years old, and some form of the county petition process has been in use for nearly 150 years. In any case, if this trend has continued since 1996, there is now a backlog equivalent to over three years worth of requests. By contrast, the MA backlog is approximately 1 year (79 requests active vs. 72 new requests annually), and the CP backlog is less than 2 years (79 requests active vs. an average of 45 new requests annually).

Examination of the data also indicates that some agencies (e.g., S-27) may have listed projects completed during the calendar year (question Q-3 and Q-9) as still active at year end (question Q-2(d) and Q-8(d)). Thus the number of active projects at the end of a calendar year may be overstated. This problem could be remedied in future surveys by having the agencies provide milestone dates for each request. For instance, agencies could list the request date, date of approval or rejection, hearing dates, and the date a
project was completed and provide this information to the researcher. The researcher could then put a consistent interpretation on the data.

Agencies were not asked for the reasons that requests were rejected or withdrawn, or even to differentiate between the two outcomes. This deficiency should be remedied in future surveys, and the agencies should be asked to specify which action occurred and why. This information would be helpful in explaining the differing rejection or withdrawal rates among the three project processes.

2.3.2 Group drainage project construction

Table 2.2 summarizes the number of projects completed by legal authority. Agencies in 37 counties reported the construction of 342 projects costing over $9.5 million for the three year period. Subsurface mains were most numerous with 153 reported, followed by 134 open ditch projects. Twenty-nine grassed waterways were reported. Subdivision drains, detention basins and other project categories made up the 26 remaining projects. Data for the subdivision drains and detention basins was compiled from the “other” category in the survey. Since a separate category for subdivision drains was not included in the survey, some subdivision drains may have been reported in the subsurface main category. Future surveys should include categories for subdivision drains and detention basins.

Finding that subsurface main projects outnumbered open ditches was unexpected, given the project distribution found in county ditch maintenance programs from previous surveys. For instance, a 1994 survey (Vigh, undated) showed 4965 miles of open ditches on maintenance programs compared with 441 miles of subsurface mains. Perhaps not all
subsurface mains in the past have been placed on the county maintenance program. Or perhaps an increasing number of aging mains are reaching replacement age, leading to more subsurface main projects. Many drainage mains date from 1890 – 1910, and were often underdesigned with respect to current standards and suffer from overloading, which leads to breakage and other maintenance problems.

Construction activity is also summarized by year in Table 2.2. In terms of the number of projects completed, construction activity was higher in 1995 than in either 1994 or 1996, mainly because of an increase in MA projects completed, especially subsurface mains. Because of the design and goals of the survey, only total construction costs were requested. Thus, we are not able to partition costs among the various project categories. While the number of subsurface main projects exceeded the number of open ditch projects, the open ditch projects were larger on average and the total length of ditches was over three times the total length of subsurface mains installed. About 192.4 miles (309.6 km) of open ditches were constructed over the three year period (Table 2.3). These open ditches reportedly benefited 144,127 ac (58,276 ha) of land. (The use of the word ‘benefited’ mainly indicates that the project authority has made a judgment that a parcel of land has benefited from these projects, and not necessarily that financial benefits were determined.) Twenty-eight projects totaling 61.4 miles (98.8 km) of subsurface mains were installed benefiting 26,535 ac (10,739 ha) (Table 2.4).
Table 2.2. Summary of the number and costs of group drainage projects completed between 1994-1996 by category and legal authority.

<table>
<thead>
<tr>
<th>Year</th>
<th>Legal Authority</th>
<th>Number of Counties</th>
<th>Open Ditches</th>
<th>Subsurface Mains</th>
<th>Grassed Waterways</th>
<th>Subdivision Drains † ‡</th>
<th>Detention Basins ‡</th>
<th>Other §</th>
<th>Other Costs</th>
<th>Construction Costs</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>CP</td>
<td>21</td>
<td>15</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>81,681.33</td>
<td>951,494.10</td>
<td>1,033,175.43</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>20</td>
<td>16</td>
<td>17</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>168,894.43</td>
<td>1,374,856.65</td>
<td>1,543,751.08</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td>23</td>
<td>14</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>103,010.27</td>
<td>880,188.11</td>
<td>983,198.38</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>45</td>
<td>39</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td></td>
<td>$353,586.03</td>
<td>$3,206,538.86</td>
<td>$3,560,124.89</td>
</tr>
<tr>
<td>1994</td>
<td>MA</td>
<td>25</td>
<td>17</td>
<td>26</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>34,000.00</td>
<td>843,227.60</td>
<td>877,227.60</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>20</td>
<td>24</td>
<td>46</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td></td>
<td>4,106.19</td>
<td>1,611,172.61</td>
<td>1,615,278.80</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td>25</td>
<td>19</td>
<td>31</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td></td>
<td>0.00</td>
<td>853,149.06</td>
<td>853,149.06</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>60</td>
<td>103</td>
<td>23</td>
<td>0</td>
<td>9</td>
<td>11</td>
<td></td>
<td>$38,106.19</td>
<td>$3,307,549.27</td>
<td>$3,345,655.46</td>
</tr>
<tr>
<td>1994</td>
<td>SB</td>
<td>13</td>
<td>10</td>
<td>3</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>37,717.91</td>
<td>931,152.58</td>
<td>968,870.49</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>13</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>1,706.19</td>
<td>227,074.26</td>
<td>228,780.45</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td>14</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>82,341.36</td>
<td>1,320,535.24</td>
<td>1,402,876.60</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>29</td>
<td>11</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
<td>$121,765.46</td>
<td>$2,478,762.08</td>
<td>$2,600,527.54</td>
</tr>
</tbody>
</table>

Total | 134 | 153 | 29 | 5 | 9 | 12 | $513,457.68 | $8,992,850.21 | $9,506,307.89 |

* CP denotes the county petition process, MA denotes the mutual agreement process, SB denotes the SB-160 process
† Subdivision drain and detention basin categories were not included in the survey; data was derived from "other" category
‡ Some subdivision drains may have been reported as subsurface mains
§ Other projects include pumping systems, grade control structures, etc.
Grassed waterways were a minor part of construction activity, amounting to 11.05 miles (17.78 km) benefiting 6,264 acres (2,535 ha) of land (Table 2.5). Subsurface mains are usually installed alongside grassed waterways, so the area benefited by the grassed waterways may also have been counted as benefited by subsurface mains. At least one group drainage project reported included a grassed waterway, subsurface main and open ditch in the one project, with the same amount of benefited area for each part of the project. Thus, the benefited areas reported may include some double counting, and thus be overstated.

Table 2.3. Summary of open ditch projects completed by year, 1994 – 1996.

<table>
<thead>
<tr>
<th></th>
<th>Number Of Projects</th>
<th>Total length</th>
<th>Total area benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ft)</td>
<td>(mi)</td>
</tr>
<tr>
<td>1994</td>
<td>42</td>
<td>389,648</td>
<td>73.80</td>
</tr>
<tr>
<td>1995</td>
<td>49</td>
<td>315,581</td>
<td>59.77</td>
</tr>
<tr>
<td>1996</td>
<td>43</td>
<td>310,601</td>
<td>58.83</td>
</tr>
<tr>
<td>Total</td>
<td>134</td>
<td>1,015,830</td>
<td>192.40</td>
</tr>
</tbody>
</table>

Table 2.4. Summary of subsurface main projects completed by year, 1994 – 1996.

<table>
<thead>
<tr>
<th></th>
<th>Number Of Projects</th>
<th>Total length</th>
<th>Total area benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ft)</td>
<td>(mi)</td>
</tr>
<tr>
<td>1994</td>
<td>41</td>
<td>98,191</td>
<td>18.6</td>
</tr>
<tr>
<td>1995</td>
<td>65</td>
<td>125,292</td>
<td>23.7</td>
</tr>
<tr>
<td>1996</td>
<td>47</td>
<td>100,702</td>
<td>19.1</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>324,185</td>
<td>61.4</td>
</tr>
</tbody>
</table>
Table 2.5. Summary of grassed waterway projects completed by year, 1994 – 1996.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number Of Projects</th>
<th>Total length</th>
<th>Total area benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ft)</td>
<td>(mi)</td>
</tr>
<tr>
<td>1994</td>
<td>9</td>
<td>24,530</td>
<td>4.65</td>
</tr>
<tr>
<td>1995</td>
<td>8</td>
<td>21,461</td>
<td>4.06</td>
</tr>
<tr>
<td>1996</td>
<td>12</td>
<td>28,865</td>
<td>5.47</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>74,856</td>
<td>14.18</td>
</tr>
</tbody>
</table>

There are some changes that could be made in future surveys to improve the data received. It would be beneficial to list the costs for each project type, rather than only overall cost for all projects constructed in a calendar year. However, the goal of this survey was to determine the overall level of activity, which is provided by the total cost.

In this survey we asked the respondents to list other costs incurred, but did not ask for an explanation of what these costs were. This would have been useful information, and should be obtained in future surveys.

The distinction between grassed waterway and subsurface main projects is not consistent among the various agencies. Often a subsurface main is installed beneath a grassed waterway, so there could be one subsurface main and one grassed waterway for one group project. For instance, agency S-25 reported one subsurface main of 12,000 ft and one grassed waterway of 4,000 ft, but listed the benefited area of both projects as 300 acres, so they probably were the same acres. In contrast, agency S-26 only listed grassed waterway projects as being completed, but when asked for the lengths and benefited area of the projects listed values for both subsurface mains and grassed waterways. Agency S-
66 also listed the same acres and lengths for grassed waterway and subsurface drain projects.

A way to obtain more consistent information is to ask the agencies to list the various components that together make up one project. It may not be practical to get the cost breakdown for each component, but this approach would make the data easier to evaluate. A proposed data collection instrument for this approach is presented in Appendix D.

2.3.3 County Ditch Maintenance Programs

Prior to 1947, maintenance of drainage projects was the responsibility of benefiting landowners and the county ditch supervisor assigned sections of a ditch to benefiting landowners to maintain. However, maintenance was haphazard and projects were often repetitioned periodically for reconstruction.

After 1947, the board of county commissioners were authorized by Sections 6546-6547 of the General Code to establish a maintenance fund for a county or joint county ditch when a majority of benefiting landowners petitioned for maintenance (Baldwin, 1948). This provision was changed in 1953 (6137.02 of the Revised Code) to allow a petition by three or more landowners (Page, 1953). In 1957, the wording of 6137.02 RC was changed so the board of county commissioners “shall establish and maintain a fund” for the maintenance of all projects constructed under the provisions of 6131, 6133 and 6135 of the Revised Code (Anderson Co., 1959). This fund was financed by special assessments on the benefiting land apportioned on the basis of the estimated benefits for construction (6137.03 RC). It was after this change in law that nearly all
ditch maintenance programs were begun. Table 2.6 shows the 10-year time period during which these drainage maintenance programs were begun in the reporting counties.

Section II of the survey asked for detailed information about county drainage maintenance programs. By law, the county engineer has administrative authority over these programs, although in some cases the SWCD for the county administers these programs through a memorandum of understanding or working agreement with the county engineer and the board of county commissioners. Of the 50 counties in the survey, 34 ditch maintenance programs are administered by the county engineer’s office and 13 by SWCDs (Table 2.7). Three counties reported no ditch maintenance program.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Programs started</td>
<td>1</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

County ditch maintenance programs are funded by special assessments on the land benefiting by the projects in the program, each project having a separate maintenance fund. Total maintenance fund expenditures reported for the 47 county programs amounted to $2,754,064.81 (Table 2.7). These counties reported $56,372.22 in

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4 When referring to their maintenance programs for drainage projects, most agencies use the term “ditch maintenance program,” which includes all classes of projects such as subsurface mains, grassed waterways, etc. in addition to open ditches.
other expenditures, for total maintenance expenditures of $2,810,437.03. Six of these counties reported no expenditures during 1996.

While we were able to obtain expenditures for all 47 maintenance programs, we were not able to obtain other summary data from all of the county ditch maintenance programs. We found that many county ditch maintenance programs do not have all of this information summarized. The information exists in individual project files, but with high workloads, and other priorities, it has not been summarized in every county. The total number of projects on maintenance programs reported by 43 counties was 3359. Two counties (Hardin and Wood) expected to have a large number of projects did not report. The total length of projects reported was 4,589 mi (7385km) from 45 counties. Only 32 counties were able to provide data on the total area benefiting from the projects on maintenance. These 32 counties reported 2,384,285 acres (964,907 ha) benefiting from 2513 projects, a figure which must be considered much less than the actual area benefiting by all group drainage projects on maintenance in Ohio. We can estimate the total benefiting area in Ohio by taking the average area per project for the 32 counties, 949 acres (384 ha) and multiply that by the 3359 projects reported, yielding a rough estimate of 3,187,691 acres (1,290,040 ha) benefited by ditch maintenance programs statewide.

Nearly all counties report open ditch projects on their maintenance programs, which represent 71% of the total number of projects reported, and 89% of the total miles of projects. Subsurface mains are the second most importance category of project on the
Table 2.7. Summary of 1996 ditch maintenance programs by county showing the number of projects, length, benefited area and expenditures.

<table>
<thead>
<tr>
<th>County</th>
<th>Number of Projects</th>
<th>Total Length of Projects</th>
<th>Total Area Benefited</th>
<th>Maintenance Fund Expenditures</th>
<th>Other Reported Expenditures</th>
<th>Total Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agency</td>
<td>(mi)</td>
<td>(km)</td>
<td>(ac)</td>
<td>(ha)</td>
<td></td>
</tr>
<tr>
<td>Allen</td>
<td>E</td>
<td>120</td>
<td>147.77</td>
<td>237.81</td>
<td>77,834</td>
<td>31,499</td>
</tr>
<tr>
<td>Ashtabula</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Auglaize</td>
<td>E</td>
<td>218</td>
<td>177.70</td>
<td>285.98</td>
<td>164,936</td>
<td>66,749</td>
</tr>
<tr>
<td>Butler</td>
<td>E</td>
<td>18</td>
<td>2.21</td>
<td>3.56</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Champaign</td>
<td>E</td>
<td>--</td>
<td>22.98</td>
<td>36.98</td>
<td>18,765</td>
<td>7,594</td>
</tr>
<tr>
<td>Clark</td>
<td>E</td>
<td>19</td>
<td>23.02</td>
<td>37.05</td>
<td>16,829</td>
<td>6,811</td>
</tr>
<tr>
<td>Clinton</td>
<td>S</td>
<td>85</td>
<td>79.40</td>
<td>127.78</td>
<td>38,703</td>
<td>15,663</td>
</tr>
<tr>
<td>Crawford</td>
<td>E</td>
<td>87</td>
<td>130.26</td>
<td>209.63</td>
<td>132,170</td>
<td>53,488</td>
</tr>
<tr>
<td>Darke</td>
<td>E</td>
<td>--</td>
<td>257.70</td>
<td>414.73</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Defiance</td>
<td>S</td>
<td>151</td>
<td>232.30</td>
<td>373.85</td>
<td>128,332</td>
<td>51,935</td>
</tr>
<tr>
<td>Delaware</td>
<td>E</td>
<td>31</td>
<td>24.00</td>
<td>38.62</td>
<td>37,000</td>
<td>14,974</td>
</tr>
<tr>
<td>Erie</td>
<td>E</td>
<td>80</td>
<td>71.80</td>
<td>115.55</td>
<td>27,073</td>
<td>10,956</td>
</tr>
<tr>
<td>Fairfield</td>
<td>S</td>
<td>2</td>
<td>1.08</td>
<td>1.74</td>
<td>815</td>
<td>330</td>
</tr>
<tr>
<td>Fayette</td>
<td>E</td>
<td>52</td>
<td>62.17</td>
<td>100.06</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Franklin</td>
<td>E</td>
<td>4</td>
<td>0.90</td>
<td>1.45</td>
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<td>--</td>
</tr>
<tr>
<td>Fulton</td>
<td>E</td>
<td>260</td>
<td>387.50</td>
<td>623.62</td>
<td>176,000</td>
<td>71,226</td>
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<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Greene</td>
<td>S</td>
<td>27</td>
<td>26.43</td>
<td>42.54</td>
<td>32,913</td>
<td>13,320</td>
</tr>
<tr>
<td>Hancock</td>
<td>E</td>
<td>108</td>
<td>196.58</td>
<td>316.37</td>
<td>156,325</td>
<td>63,264</td>
</tr>
<tr>
<td>Hardin</td>
<td>E</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Henry</td>
<td>S</td>
<td>195</td>
<td>362.07</td>
<td>582.70</td>
<td>331,077</td>
<td>133,985</td>
</tr>
<tr>
<td>Highland</td>
<td>E</td>
<td>1</td>
<td>1.15</td>
<td>1.85</td>
<td>344</td>
<td>139</td>
</tr>
<tr>
<td>Huron</td>
<td>S</td>
<td>78</td>
<td>104.60</td>
<td>168.34</td>
<td>51,339</td>
<td>20,777</td>
</tr>
<tr>
<td>Knox</td>
<td>E</td>
<td>2</td>
<td>2.00</td>
<td>3.22</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Lake</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<table>
<thead>
<tr>
<th>County</th>
<th>Agency</th>
<th>Number of Projects</th>
<th>Total Length of Projects (mi)</th>
<th>Total Area Benefited (ac)</th>
<th>Maintenance Fund Expenditures</th>
<th>Other Reported Expenditures</th>
<th>Total Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licking</td>
<td>E</td>
<td>26</td>
<td>38.84</td>
<td>15,944</td>
<td>20,800.00</td>
<td>0.00</td>
<td>20,800.00</td>
</tr>
<tr>
<td>Logan</td>
<td>E</td>
<td>55</td>
<td>44.66</td>
<td>6,452</td>
<td>22,970.69</td>
<td>0.00</td>
<td>22,970.69</td>
</tr>
<tr>
<td>Lucas</td>
<td>E</td>
<td>1</td>
<td>1.50</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Lorain</td>
<td>E</td>
<td>18</td>
<td>20.01</td>
<td>7,604</td>
<td>8,200.00</td>
<td>612.00</td>
<td>8,812.00</td>
</tr>
<tr>
<td>Madison</td>
<td>E</td>
<td>192</td>
<td>157.00</td>
<td>188,212</td>
<td>290,300.00</td>
<td>0.00</td>
<td>290,300.00</td>
</tr>
<tr>
<td>Marion</td>
<td>E</td>
<td>5</td>
<td>4.00</td>
<td>40,068</td>
<td>34,805.00</td>
<td>0.00</td>
<td>34,805.00</td>
</tr>
<tr>
<td>Mercer</td>
<td>E</td>
<td>103</td>
<td>108.00</td>
<td>16,215</td>
<td>18,000.00</td>
<td>0.00</td>
<td>18,000.00</td>
</tr>
<tr>
<td>Miami</td>
<td>E</td>
<td>24</td>
<td>19.11</td>
<td>25,400</td>
<td>9,200.00</td>
<td>0.00</td>
<td>9,200.00</td>
</tr>
<tr>
<td>Montgomery</td>
<td>S</td>
<td>6</td>
<td>38.00</td>
<td>61.16</td>
<td>1,517.22</td>
<td>0.00</td>
<td>1,517.22</td>
</tr>
<tr>
<td>Morrow</td>
<td>E</td>
<td>9</td>
<td>8.98</td>
<td>265,550</td>
<td>125,809.50</td>
<td>0.00</td>
<td>125,809.50</td>
</tr>
<tr>
<td>Ottawa</td>
<td>S</td>
<td>72</td>
<td>97.80</td>
<td>107,467</td>
<td>38,725.00</td>
<td>0.00</td>
<td>38,725.00</td>
</tr>
<tr>
<td>Paulding</td>
<td>S</td>
<td>94</td>
<td>236.50</td>
<td>104,979</td>
<td>10,842.00</td>
<td>0.00</td>
<td>10,842.00</td>
</tr>
<tr>
<td>Pickaway</td>
<td>S</td>
<td>23</td>
<td>36.32</td>
<td>21,227</td>
<td>180,000.00</td>
<td>0.00</td>
<td>180,000.00</td>
</tr>
<tr>
<td>Preble</td>
<td>E</td>
<td>140</td>
<td>66.67</td>
<td>52,451</td>
<td>131,623.98</td>
<td>0.00</td>
<td>131,623.98</td>
</tr>
<tr>
<td>Putnam</td>
<td>E</td>
<td>181</td>
<td>342.20</td>
<td>42,484</td>
<td>125,809.50</td>
<td>0.00</td>
<td>125,809.50</td>
</tr>
<tr>
<td>Richland</td>
<td>E</td>
<td>3</td>
<td>6.70</td>
<td>121,27</td>
<td>32,028.56</td>
<td>0.00</td>
<td>32,028.56</td>
</tr>
<tr>
<td>Sandusky</td>
<td>S</td>
<td>103</td>
<td>210.00</td>
<td>85,27</td>
<td>131,623.98</td>
<td>0.00</td>
<td>131,623.98</td>
</tr>
<tr>
<td>Seneca</td>
<td>S</td>
<td>271</td>
<td>259.20</td>
<td>30,199</td>
<td>80,392.59</td>
<td>0.00</td>
<td>80,392.59</td>
</tr>
<tr>
<td>Shelby</td>
<td>E</td>
<td>160</td>
<td>125.72</td>
<td>202.33</td>
<td>359,386.08</td>
<td>0.00</td>
<td>359,386.08</td>
</tr>
<tr>
<td>Union</td>
<td>E</td>
<td>26</td>
<td>54.81</td>
<td>21,227</td>
<td>359,386.08</td>
<td>0.00</td>
<td>359,386.08</td>
</tr>
<tr>
<td>Van Wert</td>
<td>E</td>
<td>64</td>
<td>78.21</td>
<td>21,227</td>
<td>32,028.56</td>
<td>0.00</td>
<td>32,028.56</td>
</tr>
<tr>
<td>Williams</td>
<td>E</td>
<td>200</td>
<td>254.00</td>
<td>21,489</td>
<td>28,494.00</td>
<td>0.00</td>
<td>28,494.00</td>
</tr>
<tr>
<td>Wood</td>
<td>E</td>
<td>98</td>
<td>64.74</td>
<td>301,99</td>
<td>28,494.00</td>
<td>0.00</td>
<td>28,494.00</td>
</tr>
<tr>
<td>Wayne</td>
<td>E</td>
<td>7</td>
<td>2.50</td>
<td>766</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Total: 3359 4,589.09 7,385.44 2,384,285 964,907 $2,766,832.61 $56,372.22 $2,823,204.83
county maintenance programs, followed by grassed waterways, which often have a subsurface main associated with them.

Not all counties made complete reports in each of the categories, so definitive statistics cannot be provided. More than one county reported that they do not have their records summarized in the detail needed to complete the survey (Ed Wilt, personal communication, February 1, 1998; Rod Creager, personal communication, February 19, 1998). Developing this information can be done, but someone will have to examine each case file on hundreds of projects in some of these counties. It is clear that open ditches make up the majority of the projects on maintenance and incur the majority of the maintenance expenses.

Table 2.8 summarizes the maintenance programs by project category for those counties that reported complete information about number, length and benefited area. The costs shown represent averages over the entire project; costs for individual parcels may be much higher or lower than the average because of the method used to allocate costs among the parcels.

Several counties place subdivision drainage mains on county maintenance programs. These apparently serve as outlets to on-site sewage disposal systems, and the county agencies feel this will insure maintenance on the outlet for these systems. Other counties are putting other storm-water management projects, such as detention basins, on the county maintenance programs. In many cases the developer is asked to do this prior to development or sale of individual lots. The mutual agreement part of the drainage laws (6131.63 RC) is used to place these projects on the maintenance program.
Table 2.8  Maintenance costs per unit length and area for selected group drainage project projects during 1996.

<table>
<thead>
<tr>
<th>Category of Project</th>
<th>Number of Projects</th>
<th>Length</th>
<th>Benefited Area</th>
<th>Expenditures</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(mi)</td>
<td>(km)</td>
<td>(ac)</td>
<td>(ha)</td>
</tr>
<tr>
<td>Grassed waterway</td>
<td>67</td>
<td>58.53</td>
<td>94.19</td>
<td>60,763</td>
<td>24,590</td>
</tr>
<tr>
<td>Open ditch</td>
<td>1254</td>
<td>1,958.44</td>
<td>3,151.82</td>
<td>1,368,823</td>
<td>553,955</td>
</tr>
<tr>
<td>Open ditch*</td>
<td>410</td>
<td>737.00</td>
<td>1,186.09</td>
<td>503,360</td>
<td>203,707</td>
</tr>
<tr>
<td>Subsurface main</td>
<td>256</td>
<td>180.35</td>
<td>290.25</td>
<td>93,968</td>
<td>38,028</td>
</tr>
</tbody>
</table>

* Values in this line are estimates provided by several of the agencies.
Table 2.9 shows the length of open ditches in the maintenance programs in the reporting counties compared with previous surveys. These data are confusing, to say the least. Many counties show a decrease in the miles of open ditch on the maintenance program, which is unrealistic, since once ditch projects are placed on the program, they are unlikely to come off on any large scale. It is likely that there are discrepancies in the numbers reported, because of inconsistencies in the way the questions were asked, the information asked for, the care the respondent took to ensure accuracy, etc. This indicates a need for consistent methods from survey to survey. An annual survey would be helpful, in that current information would be readily available, and the respondent may be more likely to respond in a consistent manner if surveys are conducted annually. The creation of a county-level database could also help achieve consistency from survey to survey.

2.3.4 **Review of selected individual open ditch projects, 1988-1992.**

Section III of the survey provided detailed information about individual open ditch projects. While sum of this information will be summarized in this section, much this information is intended to provide background information for future research. A study of land values in relation to the quality of a drainage outlet and other land characteristics using hedonic techniques is one example of research that could be conducted. In the case of land values, hedonic theory postulates that the value of land depends on both the number and amount of various characteristics. Palmquist and Danielson (1989) reported the results of a study in North Carolina relating land values to erosion, soil wetness, parcel size, presence of community water, and other characteristics.
<table>
<thead>
<tr>
<th>County</th>
<th>1979 (miles)</th>
<th>1985 (miles)</th>
<th>1994 (miles)</th>
<th>1996 (miles)</th>
<th>Percent Change from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen</td>
<td>60</td>
<td>110</td>
<td>114.3</td>
<td>121.37</td>
<td>102.3% 10.3% 6.2%</td>
</tr>
<tr>
<td>Auglaize</td>
<td>55</td>
<td>98</td>
<td>131.5</td>
<td>136.8</td>
<td>148.7% 39.6% 4.0%</td>
</tr>
<tr>
<td>Champaign</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>12.12</td>
<td>21.2% 21.2% 21.2%</td>
</tr>
<tr>
<td>Clark</td>
<td>10</td>
<td>18</td>
<td>19.76</td>
<td>19.2</td>
<td>92.0% 6.7% -2.8%</td>
</tr>
<tr>
<td>Clinton</td>
<td>29</td>
<td>35</td>
<td>42</td>
<td>51.5</td>
<td>77.6% 47.1% 22.6%</td>
</tr>
<tr>
<td>Crawford</td>
<td>116</td>
<td>123</td>
<td>121.44</td>
<td>125.98</td>
<td>8.6% 2.4% 3.7%</td>
</tr>
<tr>
<td>Defiance</td>
<td>150</td>
<td>167</td>
<td>212.5</td>
<td>226</td>
<td>50.7% 35.3% 6.4%</td>
</tr>
<tr>
<td>Delaware</td>
<td>--</td>
<td>32</td>
<td>25</td>
<td>24</td>
<td>-- -25.0% -4.0%</td>
</tr>
<tr>
<td>Eric</td>
<td>--</td>
<td>46</td>
<td>53.6</td>
<td>53.57</td>
<td>-- 16.5% -0.1%</td>
</tr>
<tr>
<td>Fayette</td>
<td>54</td>
<td>50</td>
<td>51.6</td>
<td>50.7</td>
<td>-6.1% 1.4% -1.7%</td>
</tr>
<tr>
<td>Greene</td>
<td>15</td>
<td>17</td>
<td>18</td>
<td>22.65</td>
<td>51.0% 33.2% 25.8%</td>
</tr>
<tr>
<td>Hancock</td>
<td>167</td>
<td>149</td>
<td>180.67</td>
<td>179.87</td>
<td>7.7% 20.7% -0.4%</td>
</tr>
<tr>
<td>Henry</td>
<td>231</td>
<td>311</td>
<td>363.79</td>
<td>358</td>
<td>55.0% 15.1% -1.6%</td>
</tr>
<tr>
<td>Highland</td>
<td>--</td>
<td>1</td>
<td>0</td>
<td>1.15</td>
<td>-- 15.0% --</td>
</tr>
<tr>
<td>Huron</td>
<td>75</td>
<td>85</td>
<td>97.83</td>
<td>100.46</td>
<td>33.9% 18.2% 2.7%</td>
</tr>
<tr>
<td>Knox</td>
<td>--</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-- 0.0% 0.0%</td>
</tr>
<tr>
<td>Licking</td>
<td>--</td>
<td>31†</td>
<td>40</td>
<td>33.15</td>
<td>6.9% -17.1%</td>
</tr>
<tr>
<td>Logan</td>
<td>21</td>
<td>22</td>
<td>30.3</td>
<td>31.42</td>
<td>49.6% 42.8% 3.7%</td>
</tr>
<tr>
<td>Lorain</td>
<td>--</td>
<td>19</td>
<td>19.13</td>
<td>18.62</td>
<td>-- -2.0% -2.7%</td>
</tr>
<tr>
<td>Lucas</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>1.5</td>
<td>-75.0% -75.0% -75.0%</td>
</tr>
<tr>
<td>Madison</td>
<td>117</td>
<td>91</td>
<td>106</td>
<td>109</td>
<td>-6.8% 19.8% 2.8%</td>
</tr>
<tr>
<td>Marion</td>
<td>43</td>
<td>55</td>
<td>51.7</td>
<td>3</td>
<td>-93.0% -94.5% -94.2%</td>
</tr>
<tr>
<td>Mercer</td>
<td>67</td>
<td>80</td>
<td>102</td>
<td>93</td>
<td>38.8% 16.3% -8.8%</td>
</tr>
<tr>
<td>Miami</td>
<td>13</td>
<td>12</td>
<td>11.71</td>
<td>11.95</td>
<td>-8.1% -0.4% 2.0%</td>
</tr>
<tr>
<td>Montgomery</td>
<td>--</td>
<td>8</td>
<td>15</td>
<td>32</td>
<td>-- 300.0% 113.3%</td>
</tr>
<tr>
<td>Ottawa</td>
<td>89</td>
<td>96</td>
<td>96.72</td>
<td>95</td>
<td>6.7% -1.0% -1.8%</td>
</tr>
<tr>
<td>Paulding</td>
<td>38</td>
<td>165</td>
<td>300</td>
<td>236</td>
<td>521.1% 43.0% -21.3%</td>
</tr>
<tr>
<td>Pickaway</td>
<td>15</td>
<td>23</td>
<td>25.5</td>
<td>11.3</td>
<td>-24.7% -50.9% -55.7%</td>
</tr>
<tr>
<td>Putnam</td>
<td>2</td>
<td>191</td>
<td>290</td>
<td>332.5</td>
<td>16525.0% 74.1% 14.7%</td>
</tr>
<tr>
<td>Richland</td>
<td>--</td>
<td>6</td>
<td>4.75</td>
<td>4.5</td>
<td>-- -25.0% -5.3%</td>
</tr>
<tr>
<td>Sandusky</td>
<td>170</td>
<td>185</td>
<td>200</td>
<td>201</td>
<td>18.2% 8.6% 0.5%</td>
</tr>
<tr>
<td>Seneca</td>
<td>156</td>
<td>177</td>
<td>206</td>
<td>204.5</td>
<td>31.1% 15.5% -0.7%</td>
</tr>
<tr>
<td>Van Wert</td>
<td>40</td>
<td>65</td>
<td>103.66</td>
<td>71.62</td>
<td>79.1% 10.2% -30.9%</td>
</tr>
<tr>
<td>Wayne</td>
<td>0</td>
<td>3†</td>
<td>--</td>
<td>1.9</td>
<td>-- -36.7% --</td>
</tr>
<tr>
<td>Wyandot</td>
<td>32</td>
<td>41</td>
<td>41.1</td>
<td>50.93</td>
<td>59.2% 24.2% 23.9%</td>
</tr>
</tbody>
</table>

Totals: 1616 2530 3093.56 3028.26

* 1978 data
† 1982 data
Thirty-eight agencies representing 28 counties responded to the request for detailed information concerning one ditch project constructed during the period 1988 – 1992. During this 5-year period, these 38 agencies reported assisting with the construction of 249 open ditch projects, an average of seven per agency and nine per county. Assistance ranged from 1 to 45 projects per agency and from 1 to 73 projects per county.

Table 2.10 shows the legal authority used to organize these 37 open ditch projects, which was nearly equally split among the three possible choices with 15 county petition (CP) projects, 11 mutual agreement (MA) projects and 11 Senate Bill 160 (SB) projects. Agencies have preferred methods of dealing with group requests and this includes the legal authority used. For instance, the SWCD in Montgomery County, by agreement with the county engineer and board of county commissioners, handles all group requests and uses the SB-160 process exclusively. In Huron County, the SWCD provides assistance to all group project requests and currently uses the mutual agreement process exclusively.

There are two general themes among the reasons given for choosing the county petition (CP) process for organizing a drainage project. In six instances, respondents indicated that that this was the preferred process or it was felt that this was the only process that could solve the problem. In four cases it was noted that the landowners selected the process by petition. One could assume this was done because it was the preferred process in the county. In two cases it was felt that this was the most expeditious process. In three cases the process was used because the landowners could not agree; otherwise the mutual agreement process could have been used.
Table 2.10. Reasons given for choosing the legal authority used for selected projects.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Legal Authority Chosen</th>
<th>Reason For Choosing This Legal Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>E49D1</td>
<td>CP</td>
<td>Most expeditious</td>
</tr>
<tr>
<td>E51D1</td>
<td>CP</td>
<td>Landowners could not agree to do the project together</td>
</tr>
<tr>
<td>E46D1</td>
<td>CP</td>
<td>Preferred method of landowners in Sandusky county</td>
</tr>
<tr>
<td>E50D1</td>
<td>CP</td>
<td>Landowner file petition</td>
</tr>
<tr>
<td>E39D1</td>
<td>CP</td>
<td>Landowner came in office and requested to begin petition procedure</td>
</tr>
<tr>
<td>E56D1</td>
<td>CP</td>
<td>Too many contentious owners for private agreement</td>
</tr>
<tr>
<td>E31D1</td>
<td>CP</td>
<td>Property owners felt it would be the quickest and most binding on objecting property owners.</td>
</tr>
<tr>
<td>E63D1</td>
<td>CP</td>
<td>Petitioned by landowner</td>
</tr>
<tr>
<td>E59D1</td>
<td>CP</td>
<td>Landowners choice</td>
</tr>
<tr>
<td>E60D1</td>
<td>CP</td>
<td>No other authority could be found to assist with what would otherwise have been a township problem.</td>
</tr>
<tr>
<td>E38D1</td>
<td>CP</td>
<td>Some landowners protested cleaning.</td>
</tr>
<tr>
<td>E35D1</td>
<td>CP</td>
<td>SB160 and Mutual Agreement projects are not promoted locally</td>
</tr>
<tr>
<td>S65D1</td>
<td>CP</td>
<td>Only method available at the time.</td>
</tr>
<tr>
<td>E29D84-1</td>
<td>CP</td>
<td>Method customarily used at the time.</td>
</tr>
<tr>
<td>E67D1</td>
<td>CP</td>
<td>There was no other legal action the property owner could use at that time &amp; the project involve [sic] work along a RR.</td>
</tr>
<tr>
<td>S64D1</td>
<td>MA</td>
<td>The landowners all agreed that the improvement was necessary and they all paid their assessment up front.</td>
</tr>
<tr>
<td>S46D1</td>
<td>MA</td>
<td>Mutual agreement between developer and county.</td>
</tr>
<tr>
<td>E23D1</td>
<td>MA</td>
<td>Landowners decided to do some of work themselves and hired rest of work done according to SWCD plans then petitioned for maintenance.</td>
</tr>
<tr>
<td>S37D1</td>
<td>MA</td>
<td>Because 90% of all group project are mutual agreements here in Wyandot County</td>
</tr>
<tr>
<td>S68D1</td>
<td>MA</td>
<td>Quickest and most economical.</td>
</tr>
<tr>
<td>S33D1</td>
<td>MA</td>
<td>Landowners request</td>
</tr>
<tr>
<td>S62D1</td>
<td>MA</td>
<td>Landowners were amicable. No dissension as to cost allocation. Saved time and expense compared to SB-160 process.</td>
</tr>
<tr>
<td>S58D1</td>
<td>MA</td>
<td>Promotes cooperation between neighbors; easy to understand; less expensive; fewer legalities/lawsuits; protects district image as cooperative, not regulatory agency.</td>
</tr>
<tr>
<td>S42D1</td>
<td>MA</td>
<td>At that time, the majority of landowners were in agreement, on or two key landowners helped to push project through.</td>
</tr>
<tr>
<td>S57D1</td>
<td>MA</td>
<td>SCS worked with group</td>
</tr>
<tr>
<td>E47D1</td>
<td>MA</td>
<td>One objecting landowner.</td>
</tr>
<tr>
<td>S47D1</td>
<td>SB</td>
<td>Not all landowners agreed to project and SB160 is cheaper than the county petition.</td>
</tr>
<tr>
<td>S67D1</td>
<td>SB</td>
<td>It started as Mutual agreement but went to 160 in order to collect from State Hwy. and one landowner.</td>
</tr>
<tr>
<td>S29D1</td>
<td>SB</td>
<td>continued</td>
</tr>
</tbody>
</table>
Table 2.9 (continued)

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Legal Authority Chosen</th>
<th>Reason For Choosing This Legal Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>S22D1</td>
<td>SB</td>
<td>Large number of landowners along with large number of acres drained.</td>
</tr>
<tr>
<td>S53D1</td>
<td>SB</td>
<td>Memo of understanding between the county engineer and the co. commission and the SWCD</td>
</tr>
<tr>
<td>S20D1</td>
<td>SB</td>
<td>Too large to get voluntary cooperation</td>
</tr>
<tr>
<td>E22D1</td>
<td>SB</td>
<td>Most agricultural watersheds use SB-160 petitions to save cost of engineering expenses.</td>
</tr>
<tr>
<td>S55D1</td>
<td>SB</td>
<td>Could not get 100% agreement and landowners did not want to petition through the county commissioners.</td>
</tr>
<tr>
<td>E53D1</td>
<td>SB</td>
<td>This legal authority offers the least cost to property owners. It is also the preferred method by memo of understanding between the board of city commissioners, city engineer and SWCD.</td>
</tr>
<tr>
<td>S31D1</td>
<td>SB</td>
<td>County – Petitioner was told SB-160 method would be cheaper (Co. Eng.). Mutual – requires all landowners to be in agreement (Prosecutor’s view).</td>
</tr>
<tr>
<td>S56D1</td>
<td>SB</td>
<td>County Petition was backed up. Farmers could use SB160 to get done sooner.</td>
</tr>
</tbody>
</table>

The mutual agreement (MA) process is often used when all or nearly all landowners agree on the necessity of an project, and also agree on the allocation of costs among the benefiting landowners. Three agencies felt it was the most economical and a quicker process than the other two processes. Some agencies are using this method to place subdivision drains and stormwater control structures such as detention/retention basins on the county maintenance program.

Ten projects were organized under the SB-160 (SB) process. (Eleven agencies provided responses, but two agencies submitted the same project.) This process was chosen by the majority because of the presence of objecting landowners. Two selected this process because it would save on engineering costs. One selected the SB process because of a backlog of county petition projects in the county. One county has a memorandum of understanding among the board of county commissioners, the county
engineer, and the soil and water conservation district to use the SB process exclusively in
the county.

The mutual agreement process is the easiest and provides the least cost to
landowners, since the SWCD does not assess landowners for the engineering and
administrative assistance. The SB-160 method is thought to be less expensive than a
county petition, also because the SWCD usually provides technical and administrative
assistance without assessing the landowners. The county engineer by law assesses the
benefiting landowners to recover his costs in the county petition process.

Chapters 6131 and 1515 of the Revised Code list several benefits of drainage
improvement that can be considered for assessment purposes. Respondents were asked
to rate the importance of several of these on a Likert scale with a response of 1 being not
important, 2 being important, 3 a neutral rating, 4 being important and 5 being very
important. The results of this question are shown in Table 2.11.

The most important reason given for constructing these open ditches was to
provide an adequate outlet for subsurface drains. The second most important reason was
to improve crop production. Most open ditch projects predominantly benefit agricultural
uses such as cropland. Farm owners often have a large investment in subsurface drainage
systems which depend on an outlet in the form of an open ditch to operate properly.
Protecting this investment is obviously of great importance, reflected in the high score
given to these two factors.
Table 2.11. Importance of reasons for completing the open ditch project listed in Table 2.10.

<table>
<thead>
<tr>
<th>Reason for Construction</th>
<th>Number of Responses</th>
<th>Average Response</th>
<th>Standard Deviation</th>
<th>Rank</th>
<th>Minimum Response</th>
<th>Maximum Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve crop production</td>
<td>35</td>
<td>4.54</td>
<td>0.89</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Reduce flooding damage to agricultural land*</td>
<td>35</td>
<td>4.09</td>
<td>1.25</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Reduce flooding damage to residential land</td>
<td>35</td>
<td>3.54</td>
<td>1.38</td>
<td>6</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Reduce flooding damage to agricultural buildings*</td>
<td>33</td>
<td>2.45</td>
<td>1.48</td>
<td>10</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Reduce flooding damage to residential buildings*</td>
<td>33</td>
<td>3.15</td>
<td>1.66</td>
<td>8</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Reduce flooding damage to roads†</td>
<td>34</td>
<td>3.00</td>
<td>1.61</td>
<td>9</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Provide adequate outlet for subsurface drains†</td>
<td>35</td>
<td>4.74</td>
<td>0.61</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Provide adequate outlet for accelerated runoff†</td>
<td>35</td>
<td>3.83</td>
<td>0.98</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Reduce a threat to public health†</td>
<td>33</td>
<td>3.21</td>
<td>1.45</td>
<td>7</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Place ditch on county maintenance program†</td>
<td>35</td>
<td>4.29</td>
<td>1.05</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Improve road shoulder†</td>
<td>2</td>
<td>4.00</td>
<td>--</td>
<td>--</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Obstruction by RR†</td>
<td>1</td>
<td>5.00</td>
<td>--</td>
<td>--</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Landowner's age</td>
<td>1</td>
<td>4.00</td>
<td>--</td>
<td>--</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

* These are private goods, relating to producer profitability, net return, or residential property.
† These are public goods.

The third most important was to place the ditch on the county maintenance program. As noted earlier, maintenance of drainage projects was haphazard prior to the change in the ditch maintenance laws in 1957. Lack of maintenance reduces the efficiency of many open ditches (Overmier, 1972). The high score on this item indicates a recognition that a maintenance program can reduce the risk of poor drainage. Reduced
flooding concerns were relatively less important on average as reasons to construct these projects.

Table 2.12 lists some basic characteristics of the open ditch projects submitted by the agencies. Only 33 of the 38 projects submitted are presented here because of incomplete information or duplication. Ditch E47D1 was removed from the table since the agency did not list any costs other than some design costs. Evidently the landowners constructed this project with design assistance from the engineer’s office, but the agency did not report the excavation or other costs associated with this project.

Although projects of varying sizes occur for each of the legal authority groups, the data in Table 2.12 quite clearly show that mutual agreement projects are typically smaller projects, measured either by length or area, than are county petition (CP) or Senate Bill 160 (SB) projects. SB projects seem to be slightly shorter than CP projects, 2.17 mi vs. 2.51 mi, although not greatly so. However, the average benefited area for the SB projects is less than half the benefited area of the CP projects, resulting in an area/length ratio only about 50% of the CP value. The area/length ratio for MA projects is only slightly less than for the CP projects. It is not known why the area/length ratio should be so dramatically different for SB vs. CP projects. Perhaps the counties that more often use the SB process have landscapes that are considerably different than the counties typically using the CP process.
Table 2.12. Characteristics of selected open ditch projects.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Number Constructed 1988-92</th>
<th>Date Project Completed</th>
<th>Legal Authority Used</th>
<th>Project Length (ft)</th>
<th>(mi)</th>
<th>(m)</th>
<th>Benefited Area (ac)</th>
<th>(ha)</th>
<th>(ac/mi)</th>
<th>Total Construction Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>E23D1</td>
<td>0</td>
<td>1/1/91</td>
<td>MA</td>
<td>469</td>
<td>0.09</td>
<td>140.2</td>
<td>13</td>
<td>5.3</td>
<td>144</td>
<td>13,403.29</td>
</tr>
<tr>
<td>S68D1</td>
<td>5</td>
<td>5/1/89</td>
<td>MA</td>
<td>9,525</td>
<td>1.80</td>
<td>2,903.2</td>
<td>783</td>
<td>316.9</td>
<td>435</td>
<td>21,903.00</td>
</tr>
<tr>
<td>S38D1</td>
<td>5</td>
<td>10/1/88</td>
<td>MA</td>
<td>12,600</td>
<td>2.39</td>
<td>3,840.5</td>
<td>1,047</td>
<td>423.7</td>
<td>438</td>
<td>38,443.25</td>
</tr>
<tr>
<td>S58D1</td>
<td>4</td>
<td>5/1/91</td>
<td>MA</td>
<td>3,175</td>
<td>0.60</td>
<td>967.7</td>
<td>338</td>
<td>136.8</td>
<td>563</td>
<td>32,187.00</td>
</tr>
<tr>
<td>E47D1</td>
<td>1</td>
<td>11/1/90</td>
<td>MA</td>
<td>1,390</td>
<td>0.26</td>
<td>423.7</td>
<td>237</td>
<td>95.9</td>
<td>912</td>
<td>800.00</td>
</tr>
<tr>
<td>S62D1</td>
<td>2</td>
<td>11/1/89</td>
<td>MA</td>
<td>4,800</td>
<td>0.91</td>
<td>1,460.5</td>
<td>896</td>
<td>362.6</td>
<td>985</td>
<td>26,334.00</td>
</tr>
<tr>
<td>S33D1</td>
<td>4</td>
<td>10/1/91</td>
<td>MA</td>
<td>3,094</td>
<td>0.59</td>
<td>943.1</td>
<td>605</td>
<td>244.8</td>
<td>1,025</td>
<td>16,500.00</td>
</tr>
<tr>
<td>S42D1</td>
<td>7</td>
<td>7/1/91</td>
<td>MA</td>
<td>2,350</td>
<td>0.45</td>
<td>716.3</td>
<td>472</td>
<td>191.0</td>
<td>1,049</td>
<td>18,093.70</td>
</tr>
<tr>
<td>S46D1</td>
<td>3</td>
<td>9/1/92</td>
<td>MA</td>
<td>3,400</td>
<td>0.64</td>
<td>1,036.3</td>
<td>705</td>
<td>285.3</td>
<td>1,102</td>
<td>14,263.76</td>
</tr>
<tr>
<td>S57D1</td>
<td>4</td>
<td>6/1/88</td>
<td>MA</td>
<td>1,365</td>
<td>0.26</td>
<td>416.1</td>
<td>291</td>
<td>117.8</td>
<td>1,119</td>
<td>73,774.00</td>
</tr>
</tbody>
</table>

Average of 10 projects: 4,216 ft, 0.80 mi, 1,285.0 m, 539 ac, 218.0 ha, 777 ac/mi, 25,570.19 Cost

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Number Constructed 1988-92</th>
<th>Date Project Completed</th>
<th>Legal Authority Used</th>
<th>Project Length (ft)</th>
<th>(mi)</th>
<th>(m)</th>
<th>Benefited Area (ac)</th>
<th>(ha)</th>
<th>(ac/mi)</th>
<th>Total Construction Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>S31D1</td>
<td>1</td>
<td>12/1/95</td>
<td>SB</td>
<td>2,845</td>
<td>0.54</td>
<td>867.2</td>
<td>58</td>
<td>23.5</td>
<td>107</td>
<td>2,241.00</td>
</tr>
<tr>
<td>S53D1</td>
<td>1</td>
<td>7/1/87</td>
<td>SB</td>
<td>13,570</td>
<td>2.57</td>
<td>4,136.1</td>
<td>350</td>
<td>141.6</td>
<td>136</td>
<td>67,069.00</td>
</tr>
<tr>
<td>S29D1</td>
<td>15</td>
<td>3/1/96</td>
<td>SB</td>
<td>6,500</td>
<td>1.23</td>
<td>1,981.2</td>
<td>240</td>
<td>97.1</td>
<td>195</td>
<td>16,917.95</td>
</tr>
<tr>
<td>S22D1</td>
<td>45</td>
<td>3/1/96</td>
<td>SB</td>
<td>8,271</td>
<td>1.57</td>
<td>2,521.0</td>
<td>454</td>
<td>183.7</td>
<td>289</td>
<td>42,964.20</td>
</tr>
<tr>
<td>S55D1</td>
<td>1</td>
<td>12/1/89</td>
<td>SB</td>
<td>19,160</td>
<td>3.63</td>
<td>5,840.0</td>
<td>1,370</td>
<td>554.4</td>
<td>377</td>
<td>68,137.00</td>
</tr>
<tr>
<td>S56D1</td>
<td>2</td>
<td>6/1/92</td>
<td>SB</td>
<td>9,000</td>
<td>1.70</td>
<td>2,743.2</td>
<td>800</td>
<td>323.8</td>
<td>471</td>
<td>46,094.90</td>
</tr>
<tr>
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<td>28</td>
<td>6/1/91</td>
<td>SB</td>
<td>32,460</td>
<td>6.15</td>
<td>9,893.8</td>
<td>3,282</td>
<td>1,328.2</td>
<td>534</td>
<td>76,667.00</td>
</tr>
<tr>
<td>S67D1</td>
<td>2</td>
<td>9/1/92</td>
<td>SB</td>
<td>6,900</td>
<td>1.31</td>
<td>2,103.1</td>
<td>960</td>
<td>388.5</td>
<td>733</td>
<td>38,950.00</td>
</tr>
<tr>
<td>S47D1</td>
<td>2</td>
<td>8/1/90</td>
<td>SB</td>
<td>1,390</td>
<td>0.26</td>
<td>423.7</td>
<td>198</td>
<td>80.1</td>
<td>762</td>
<td>6,670.00</td>
</tr>
<tr>
<td>S20D1</td>
<td>2</td>
<td>9/1/90</td>
<td>SB</td>
<td>14,650</td>
<td>2.77</td>
<td>4,465.3</td>
<td>2,327</td>
<td>941.7</td>
<td>840</td>
<td>51,944.92</td>
</tr>
</tbody>
</table>

Average of 10 projects: 11,475 ft, 2.17 mi, 3,497.5 m, 1,004 ac, 406.3 ha, 444 ac/mi, 41,765.51 Cost
<table>
<thead>
<tr>
<th>Project ID</th>
<th>Number of Projects Constructed</th>
<th>Completed</th>
<th>Project Length (ft)</th>
<th>(mi)</th>
<th>(m)</th>
<th>Benefited Area (ac)</th>
<th>(ha)</th>
<th>(ac/mi)</th>
<th>Total Construction Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>E31D1</td>
<td>3</td>
<td>7/1/89</td>
<td>9,337</td>
<td>1.77</td>
<td>2,845.9</td>
<td>71</td>
<td>28.7</td>
<td>40</td>
<td>26,615.00</td>
</tr>
<tr>
<td>E50D1</td>
<td>1</td>
<td>9/1/95</td>
<td>4,396</td>
<td>0.83</td>
<td>1,339.9</td>
<td>215</td>
<td>87.0</td>
<td>259</td>
<td>39,077.00</td>
</tr>
<tr>
<td>E61D1</td>
<td>2</td>
<td>4/1/92</td>
<td>16,492</td>
<td>3.12</td>
<td>5,026.8</td>
<td>950</td>
<td>384.5</td>
<td>304</td>
<td>52,412.49</td>
</tr>
<tr>
<td>E56D1</td>
<td>15</td>
<td>10/1/89</td>
<td>12,500</td>
<td>2.37</td>
<td>3,810.0</td>
<td>855</td>
<td>346.0</td>
<td>361</td>
<td>39,055.79</td>
</tr>
<tr>
<td>E63D1</td>
<td>7</td>
<td>8/1/89</td>
<td>5,584</td>
<td>1.06</td>
<td>1,702.0</td>
<td>429</td>
<td>173.6</td>
<td>405</td>
<td>27,003.96</td>
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<tr>
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<td>3</td>
<td>9/1/90</td>
<td>6,171</td>
<td>1.17</td>
<td>1,880.9</td>
<td>507</td>
<td>205.2</td>
<td>433</td>
<td>87,244.07</td>
</tr>
<tr>
<td>E59D1</td>
<td>10</td>
<td>7/1/88</td>
<td>13,655</td>
<td>2.59</td>
<td>4,162.0</td>
<td>1,532</td>
<td>620.0</td>
<td>592</td>
<td>29,496.00</td>
</tr>
<tr>
<td>E38D1</td>
<td>3</td>
<td>8/1/91</td>
<td>18,131</td>
<td>3.43</td>
<td>5,526.3</td>
<td>2,444</td>
<td>989.1</td>
<td>713</td>
<td>100,652.52</td>
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<tr>
<td>E51D1</td>
<td>7</td>
<td>--</td>
<td>30,158</td>
<td>5.71</td>
<td>9,192.2</td>
<td>4,440</td>
<td>1,796.8</td>
<td>778</td>
<td>120,100.00</td>
</tr>
<tr>
<td>E65D1</td>
<td>10</td>
<td>11/1/88</td>
<td>24,088</td>
<td>4.56</td>
<td>7,342.0</td>
<td>4,315</td>
<td>1,746.3</td>
<td>946</td>
<td>50,424.61</td>
</tr>
<tr>
<td>E49D1</td>
<td>24</td>
<td>9/1/90</td>
<td>3,510</td>
<td>0.66</td>
<td>1,069.8</td>
<td>735</td>
<td>297.5</td>
<td>1,114</td>
<td>13,835.00</td>
</tr>
<tr>
<td>E29D84-1</td>
<td>1</td>
<td>12/1/90</td>
<td>13,385</td>
<td>2.54</td>
<td>4,079.7</td>
<td>3,014</td>
<td>1,219.7</td>
<td>1,187</td>
<td>75,903.00</td>
</tr>
<tr>
<td>E35D1</td>
<td>6</td>
<td>10/1/89</td>
<td>17,202</td>
<td>3.26</td>
<td>5,243.2</td>
<td>4,251</td>
<td>1,720.4</td>
<td>1,304</td>
<td>28,909.00</td>
</tr>
<tr>
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<td>23</td>
<td>7/1/92</td>
<td>11,070</td>
<td>2.10</td>
<td>3,374.1</td>
<td>8,184</td>
<td>3,012.0</td>
<td>3,897</td>
<td>58,734.52</td>
</tr>
</tbody>
</table>

**Average of 14 projects**: 13,263 2.51 4,042.5 2,282 923.3 881 53,533.07

**Total**: 249 342,584 64.89 104,419.5 47,368 19,169.5 1,422,819.94
It is expected that the cost per unit length of an open ditch project would be similar among the three methods if all costs were accounted for in similar fashion. However, the data in Table 2.13 indicates that the average cost per mile for constructing the mutual agreement projects is greater than for open ditch projects organized under the other procedures. The cost per acre is also higher ranging from just over $20.00 to over $95.00 per acre. By comparison, the cost of Senate Bill 160 projects ranges from $22.32 to $191.63 per acre, with an average cost of $62.27 per acre, and the county petition (CP) projects range from $6.80 to $374.86 per acre. The latter is a large range and reflects the wide range in area/length ratios. The high cost per acre project had a very low ratio of 40 acres per mile, while the low cost project had a high ratio of 1,304 acres per mile. Of course, costs vary widely among the projects, depending on site specific characteristics.

Respondents were asked to provide all costs of these projects by work item and source of funds. The source of funds reflects cost-share or grant funds available to groups for constructing projects. These data are listed in Table 2.14, and show that nearly 88% of the costs of these projects was borne by the landowners. The agency costs amounted to 8% of the total reported costs, while state and federal funds used for these projects amounted to 2.6% and 1.7% respectively. The federal share of expenses may be low, since many agencies did not report design costs for SB and MA projects. It is to be expected that there are some federal expenses in the design stage, because of soil scientist and engineer involvement, although these expenses are probably quite low in comparison to the total expenses incurred.
Table 2.13. Unit costs for construction of selected open ditch projects, 1988-1992.

<table>
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<tr>
<th>Project ID</th>
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<th>Unit Cost</th>
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<td>Per Mile</td>
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42
Table 2.14. Funding of individual ditch projects by source.

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Total: 1,301,746.97  115,197.15  42,298.00  25,646.82  1,484,888.94

Percent of total cost: 87.7%  7.8%  2.8%  1.7%
The cost by work item is broken down in Table 2.15. The earthwork costs were remarkably consistent across the three legal authorities, amounting to about 30% of total expenses. Surface inlets and rock chute expenses were a much higher proportion of the expenses for SB and MA projects, 15 – 18% of the total, compared to 1% for CP projects. This was unexpected, but may reflect the design practices of the agencies involved. The MA and SB projects are more likely to be designed by SWCD and NRCS personnel, who may be more aware of erosion concerns than county engineer personnel. By combining all erosion control related expenses, rock chutes, surface inlets, seeding and outlet pipes, we find that these expenses average 39% of the total for MA projects, 46% for SB projects, and only 19% for CP projects. These expenses are about twice as great for MA and SB as for CP projects, which may explain why we don’t see a large cost difference because of the differences in the way engineering costs are charged. Survey and design costs are about 9% of the total costs for CP projects. These costs were not well reported for SB projects. For MA projects, survey, design and layout costs averaged about 7.5% of the total, and were better reported than for SB projects.
Table 2.15. Ditch project construction expenses by item category for selected ditches.

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4.9% 2.6% 32.5% 11.0% 4.4% 15.6% 15.1% 5.6% 0.4% 4.2%
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|       | 1.7%              | 1.7%           | 32.2%                        | 9.6%              | 5.9%         | 18.1%          | 16.1%                  |

|       |       |       | 3.83500                      | 5.89420           | 29.15475    |

|       | 0.8%  | 1.2% | 6.1%                         |
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|                  | 13.2%     | 3.8%       | 36.6%          | 24.2%                        | 5.2%              | 1.0%        | 8.1%            | 1.2%                     | 0.8%     | 4.8%     |

Overall total    | 99,000.62 | 36,556.75  | 444,000.15     | 216,855.80                   | 69,204.98         | 123,741.26  | 156,961.79      | 22,022.80                | 71,723.76 | 67,028.64|
|                  | 6.7%      | 2.5%       | 30.0%          | 14.6%                        | 4.7%              | 8.3%        | 10.6%           | 1.5%                     | 4.8%     | 4.5%     |
Table 2.15. (continued)

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<th>Total Construction Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>E29D84-1</td>
<td>CP</td>
<td>4,480.00</td>
<td>0.00</td>
<td>3,500.00</td>
<td>2,150.00</td>
<td>3,736.00</td>
<td>0.00</td>
<td>75,903.00</td>
</tr>
<tr>
<td>E31D1</td>
<td>CP</td>
<td>10,500.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>215.00</td>
<td>987.00</td>
<td>26,615.00</td>
</tr>
<tr>
<td>E35D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>466.00</td>
<td>0.06</td>
<td>28,990.00</td>
</tr>
<tr>
<td>E38D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>5,984.70</td>
<td>154.64</td>
<td>26,515.00</td>
<td>0.00</td>
<td>100,652.52</td>
</tr>
<tr>
<td>E39D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>7,485.00</td>
<td>0.00</td>
<td>480.00</td>
<td>0.00</td>
<td>58,734.52</td>
</tr>
<tr>
<td>E49D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>560.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>13,835.00</td>
</tr>
<tr>
<td>E50D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>700.00</td>
<td>0.00</td>
<td>39,077.00</td>
</tr>
<tr>
<td>E51D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.00</td>
<td>0.00</td>
<td>120,100.00</td>
</tr>
<tr>
<td>E56D1</td>
<td>CP</td>
<td>150.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>2,055.54</td>
<td>350.00</td>
<td>39,055.79</td>
</tr>
<tr>
<td>E59D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>29,496.00</td>
</tr>
<tr>
<td>E61D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>458.36</td>
<td>3,000.60</td>
<td>52,412.49</td>
</tr>
<tr>
<td>E63D1</td>
<td>CP</td>
<td>0.00</td>
<td>240.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>27,003.96</td>
<td>50,424.61</td>
</tr>
<tr>
<td>E65D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>4,027.60</td>
<td>1,755.00</td>
<td>87,244.07</td>
</tr>
<tr>
<td>E67D1</td>
<td>CP</td>
<td>0.00</td>
<td>0.00</td>
<td>2,511.55</td>
<td>0.00</td>
<td>2,300.00</td>
<td>51,000.00</td>
<td>87,244.07</td>
</tr>
<tr>
<td>Subtotal for CP</td>
<td>15,130.00</td>
<td>240.00</td>
<td>20,041.25</td>
<td>2,304.64</td>
<td>40,953.50</td>
<td>57,692.00</td>
<td>618,035.96</td>
<td></td>
</tr>
<tr>
<td>Overall total</td>
<td>15,131.00</td>
<td>240.00</td>
<td>23,042.25</td>
<td>8,304.64</td>
<td>63,841.5</td>
<td>64,733</td>
<td>1,482,388.94</td>
<td></td>
</tr>
<tr>
<td>Percent of total</td>
<td>1.0%</td>
<td>0.0%</td>
<td>1.6%</td>
<td>0.6%</td>
<td>4.3%</td>
<td>4.4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
While these figures don’t give an entirely accurate picture of the cost breakdown by work item for the various types of projects, the author believes they are a fair approximation, since survey, design and engineering costs are a small fraction of the total cost. And while individual projects will vary in their cost breakdown, we can estimate that survey, design and layout costs for the average open ditch project will be about 10% of the cost, earthwork will amount to about 30%, brush 10 – 15%, and erosion control practices about 40% of the total costs.

Unit costs of ditch maintenance are shown for these open ditch projects in Table 2.16. Respondents listed maintenance expenditures by year for each of these projects. Using the year of construction as year one, these expenditures were converted to a present value at year one, then an annual payment was calculated that would equal the present value. The interest rate assumed was 7.5%.

Overall, unit costs range from $0.00 to $2,996.63 per mile and from $0.00 to $20.08 per acre. The high values are caused by the very small size of the project, rather than by large total costs. If we ignore the projects for which no expenses were reported and the very small project, E23D1, we find the average ditch maintenance cost for individual projects ranges from $0.01 to 7.93 per acre and from $5.95 to $1,030.29 per mile. Average cost by legal authority for projects with non-zero expenditures is $0.52 per acre and $484.10 per mile for MA projects, $0.58 per acre and $228.04 per mile for SB projects, and $1.11 per acre and $327.39 per mile for CP projects. Nearly all projects have an annual maintenance cost of less than $1.00 per acre. Of course, individual parcel costs may be many times more or less than the average, depending on the way the costs
are allocated among the benefiting parcels. Cost allocation methods are reviewed in chapter 3.

This large variation in maintenance costs for these ditch projects is intriguing, and would make an interesting study. Possible explanatory variables include the soils, weather conditions at and soon after the time of construction, inclusion of erosion control measures, the cost categories that are included as maintenance costs (for example, how are administrative fees handled), adequacy of design, attitude of administering authority towards maintenance, size of project, area/length ratio, and others.
Table 2.16. Unit costs of ditch maintenance for selected open ditch projects through 1996.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Legal Authority</th>
<th>Year Constructed</th>
<th>Benefited Area (ac)</th>
<th>Project Length (ft)</th>
<th>Annual Maintenance Expenses</th>
<th>Equivalent Average Project Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>per acre</td>
<td>per hectare</td>
</tr>
<tr>
<td>E31D1</td>
<td>CP</td>
<td>1989</td>
<td>71</td>
<td>9,337</td>
<td>562.91</td>
<td>7.93</td>
</tr>
<tr>
<td>E35D1</td>
<td>CP</td>
<td>1989</td>
<td>4,251</td>
<td>17,202</td>
<td>137.93</td>
<td>0.03</td>
</tr>
<tr>
<td>E38D1</td>
<td>CP</td>
<td>1991</td>
<td>2,444</td>
<td>18,131</td>
<td>445.59</td>
<td>0.18</td>
</tr>
<tr>
<td>E39D1</td>
<td>CP</td>
<td>1992</td>
<td>8,184</td>
<td>11,070</td>
<td>1,637.22</td>
<td>0.20</td>
</tr>
<tr>
<td>E49D1</td>
<td>CP</td>
<td>1990</td>
<td>735</td>
<td>3,510</td>
<td>684.91</td>
<td>0.93</td>
</tr>
<tr>
<td>E51D1</td>
<td>CP</td>
<td>--</td>
<td>4,440</td>
<td>30,158</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>E56D1</td>
<td>CP</td>
<td>1989</td>
<td>855</td>
<td>12,500</td>
<td>368.74</td>
<td>0.43</td>
</tr>
<tr>
<td>E59D1</td>
<td>CP</td>
<td>1988</td>
<td>1,532</td>
<td>13,655</td>
<td>40.97</td>
<td>0.03</td>
</tr>
<tr>
<td>E60D1</td>
<td>CP</td>
<td>1991</td>
<td>27</td>
<td>1,022</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>E61D1</td>
<td>CP</td>
<td>1992</td>
<td>950</td>
<td>16,492</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>E63D1</td>
<td>CP</td>
<td>1989</td>
<td>429</td>
<td>5,584</td>
<td>404.39</td>
<td>0.94</td>
</tr>
<tr>
<td>E65D1</td>
<td>CP</td>
<td>1988</td>
<td>4,315</td>
<td>24,088</td>
<td>1,881.06</td>
<td>0.44</td>
</tr>
<tr>
<td>E67D1</td>
<td>CP</td>
<td>1990</td>
<td>507</td>
<td>6,171</td>
<td>6.95</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Average costs for all ditches in this category

<table>
<thead>
<tr>
<th>Equivalent Average Project Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>per acre</td>
</tr>
<tr>
<td>0.79</td>
</tr>
</tbody>
</table>

Average costs for ditches with non-zero expenditures

<table>
<thead>
<tr>
<th>Equivalent Average Project Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>per acre</td>
</tr>
<tr>
<td>1.11</td>
</tr>
<tr>
<td>Project ID</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>E23D1</td>
</tr>
<tr>
<td>E47D1</td>
</tr>
<tr>
<td>S33D1</td>
</tr>
<tr>
<td>S37D1</td>
</tr>
<tr>
<td>S42D1</td>
</tr>
<tr>
<td>S46D1</td>
</tr>
<tr>
<td>S57D1</td>
</tr>
<tr>
<td>S58D1</td>
</tr>
<tr>
<td>S62D1</td>
</tr>
<tr>
<td>S68D1</td>
</tr>
</tbody>
</table>

Average costs for all ditches in this category: 2.42 5.99 686.95 426.85
Average costs for ditches with non-zero expenditures, less E23D1: 0.52 1.28 484.10 306.81

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Legal Authority</th>
<th>Year Constructed</th>
<th>Benefited Area (ac)</th>
<th>Project Length (ft)</th>
<th>Equivalent Annual Maintenance Expenses</th>
<th>Average Project Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>E22D1</td>
<td>SB</td>
<td>1991</td>
<td>3,282</td>
<td>32,460</td>
<td>1,912.50</td>
<td>0.58</td>
</tr>
<tr>
<td>S20D1</td>
<td>SB</td>
<td>1990</td>
<td>2,327</td>
<td>4,650</td>
<td>1,020.57</td>
<td>0.44</td>
</tr>
<tr>
<td>S22D1</td>
<td>SB</td>
<td>1996</td>
<td>454</td>
<td>8,271</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>S29D1</td>
<td>SB</td>
<td>--</td>
<td>240</td>
<td>6,500</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>S53D1</td>
<td>SB</td>
<td>1987</td>
<td>350</td>
<td>13,570</td>
<td>422.27</td>
<td>1.21</td>
</tr>
<tr>
<td>S55D1</td>
<td>SB</td>
<td>1989</td>
<td>1,370</td>
<td>19,160</td>
<td>376.21</td>
<td>0.27</td>
</tr>
<tr>
<td>S56D1</td>
<td>SB</td>
<td>1992</td>
<td>800</td>
<td>9,000</td>
<td>329.56</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Average costs for ditches with non-zero expenditures: 0.58 1.44 228.04 141.70
2.4 Summary and Recommendations

A survey of county engineer offices and SWCDs in 50 counties was conducted in 1997 to measure the extent of new group drainage project activity and obtain information about the size of ditch maintenance programs to compare with previous survey data. The participation rate was high, although some information was not provided by several agencies because of high workloads preventing the research necessary for local agency personnel to summarize the data. In particular, the information obtained for total benefited area and the breakdown of projects by legal authority is not complete.

Demand for group drainage projects remains high in many counties in Ohio. The number of requests for assistance with group drainage projects during 1994-1996 remained fairly steady, averaging about 150 requests annually for the counties reporting. Nearly half (48%) of the requests were for projects to be organized under the mutual agreement (MA) process. These requests were almost always approved by the administrative authority.

County petition requests are the second most numerous, with 136 total requests made during 1994 – 1996, 30% of the total requests for all legal authorities. Only 75% of these requests were approved, with 26% of the total being rejected or withdrawn. These total more than 100% presumably because of requests carried over from the previous year.

SB-160 requests make up 22% of the total. The smaller number of SB requests reflects the smaller number of counties using this process. The number of active SB requests at the end of the year increased dramatically from 55 in 1994 to 86 in 1996, an increase of 56%. At the end of 1996, there was a backlog equivalent to over three years
worth of SB requests. By contrast, the MA backlog is approximately 1 year (79 requests active vs. 72 new requests annually), and the CP backlog is less than 2 years (79 requests active vs. an average of 45 new requests annually).

Agencies in 37 counties reported the construction of 342 projects costing over $9.5 million for the three year period. Subsurface mains were most numerous with 153 reported, followed by 134 open ditch projects. About 192.4 miles (309.6 km) of open ditches were constructed over the three year period. These open ditches benefited 144,127 ac (58,276 ha) of land.

Of the 50 counties in the survey, 34 ditch maintenance programs are administered by the county engineer’s office and 13 by SWCDs. Three counties reported no ditch maintenance program. Total maintenance fund expenditures reported for the 47 county programs in 1996 amounted to $2,754,064.81. These counties reported $56,372.22 in other expenditures, for total maintenance expenditures of $2,810,437.03. Six counties reported no expenditures for the ditch maintenance program during 1996. Thirty-two counties reported 2,384,285 acres (964,907 ha) benefiting from projects on their ditch maintenance programs. Projecting from these numbers, the author estimates that about 3.1 million acres (1.25 million ha) of land is benefited by ditch maintenance programs statewide.

Thirty-eight agencies provided detailed information about open ditch projects constructed during the period 1988-1992. The most important reason given for constructing these open ditches was to provide an adequate outlet for subsurface drains, the second most important reason was to improve crop production, and the third most important was to place the ditch on the county maintenance program.
Mutual agreement projects are typically smaller projects, measured either by length or area, than are county petition (CP) or Senate Bill 160 (SB) projects. SB projects seem to be slightly shorter than CP projects, 2.17 mi vs. 2.51 mi, although not greatly so. However, the average benefited area for the SB projects is less than half the benefited area of the CP projects for these projects.

Landowners bore 88.7% of the costs of the individual ditch projects reported in this survey. The agency costs amounted to 7.8% of the total reported costs, while state and federal funds used for these projects amounted to 2.8% and 1.7% respectively. By combining all erosion control related expenses, rock chutes, surface inlets, seeding and outlet pipes, we find that these expenses average 39% of the total for MA projects, 46% for SB projects, and only 19% for CP projects. The earthwork costs were remarkably consistent across the three legal authorities, amounting to about 30% of total expenses. Survey and design costs are about 9% of the total costs for CP projects and about 7.5% for MA projects. These costs were not well reported for SB projects. We can estimate that for new open ditch improvements that survey, design and layout costs for the average open ditch project will be about 10% of the cost, earthwork will amount to about 30%, brush 10 – 15%, and erosion control practices about 40% of the total costs.

This was the first time new group drainage construction activity in Ohio has been quantified. The main problem was the lack of complete participation by the counties. This was because of a high workload and the lack of a current summary of projects that are currently on the maintenance program.

To address the first deficiency, we could prepare worksheets (Fig. 2.1) that agencies could use to summarize data for individual project requests as they are
A. Draft worksheet for tracking the fate of requests for group drainage project assistance.

<table>
<thead>
<tr>
<th>Project Name or ID</th>
<th>Type of Request (CP, MA, Component SB)</th>
<th>Date Action Was Taken on Request</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>First Hearing or Meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second Hearing or Meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Final Hearing or Meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approved for Construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rejected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Withdrawn</td>
</tr>
<tr>
<td>Date Construction Completed</td>
<td>Date Placed on Maintenance Program</td>
<td></td>
</tr>
</tbody>
</table>

B. Draft worksheet for tracking construction costs of group drainage projects constructed under the authority of the Ohio drainage laws.

<table>
<thead>
<tr>
<th>Project Name or ID</th>
<th>Component attributes</th>
<th>Project Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Length (feet)</td>
<td>Costs Paid by Landowners Jointly (assessments)</td>
</tr>
<tr>
<td></td>
<td>Area Benefited (acres)</td>
<td>Special Charges To Individuals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Costs Incurred By Your Agency Not Assessed To Landowners</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Costs Assessed To Or Paid By Local Government (including cost-share)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Costs Assessed To Or Paid By State Government (including cost-share)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Costs Paid By Federal Government (including cost-share)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Costs Funded By Other Entities (grants)</td>
</tr>
</tbody>
</table>

Figure 2.1 Draft worksheets to be completed by local agency in order to facilitate the collection of information regarding the fate and cost of group drainage projects requested by landowner.
submitted and processed through rejection or construction. If agency personnel are
diligent in keeping these worksheets up-to-date, the information could be submitted and
summarized on a statewide basis annually or less often, with little extra effort on the part
of agency personnel. This would also eliminate the need for agency personnel to
summarize the information; it could be done at the state level. The worksheet could be
implemented as a computer spreadsheet or database at the local level, in which case it
would provide the agencies with current information whenever needed. As resources
become available, this same information could be entered on this worksheet for projects
already on the maintenance program.

It may be worth considering a statewide project to obtain this information for all
counties in Ohio. Several agencies do not have their group drainage records summarized
or in a computer database. A multi-agency project could be developed to create a
database of information regarding historic group drainage activities and background data
of projects on the county maintenance program in each county.

This worksheet could be based on the survey instrument used in this study, but
with some enhancements to improve the quality of the information. For instance,
agencies were not asked for the reasons that requests were rejected or withdrawn, or even
to differentiate between the two outcomes. The agencies should be asked to specify
which action was taken and why.

Ohio drainage laws are used for projects other than ditches, grassed waterways
and agricultural subsurface drains. These additional types of projects include subdivision
storm drains, stormwater detention/retention basins and logjam removal in streams.
These items should be covered in the spreadsheets
Last, there is some confusion generated when one project contains more than one component. For instance, one project may include both a subsurface main and an open ditch. A solution would be to categorize the project by its major component, but also to list any other components that are a part of the project. This could easily be implemented in the worksheet mentioned earlier.

2.5 References


CHAPTER 3

SURVEY AND EVALUATION OF GROUP DRAINAGE IMPROVEMENT
ASSESSMENT PROCEDURES IN OHIO

3.1 Introduction

In the previous chapter, we saw that Ohio landowners spend approximately $3 million annually for the construction of over 100 new group drainage improvements - defined as a drainage improvement for which more than one landowner contributes to the construction and maintenance - which benefit over 23,000 ha of land. This represents an average capital investment of about $130/ha for improved drainage. In addition, over $1.8 million is spent by Ohio landowners for maintenance of previously completed group drainage improvements which have been placed under county drainage maintenance programs. These group drainage improvements serve as outlets for subsurface drainage and on-site septic systems, and help reduce the impacts of flooding on agricultural and rural residential land. Improvements may also include stormwater detention and retention basins in urban areas, but these make up a small part of the totals reported above.

Construction and maintenance costs of these improvements are paid by special assessment of the benefiting land. As with any assessment or tax, these assessments are often controversial. By law, these assessments are to be made in proportion to the special benefits resulting from the improvement. However, mechanisms for estimating special
benefits resulting from group drainage improvements have not been well defined. The agencies calculating the assessments use formulae that have not been rigorously researched or shown to correspond to the special benefits resulting from the construction of these improvements. The relationship of assessments to benefits is often difficult to explain to landowners. Thus, there is a need to determine better ways to estimate the special benefits that result from construction of group drainage improvements.

Finally, it is not only the landowners who lack understanding of assessment methodology. Agency personnel in counties that do not have a history of drainage improvement work often do not have the understanding needed to provide a high level of service to their constituency. Merely reading the statutes does not reveal all of the issues that are involved in group drainage improvement projects. It is hoped that this chapter will provide improved understanding to agency personnel involved in the group drainage process.

The research described here was conducted as part of a larger project, part of which was presented in Chapter 2. In this paper, the development of the legal system for group drainage improvements is reviewed, assessment methods used in Ohio are identified, and their implementation is discussed. Agency comments and suggestions are reviewed and suggestions made for future work.

3.1.1 Ohio drainage laws

Both the legislature and the courts have influenced the development of drainage laws in Ohio. In this section we will review the laws and important court decisions that have affected the development of drainage law in Ohio, especially as they relate to the
assessment of property for the costs of drainage improvements. We will see that the wording found in most of the current statutes dates from 1923, although there were important additions in 1957 and 1969.

As we relate the history of drainage statutes in Ohio, we find that the overall body of laws has been named differently at various times. There have been two major recodifications of Ohio statutes following the first general revision and consolidation of all Ohio statutes published in 1880 and known as the Revised Statutes. In 1910, a new codification, the General Code took effect. The statutes were again recodified and renumbered in 1953 by the Bureau of Code Revision. These are known as the Revised Code of Ohio which is in use today (Anderson, 1998).

Ohio drainage law dates to March 26, 1841, when the General Assembly, in 39 Ohio Laws 122, first provided for the appointment of 'commissioners of sewers' in certain counties. Under the provisions of this law, the courts of common pleas were empowered to appoint persons for "clearing and removing the banks and obstructions of the passages of the water in rivers, brooks, streams or ponds, which occasion the overflowing and drowning of meadows, swamps and lowlands..." (Schwartz, 1955). These commissioners were given the right to enter onto any adjoining lands or open drains, and were to assess the landowner for the costs of the improvement "according to their quantity of land and the benefits they receive in such proportion as they shall judge to be equal and just..." (Schwartz, 1955).

In 1859 the legislature, in 56 Ohio Laws 58, gave control of the construction of group drainage improvements to the boards of county commissioners. These laws specified that a landowner or landowners who desired a group drainage improvement had
to file a petition with the county auditor to start the process, and had to file a bond to cover costs in case the board of commissioners did not grant the petition. There was provision for a hearing on the merits of the improvement by the board of county commissioners, and for a levy upon the lands benefiting from the improvement (Schwartz, 1955). These basic provisions continue to this day as part of the county petition process found in ORC Chapter 6131.

Property benefited by construction of a drainage improvement was to be assessed in proportion to those benefits. In Blue v. Wentz (54 Ohio St. 247, 1896), the Ohio Supreme Court upheld the application of the civil-law rule to drainage assessments. In the syllabus the court stated:

“1. Where the lands of an owner, by reason of their situation, are provided with sufficient natural drainage, they are not liable for the costs and expense of a ditch necessary for the drainage of other lands, simply for the reason that the surface water of his lands naturally drain therefrom to and upon the lands requiring artificial drainage.

“2. A lower tenement is under a natural servitude to a higher one to receive from it all the surface water, accumulating from falling rains and melting snows, or from natural springs, that naturally flow from it to and upon the lower one. This advantage of the higher tenement is a part of the property of the owner in it, and he is not indebted to the lower tenement therefor.

“3. In making an assessment on lands, benefited by artificial drainage, the extent of their watershed is not the proper rule, but the amount of surface water for which artificial drainage is required to make them cultivable, and the benefits that will accrue to the lands from such drainage. However much water may fall on them or arise from
natural springs, if, by reason of their situation, they have adequate natural drainage therefore, they are not liable for the cost of artificial drainage to other lands."

In 1900 this decision was codified into Section 4448 of the Revised Statutes by the legislature: "The words 'according to the benefits' used in this chapter in directing boards of county commissioners to assess lands for ditches and in directing engineers to report assessments for the same shall not be held to authorize any assessments for benefits conferred upon lands by nature nor the right of easement of the owners of superincumbent lands to pass the water therefrom through natural watercourses" (Mason v. Commissioners of Fulton County, 80 Ohio St. 151, 1910).

In 1910, in the case of Mason v. Commissioners of Fulton County (80 Ohio St. 151) the Ohio Supreme Court upheld the application of the civil-law rule and found that "a landowner may, in the reasonable use of his land, drain the surface water from it into its natural outlet, a watercourse, upon his own land, and thus increase the volume and accelerate the flow of water without incurring liability for damages to owners of lower lands; and his land is not subject to assessment for the cost of a ditch, or an improvement, that will not benefit its drainage but is constructed to prevent overflow from the watercourse or to benefit the drainage of servient lands."

The ditch laws were recodified in 1919 in 108 Ohio Laws 926 with extensive changes. All terms were more carefully defined, especially 'benefit' or 'benefits' which "shall be deemed to cover any advantage to the owner of the land or lands by reason of the improvement either by making the same more healthful or increasing the productivity or value thereof to him, or by reclamation [sic] and increase of market value adding to the
taxable value for the purpose of public taxation or increasing the healthfulness of the vicinity" (Schwartz, 1955).

Certain provisions in the drainage laws were soon found unconstitutional by the courts (Cottrell et al. v. County Commissioners et al., 24 ONPNS 281; The State, ex rel. Shafer et al., v. Otter, County Surveyor, 106 Ohio St. 415). Because of these decisions, the drainage laws were again revised in 1923 in 110 Ohio Laws 161. Regarding assessments and benefits, the law now provided that "the surveyor ... shall levy the assessments according to benefits; and all land affected by said improvement shall be assessed in proportion as it is specially benefited by the improvement and not otherwise" (Schwartz, 1955). The wording of this and other sections of the drainage laws is very similar to that found in present day Chapters 6131 and 6133 of the Revised Code.

However, the provision relieving upper lands of their burden if they had sufficient natural drainage was not included in 110 Ohio Laws 161. How this affected drainage assessments after that date is unclear, but in 1952, the Court of Appeals of Ohio, Third Appellate District, noted that the statutory provisions had changed since Mason v. Commissioners of Fulton County (In re Joint County Ditch No. 1108-2, 94 Ohio App. 169, 1952). This court found that the dominant lands of this project would be specially benefited by the improvement through the removal of silt and sewage. Later, in 1991, the Court of Appeals of the Sixth Appellate District also cited the change in statutory provisions and noted that the legislature in paragraph 6131.01(F) expressly codified the intent that upper lands were benefited when an improvement was made to discharge water resulting from a change in land use from its natural state. Thus, the legislative intent at the beginning of the century was entirely different than it is now.
Another provision of the 1923 revisions provided that landowners could appeal assessments in Common Pleas Court. A review of the appeal process and some of the important cases will serve to illustrate the application of drainage law, especially as it pertains to assessments and benefits. Appeals are provided in Section 6131.25 of the Revised Code which is based on Section 6467 of the General Code: "Any affected owner may appeal to the court of common pleas within twenty-one days of the date that any order was issued by the board of county commissioners, as provided in Sections 6131.01 to 6131.64 of the Revised Code, and may appeal any one or more of the following questions:

(A) Is the improvement necessary?

(B) Will the improvement be conducive to the public welfare?

(C) Is the cost of the improvement greater than the benefits conferred?

(D) Is the route, termini, or mode of construction the best to accomplish the purpose of the improvement?

(E) Are the assessments levied according to benefits?

(F) Is the award for compensation or damages just?

The appeal may be taken from any order affecting any part of the improvement as well as from any order affecting the entire improvement" (Anderson, 1997).

In considering the appropriateness of special assessments, the reviewing court will ordinarily indulge a presumption in favor of the correctness and propriety of the order under review (84 Ohio Jur. 3d, Section 462). Indeed, it is incumbent upon the appellant, the person appealing the order, to prove his case. In Lucas v. Blaine (1931, 42 Ohio App. 177; 181 N.E. 269), the Court of Appeals held that: "Assessments according
to benefits of land affected by proposed drainage ditch as prepared by surveyor and board of county commissioners cannot be lightly set aside." In the absence of proof to the contrary, when the board of commissioners has apportioned the cost of an improvement, and has, on due notice, heard exceptions thereto, it will be presumed that such apportionment is just and fair and was made with reference to benefits to be derived from the improvement (84 Ohio Jur. 3d, Section 462). In its discussion in Lucas v. Blaine (42 Ohio App. 177), the court recognized that "...there is no hard and fast rule by which the benefits can be determined with mathematical accuracy. That, in the very nature of things, is a matter of forecast and estimation. The experience of the county surveyor, who made the assessments, and the conclusions of the board of county commissioners, who amended, corrected, confirmed, and approved the assessments, cannot be recklessly set aside and a mere guess substituted therefor." Thus, it appears that so long as the county engineer (surveyor) and board of county commissioners act in a reasonable way, in substantial compliance with the law regarding notification and hearings, it will be difficult for an appellant to have the assessments set aside.

Another often misunderstood provision of the drainage laws is the provision that the public welfare must also be benefited by an improvement (Section 6131.25 ORC). However it is not the general public that must be benefited, but that of the local area. The courts have held that if it appears that the proposed ditch will be "conducive to the public health, convenience and welfare of the neighborhood" through which it will pass, the commissioners are authorized to construct the improvement (Chesbrough v. Commissioners, 37 OS 508, 1882).
Following the recodification of the General Code into the Ohio Revised Code, the Ohio Legislative Service Commission investigated several questions for the legislature, among them: “Are present methods of benefit assessment workable and equitable? How might they be improved?” In their report, Peters and Ingler (1955) found that the “drainage laws do not provide a clear, specific, workable scheme for apportionment of costs of drainage improvements. This causes confusion, controversy, and considerable dependence upon the courts for development of rules for distribution of the financial burden. There is need to establish an understandable and equitable rule for assignment of costs.” They also felt that the statutes directed the county engineer and the board of county commissioners to “…levy assessments according to benefits, without giving guidance as to what benefit is and how it is to be measured.”

Peters and Ingler (1955) found several general ways in which assessments were calculated:

1. Percent of the ditch used;
2. Proximity to the channel;
3. Acreage drained;
4. Volume of water discharged into the channel; and
5. Negotiation.

They also found that various combinations of these were used. They noted: “It is widely believed that there is need for a uniform statutory rule for the definition of benefits, which would clearly and formally authorize assessments against any landowners in the watershed whose properties contribute to the need for the drainage facility and cost of it.”
The findings of Peters and Ingler (1955) apparently resulted in a revision of the definition of benefits which took effect in 1957. The term "benefit" was defined in greater detail, with several factors itemized in paragraph 6131.01 (F) of the Revised Code (Anderson, 1997):

"Benefit" or "benefits," except as ordered in section 6131.31 of the Revised Code, means advantages to land and owners, to public corporations as entities, and to the state resulting from drainage, conservation, control and management of water, and environmental, wildlife, and recreational improvements. Factors relevant to whether such advantages result include:

(1) The watershed or entire land area drained or affected by the improvement;

(2) The total volume of water draining into or through the improvement and the amount of water contributed by each land owner;

(3) The use to be made of the improvement by any owner, public corporation, or the state.

"Benefit" or "benefits" includes any or all of the following factors:

Elimination or reduction of damage from flood;

Removal of water conditions that jeopardize public health, safety, or welfare;

Increased value of land resulting from the improvement;

Use of water for irrigation, storage, regulation of stream flow, soil conservation, water supply, or any other purpose incidental thereto;
Providing an outlet for the accelerated runoff from artificial drainage whenever the stream, watercourse, channel, or ditch under improvement is called upon to discharge functions for which it was not designed by nature; it being the legislative intent that uplands that have been removed from their natural state by deforestation, cultivation, artificial drainage, urban development, or other manmade causes shall be considered as benefited by an improvement required to dispose of the accelerated flow of water from the uplands.”

Ohio Revised Code Section 6131.01 is referenced by Section 1515.24 with respect to assessments for conservation works of improvement constructed by soil and water conservation districts, and in Section 6131.15 with respect to county petition drainage improvements. Section 6131.15 reads, in part:

“...In determining the estimated drainage assessments for a parcel, the county engineer shall give primary consideration to the potential increase in productivity that the parcel may experience as a result of the improvement and shall also give consideration to the quantity of drainage contributed, the relative location of the property to the project, the portion of the project through which the drainage from the parcel flows, the value of the project to the watershed, and benefits as defined in section 6131.01 of the Revised Code...(emphasis added)

This section goes on to add: “The county engineer, in making his estimate of the amount to be assessed each tract of land, each public corporation, and the state in accordance with this section, and the board of county commissioners, in amending, correcting, confirming, and approving the assessments in accordance with section 6131.22 of the Revised Code, shall levy the assessments according to
benefits. *Each tract of land and public corporation affected by an improvement and the state shall be assessed in the proportion that each is benefited by the improvement, as "benefit" and "improvement" are defined in section 6131.01 of the Revised Code, and not otherwise* (emphasis added).

The determination of benefits is important not only for construction assessments, but also for maintenance of drainage improvements. In 1957, Section 6137.02 of the Revised Code mandated the establishment of a maintenance fund for all new drainage improvements constructed under the authority of Chapters 6131, 6133 and 6135 of the Revised Code. Maintenance funds are obtained by assessments against benefiting property based on the original construction assessments. However, this was not always the case.

The maintenance of group drainage projects is a problem of the commons; that is, the group of landowners effectively “own” the project, but it may not be in each owner’s best interest to maintain the entire ditch. Early Ohio drainage law provided that each owner was responsible for maintaining a section of the project assigned him by the drainage supervisor (Schwartz, 1955). However, not all ditches, and not all sections of ditches were maintained properly, and early records show that many ditches were repetitioned and re-constructed every 10-15 years (Channel Modification Task Force, 1972). To properly maintain drainage improvements, it was found necessary to establish a county maintenance fund that could pay for annual maintenance of a drainage improvement.

It was not until 1947 that the statutes provided for the establishment of a fund by the county commissioners for maintenance of single and joint county ditches after
construction. Under the 1947 law, a maintenance fund could be established by petition of a majority of landowners in a drainage area following hearings to determine if the establishment of the maintenance fund would be conducive to public welfare. The fund was to be maintained by an annual assessment upon the benefited lands at a sum per acre as found adequate by the board or joint board (122 Ohio Laws 655 from Schwartz, 1955). However, this apparently did not solve the maintenance problem, and a bill was passed in 1957 that provided for all county petition ditches to be placed on a county ditch maintenance program following construction. Later, in 1965, provision was made for mutual agreement projects to be placed on a county maintenance program.

In 1969, Senate Bill 160 (SB-160) was passed by the legislature which authorized conservation works of improvement by the SWCDs. The SB-160 procedure was often used to construct drainage improvements. Section 1515.29 ORC mandated that these improvements be maintained by the board of county commissioners following construction. Although this section did not explicitly mention the county ditch maintenance laws found in Chapter 6137 ORC, these provisions were often used to maintain Senate Bill 160 projects. This situation was formalized in 1998 when Section 1515.24 RC was amended to allow the board of county commissioners to use Chapter 6137 RC procedures for the levying of maintenance assessments for SB-160 projects (Anderson, 1999).

3.1.2 Group drainage assessment methodology

Very little published work has been found on group drainage assessment methods. In a USDA bulletin, Boyd and Hart (1924) provide a general review of assessment

The bulletin by Boyd and Hart (1924) resulted from a study of the practices used to assess benefits under the state drainage laws in the United States. Boyd and Hart (1924) suggest that the construction of drainage improvements involves two major tasks, an engineering problem of providing the required drainage, and the financial problem of how to pay for the improvement. They suggest that the latter problem results in the greatest number of failures to complete a project, often involving lawsuits and subsequent delay and expense. Boyd and Hart (1924) found “a very evident lack of appreciation of the principles of assessments on the part of lawmakers, engineers, and assessors.” Although written in 1924, this bulletin provides a good review of the subject of drainage assessments.

Relative to assessments, there are two kinds of benefits resulting from local improvements - general benefits and special benefits. General benefits are those enjoyed by the public, such as increased healthfulness, convenience and general prosperity (Boyd and Hart, 1924). Examples of general benefits include public health benefits, public road
benefits and public interest in the condition of the land\textsuperscript{5}. In Ohio, the courts have held that it is the public health, convenience or welfare of the community to be affected by the proposed ditch, and not that of the public at large, that is to be regarded in the construction of a ditch (Chesbrough v. Commissioners, 37 Ohio St. 508).

A special assessment is defined in 84 Ohio Jur. 3d (Glown, 1988): "Special assessments, as distinguished from taxes in the strict sense, are charges imposed by the public authorities on property in the immediate vicinity of a public improvement, to pay the cost of the construction, and made with reference to the special benefit which the property derives from the improvement." The term benefit, with respect to the validity of special assessments, is defined in the same volume as "an actual increase in money value, and a potential or actual or added use and enjoyment of the property; rather than simply an advance or increase in market value..." This reference also notes that: "In the apportionment of an assessment, the assessing authorities may properly formulate and apply general rules to aid in determining the proportionate amount of benefit to each tract (84 Ohio Jur. 3d, Section 63).

Depending on the circumstances in each case, several special benefits may accrue to a property from drainage improvement. However, only those specific benefits because of the improvement can be entertained. Boyd and Hart (1924) found this principle to be

\textsuperscript{5} Publics perceptions change over time, and what is perceived as a public benefit in the late twentieth century is different from perceived public benefits in the late nineteenth century. For example, wetlands were perceived a public nuisance and their draining was deemed to be beneficial 100 years ago. Today, the public perception of wetlands appears to have shifted towards wetlands as being a public asset, to the extent that public funds are expended to maintain and enhance existing wetlands and re-establish lost wetland areas. What Boyd and Hart describe as the universal recognition of "the general benefit to public health from drainage of swamp and overflowed lands..." no longer holds, as witnessed by legislation such as the Clean Water Act and the 1995 Farm Bill.
commonly violated, because of the failure of the assessor to give proper credit for the
natural or artificial advantages possessed by a tract of land.

"The basic rules which should be followed in all cases are that the assessments
must be proportional to the resulting benefits and the ratio of assessments to benefits
must the be same throughout the district. The assessments are not to be based upon the
cost of any part of the work but upon the benefits resulting from such work." Lands that
require a deeper ditch than others will probably be valued lower for drainage purposes
than more favorably situated ditches, and thus have greater benefit if the restrictions are
removed, which would then value all land nearly the same after the project (Boyd and
Hart, 1924).

One of the main benefits to agricultural land is the increase in productivity
resulting from a drainage improvement. While increased productivity from the
installation of subsurface and surface drainage at the field level has been studied and
documented in Ohio (Schwab et al., 1963; 1975; 1985; Brown et al., 1998), and
elsewhere, comparatively little has been done to investigate the benefits because of
having an outlet for these subsurface drains, and for providing for improved conveyance
of runoff by an improved ditch. Other benefits include improved access, for example,
when a tract of land is surrounded by low, wet lands (Boyd and Hart, 1924).

Boyd and Hart (1924) state that "...the measure of the benefit derived from
drainage is the increase in the value of the land, due solely to the improvement..." and
suggest that the improved value of the land after drainage is equivalent to the value of
high or drained lands in the vicinity, which, in their opinion, should make it fairly easy to
evaluate the benefits. They also identify the following general factors that can be considered when assessing benefits:

a) The need for drainage or the wetness of the property;
b) The amount of drainage furnished;
c) Increased healthfulness;
d) Increased accessibility; and
e) The use made of the property.

The process of apportioning assessments assigns benefits and costs to each parcel of land. Two approaches are generally used in apportioning assessments according to the benefits. One is to evaluate the benefits received by the various tracts of land in dollars and apportion the costs according to the respective benefits. The other approach is to estimate the separate factors involved in percentages or other indefinite quantities to arrive at a relative benefit among the parcels, and then apportion the costs according to the relative benefits. The second approach is most often used in Ohio.

Sometimes topographic or other features which clearly affect the cost of a project result in the division of a project into subdistricts for assessment purposes. This might occur on larger drainage projects when an easily identifiable subwatershed exists. In these cases, parcels must be evaluated for benefits from each part of the main project. Land is subject to assessment by two improvements if it receives special benefits from both improvements.

It is more difficult to determine benefits for land uses other than agriculture. Boyd and Hart (1924) found that it was often difficult to measure the benefits to railroad property. They suggested three factors that could be evaluated to determine benefits: a) a
reduction in flood damage to the railway; b) removal of surface water from the right-of-way; and c) a decrease in the length or number of trestles and bridges required after completion of the project. The determination of highway assessments is similar to railroad assessments. To evaluate the benefits of a drainage improvement on roads, one could a) compare maintenance costs of undrained roads with costs of roads with improved drainage, or b) evaluate the amount of traffic that avoids a road because of poor drainage conditions.

Three major methods of determining assessments were found by Boyd and Hart (1924): 1) The classification method; 2) the percentage method; and 3) the actual value of the benefits method. Each is described below.

As of 1924, the classification method was prescribed by statute in North Carolina and in several southern states. Boyd and Hart (1924) describe the operation of this method as follows: Parcels of land are divided for assessment into five classes, based on the degree of wetness of the land, its proximity to the ditch or natural outlet, and the fertility of the soil. The land with the highest benefit is identified as Class A, the next highest benefit Class B, the third highest benefit Class C, the fourth highest benefit Class D, and the land receiving the least benefit is identified as Class E, with the assessments for each class of land assigned in the ratio of 5, 4, 3, 2 and 1 for classes A through E, respectively.

Boyd and Hart (1924) had several objections to this method. First, the benefiting parcels of land must be divided into the appropriate classes, with the relative benefits among the classes in the prescribed ratio. This would involve adjusting boundaries of the various classes until the appropriate ratio is approximated, and would be difficult to do.
They also felt that this method would be confusing to landowners, and it would be impossible for the assessors or landowners to know the effects of any change in classification of a parcel until all computations are completed. Their conclusion was that this method is far too inflexible to provide for equitable assessments.

The second method described by Boyd and Hart (1924) is the percentage method, which they suggested was "...evidently the invention of an engineer. In this method, each of several factors that affects both the physical conditions of the tract of land and its drainage is given a separate value as a percentage. These values are then combined in a certain way to arrive at a final relative benefit.

The first step in the percentage method is to divide all land into classes according to need for drainage and assign a percentage value to each class. The second step is to divide all land into classes according to its proximity to the improvement and assign a percentage value to each of these classes. Then the value of any extraordinary benefits (e.g., access, special flood protection, construction of closed drain in lieu of open ditch) is evaluated in dollars. Each parcel's actual assessment is determined by multiplying the parcel's benefited area, in acres, by the need of drainage percentage and again by the proximity percentage giving what is called a product. The products for each parcel in the project area are added together. The sum of extraordinary benefits is subtracted from the total cost of the improvement to get the assessable cost, which is divided by sum of the products to give a per unit product dollar cost. The per unit dollar cost is multiplied by each tract's 'product' to give the base assessment for each tract. Any extraordinary assessments is then added to the parcel's base amount to yield the total assessment for each parcel.
In evaluating assessment methods based on the percentage method, Boyd and Hart (1924) found that the percentage values were often “arbitrarily assigned, being without foundation in fact, and that the same values are used, almost without exception, over wide areas and under widely different conditions.” For example, they found that often predetermined percentages were used, often four classes: swamp land (100%), wetland (70%), low land (30%) and high land (5%). They felt that such arbitrary classifications were without foundation in fact, except perhaps in certain specific situations. They also felt that it would be hard to justify such a classification scheme in varying districts, and that the proportions must be varied among districts to account for the varied conditions.

They also found that proximity percentages are often the same among drainage districts, although cost, and the resulting benefit of a lateral connection to the main improvement will vary depending on the terrain. This factor is used to compensate for the disadvantage of being remote from the main improvement. “There appears to be very little foundation in reason for the use of a percentage system in evaluating this disadvantage” (Boyd and Hart, 1924). They suggested that the percentage method is complicated, and thus confusing, and never provides an estimate of the actual benefits received by each parcel.

Boyd and Hart (1924) recommended modifications in the way the percentage methods are applied. The efficacy of the improvement, how well it will work should be evaluated. One can predict how often and to what extent the capacity of the channel will be exceeded to get an idea of this factor. The effectiveness of the outlet should also be
considered. The lower properties in the watershed will generally suffer compared to upper properties.

Although Boyd and Hart (1924) suggested these modification in the percentage methods, they noted that this method would be very complicated and cumbersome. It is unlikely the drainage commissioners would be able to predict how changes in the percentages would affect assessments, until the calculations are completed.

The third method is the actual value of benefits method, which Boyd and Hart (1924) believe to be the most equitable and best understood method. This method bases assessments on benefits, while other methods are based on assumptions as to the effect of physical properties or conditions of parcels of land upon the relative benefits received by each. Application of actual value of benefits method will show both that the total benefits exceed the total costs, and that the individual assessments are in the same ratio as the total costs and total benefits. This method should be simple and easily explained.

The actual value of the benefits method determines the increased value of the property resulting from the improvement. The assessment for a parcel is its proportion of the total benefits times the assessable cost. This method follows the theory of making special assessments according to special benefits, which have been defined as “benefits so distinct and peculiar as to affect the value of the individual tracts” (Boyd and Hart, 1924).

The first step in this method is to fix the market value of undrained land. The value of all land after the project is completed should be similar to the market value of completely drained lands in the vicinity. However, in some cases the undrained land is held at a speculative price equal to the drained land value less the cost of drainage. Thus
the value of the benefits is already accounted for in the price. Another approach is to compute the value of undrained lands as the capitalized value of its earning power. For partially drained lands, if the market value is not known or is speculative, parcels can be valued as undrained plus the capitalized annual profits that would result from the drainage improvement in place. If a ditch is replaced by a subsurface drain, one of the benefits would be the value of the newly created land.

A parcel’s benefits should be adjusted for situations that result in greater or lesser benefits than those estimated in step one. Most group drainage improvements do not result in a complete drainage system. If incomplete drainage is provided by the project, the owner should be given credit not for the cost of completing the drainage, but for the benefit received for this work. Usually, at least in Ohio, only the open channels or subsurface drainage mains are installed through group action. Surface or subsurface drainage for the individual parcels remains the responsibility of the owner. In such cases, a reduction is made in the benefits estimated in step one. For example, if subsurface drainage is not to be installed by the group, the reduction would be equal to the benefit of the subsurface drainage system the landowner would install to achieve full drainage benefits. One approach would be to assume that the same ratio between costs and benefits of the subsurface drainage system exists as between the costs and benefits of the work done by the drainage district.

The actual value of the benefits method does have certain limitations. It cannot be used when the amount of the benefit is very small in relation to the value of the property, thus having negligible effect on its value. For example, the drainage benefits of roads, railroads, and municipalities when assessed as a whole would likely be small
relative to the value of the property. Instances of indirect benefits or of benefits as a matter of law would not result in increased property values.

Boyd and Hart (1924) found that a number of methods made assessments on an arbitrary basis, using indefinite and indeterminate quantities that made these methods complicated and cumbersome. They stated: “To the end that drainage assessments may be more firmly established upon true principles, it is recommended that the individual benefits which will accrue be evaluated by the assessors in dollars and cents, and that the costs be apportioned to such benefits.”

A more recent drainage assessment distribution study was conducted by Bengston et al. (1969) in Illinois. They developed a procedure which used a regression equation for assessments based on physical land features and the estimated increase in corn yields resulting from the improvement. After some initial investigation, they found the following physical land features important in describing the effects of the drainage improvement:

1. Distance, expressed in feet, from the tract of land to the main drain;
2. Distance, in feet, from the tract of land to the main outlet; and
3. Permeability of the soil on the tract of land.

Bengston et al. (1969) developed the following equation to account for these land features:

\[ B_n = 1.4845 - 0.3476 \times \left( \frac{L_n}{\hat{L}} \right) - 0.468 \left( \frac{D_n}{\hat{D}} \right) - 0.4434 \left( \frac{K_n}{\hat{K}} \right) \]  

[1]

where:

- \( B_n \) is the benefit index for the \( n \)th parcel
\( L_n \) is the shortest horizontal distance from the centroid of the \( n \)th parcel to the main drain;

\( D_n \) is the shortest horizontal distance from the centroid of the \( n \)th parcel to the main outlet;

\( K_n \) is the coefficient of permeability of the soil on the \( n \)th parcel of land; and

\( \hat{L}, \hat{D}, \) and \( \hat{K} \) represent the value of the highest measurement of each variable \( L, D, \) and \( K \) on the improvement.

To compute the parcel assessments, the benefit index, \( B_n \), is divided by the sum of all parcel benefit indices, and multiplied by the total cost of the improvement, as in Eq. 2:

\[
P_n = \left( B_n / \sum B_n \right) * Ca \tag{2}
\]

where \( P_n \) is the assessment for the \( n \)th parcel, and \( Ca \) is the assessable cost of the drainage improvement.

Bengston et al. (1969) based the benefits on the before-drainage and after-drainage corn yields for two years prior to and two years after the improvement. Yields were corrected for weather variation. They found that 36% of the dependent variable was explained by the independent variables. They also observed that other factors such as management and technology effects on yield complicate this type of analysis. Bengston et al. (1969) stressed that Eq. 1 was only valid for agricultural lands in Illinois. They noted, however, that the important physical features could be assumed to be similar in any area, but no similar study has been found.

as found in the Ohio Revised Code. Three assessment methods were attached to this report. These were provided by the Preble and Sandusky County Engineers, and the Seneca SWCD.

3.1.3 Studies of the benefits of group drainage and assessments

In Ohio, The Ohio Soil and Water Conservation Commission formed the Channel Modification Task Force in 1972 to provide "a summary of primary and secondary economic effects resulting from a prohibition of stream and channel modification in Ohio at different intervals of time (Channel Modification Task Force, 1972). Also in Ohio, Overmier (1982) analyzed the economic return to ditch maintenance in Defiance and Henry Counties in Ohio. Palmquist and Danielson (1989) studied the effects of erosion control and drainage on farmland values using hedonic analysis techniques.

The Channel Modification Task Force (1972) investigated drainage benefits resulting from four drainage improvement projects in Northwest Ohio: Hog Creek in Hardin County, Sugar Creek in Sandusky County, Town Creek in Van Wert County, and Grave Creek in Marion County. They also examined property values with respect to wetness conditions in the city of Bowling Green, Ohio. They used a comparative land value approach to measure benefits of drainage and channel modification. This approach attempted to measure the difference in income between economic activity within the wetness or flood plain area and areas in locations outside the watershed which were relatively free of wetness problems. It was felt the land values would capture the difference in economic return and the discount attributable to flood or drainage risk.
In order to implement this land value approach, the Channel Modification Task Force obtained land sales data and associated physical, hydrological, and economic variables for each of the five watersheds in the study. These data came from various locations both in and out of the project area, and from locations in and out of the flood plain and wetness areas. Using regression equations, they then estimated a statistical relationship between the land values and the physical, hydrological, and economic variables thought to influence land values. They assessed the reduced value of land located in unimproved drainage areas versus land within the project area, and estimated the benefits of the drainage improvement on the basis of this 'wetness discount.'

Table 3.1 summarizes the results of this study for the five watersheds. The range in wetness discounts is thought to represent the upper limit to the amount that a landowner would have been willing to pay for the drainage improvement. For the two agricultural watersheds, the wetness discounts range from an average of $21 to $73 per acre. Property values at the time ranged between $400 and $600 per acre. Compared to Hog Creek, Sugar Creek had cropping systems which included higher value crops such as sugar beets and tomatoes in addition to cash grain, which probably led to the higher wetness discount.
Table 3.1. Wetness discounts, in dollars per acre, calculated for six group drainage improvements in Ohio (from Channel Modification Task Force, 1972).

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Predominant Land Use</th>
<th>Wetness Discount ($/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low Value</td>
</tr>
<tr>
<td>Hog Creek</td>
<td>Agricultural</td>
<td>19</td>
</tr>
<tr>
<td>Sugar Creek</td>
<td>Agricultural</td>
<td>--</td>
</tr>
<tr>
<td>Bowling Green</td>
<td>Residential</td>
<td>397</td>
</tr>
<tr>
<td>Town Creek</td>
<td>Residential</td>
<td>-380</td>
</tr>
<tr>
<td>Town Creek</td>
<td>Commercial</td>
<td>46</td>
</tr>
<tr>
<td>Grave Creek</td>
<td>Residential</td>
<td>-37</td>
</tr>
</tbody>
</table>

Another method that may be used to determine the value of drainage and other characteristics of land is a hedonic land value study. Palmquist and Danielson (1989) conducted a hedonic study of the effects of drainage and erosion control on land values in North Carolina. A hedonic equation with up to 15 variables was created, with a dummy variable used to measure the need for drainage. They found that draining wet soils would increase land values about 34% on average, which they felt was within the range of estimated costs to drain the farmland in the study. They felt that the hedonic equation performed quite well, and stated that the results can provide an estimate of the average increase in land value because of drainage.

Shaudys and Overmier (1984) analyzed the economic return to ditch maintenance in Defiance and Henry Counties in Ohio. Six watersheds were compared over a simulated 30 year period. Each watershed was modeled once as being reconstructed every 15 years with a linear reduction in efficiency from 100% in year 1 to 0% in year 15, and then modeled as being on a maintenance program with 100% efficiency at year 1, with the same rate of reduction in efficiency to the 80% level which would then remain constant. A net income analysis was conducted with crop revenue, crop production costs
and ditch reconstruction and maintenance costs priced at then current price levels. An interest rate of 10% was used.

For the non-maintenance model, the reconstruction costs were amortized over fifteen year period. Per acre costs were calculated by dividing the project costs by the acres in each watershed. For the maintenance model, the annualized reconstruction costs were added to the actual average annual maintenance charges being incurred by the projects selected for the study. Crop yields were based on the average yields obtainable for each of the soil types found in the watershed. A linear reduction in yields was assumed based on drainage efficiency.

Shawdys and Overmier (1984) found that an annual maintenance program produced a greater net return than a cyclical reconstruction approach for the three soil types (heavy clay, medium clay, and sand) considered. The annual net benefit for the six open ditches included in the study ranged from $3.85 to $15.79 per acre. The benefit was greatest from an annual maintenance program on the medium clay soils, primarily as a result of soil characteristics that produced the lowest maintenance costs of the three soil types.

3.1.4 Objectives

The research objectives of the study reported in this paper are: 1) to identify of the assessment methods used by agencies responsible for administering multi-landowner drainage projects in Ohio; 2) to assess the extent to which the agencies monetized benefits using these methods on selected drainage projects; 3) to assess the differences among the methods and effects of using various methods on individual drainage
assessments in a model watershed; and 4) to assess the agencies attitudes towards assessment methods used in Ohio.

3.2 Methods

To obtain the data needed to fulfill the objectives of this chapter, and the objectives in Chapter 2, a survey instrument was developed. The author drafted a proposed instrument, based on his experience and comments and suggestions from a number of agency specialists in Ohio, and the author’s thesis committee. The proposed instrument was then reviewed by the thesis committee; Doug Dunakin, Deputy Engineer, Paulding County Engineer’s office; Cary Brickner and Don Ruffing, Group Projects Coordinator and Ditch Maintenance Supervisor, respectively, with the Huron SWCD; Doug Deardorff, District Conservationist in Hardin County; Fred Gurile, Urban Technician with the Fairfield SWCD; Kevin Elder, Cost Share Coordinator with the Division of Soil and Water Conservation - ODNR and Art Brate, State Conservation Engineer, with the Natural Resources Conservation Service (NRCS). Save for reservations concerning the overall length of the instrument, all comments by the reviewers were addressed in the final instrument.

The final instrument contained four sections: I. Drainage Project Type and Annual Activity; II. County Ditch Maintenance Program Update; III. Selected Ditch Project Details; and IV. Assessment or Cost Allocation Methods. While each of these sections and the overall methodology are described below, the results and discussion section of this paper pertains to a portion of Section III and Section IV. The results for Sections I and II, and the remainder of Section III are presented in Chapter 2.
Section I was designed to assess the level of recent project activity in Ohio. The agencies were asked to provide information regarding the number of projects and total costs associated with assistance provided for new group project activity during 1994, 1995 and 1996. For projects constructed during this time period, respondents were asked to provide this information by project type - open ditches, subsurface mains, grassed waterways, and other project types - for each of the three organizational authorities - County Petition (CP), Senate Bill 160 (SB), and Mutual Agreement (MA) - provided for by the Ohio Revised Code. The specific agency having responsibility for ditch maintenance in each of the surveyed counties was asked to provide detailed information about its county ditch maintenance program in Section II.

Section II was designed to obtain specific information on the types of projects identified in Section I. The agencies were asked to provide the number of projects, total length, total benefited acres, total maintenance fund expenditures, and the total of other expenditures.

The third section was designed to obtain information that would allow the author to evaluate how the agencies determine costs and benefits in practice, and to provide base information that could be used in a future hedonic price study. In Section III, each agency was asked to provide detailed information about one ditch project constructed during the time period 1988-1992. This time frame is after the implementation of the Swampbuster provisions of the 1985 Farm Bill, and thus reflects current regulatory conditions. Presumably, few non-cropped areas have been brought back into production by improved drainage since Swampbuster implementation. The agencies were asked
about ditch projects only since about 90% of the total length of projects on county maintenance programs were found to be ditches (Vigh, undated).

Section III was extensive, asking for information about the importance of several factors, referenced in the Ohio Revised Code, for completing the ditch and the amount of benefits, in dollars, that was calculated for each of these factors for the selected project. The agencies were also asked about dollar values placed on other consequences of the project, either upstream or downstream. The agencies were asked to provide costs broken down in up to 14 categories for each of four sources of funds: landowners, local agency, state, and federal. Finally, the maintenance expenditures by year were requested for each of these sources of funds in addition to the maintenance fund.

Section IV was designed to obtain as much detail as possible on assessment or cost allocation methods used by the agencies. In addition, the agencies were asked if the method used had ever been challenged in court. To gauge the agencies’ satisfaction with the current process, they were asked four open-ended questions relating to improving the group drainage improvement process, unique aspects of their program, and how projects might be classified. Each agency was then asked to rate its willingness to change assessment methods, and asked to suggest changes that might be made.

The instruments designed for the County Engineers and for the SWCDs differed only in that reference to county petitions (CP) were placed in the county engineer’s instrument and reference to Senate Bill 160 (SB) projects was placed in the SWCD instrument. Both agencies received questions pertaining to mutual agreement (MA) improvements. The instrument is found in Appendix A, along with correspondence sent to the counties.
The agencies selected to receive the survey instrument were in counties listed in the "Directory of Ohio Ditch and Drainage Maintenance Programs, 1994" (Vigh, undated), counties which participated in earlier drainage surveys (Nolte, 1972b; 1979), counties suggested by ODNR personnel, and other counties based on the author's knowledge. Initially, 49 counties were selected, but Wayne County was later included in the study, bringing the total to 50. These 50 counties are shown in Fig. 1.

The instrument was designed to be implemented as a mail survey, using a modified Dillman approach, which uses multiple mailings to increase the response rate (Dillman, 1978). In this study, the Dillman approach was implemented as follows.

To alert the agencies that a mail survey on drainage projects was going to be sent to them, a pre-survey postcard was mailed to each of the agencies in the 50 selected counties. One week following the mailing of the pre-survey postcard, on November 18, 1997, the survey instrument, cover letter, and a stamped, self-addressed return envelope were mailed to the county engineer and soil and water conservation district in 49 counties. The survey instrument, cover letter, and a stamped, self-addressed return envelope was mailed to the Wayne County Engineer and the Wayne SWCD in February 1998 bringing the total initial mailing to 100 agencies in 50 counties.

The cover letter introduced the study and the need to conduct it. The recipient was asked to complete and return the survey by December 15. A coupon worth $25 off the registration fee for certain departmental extension programs over the succeeding two years was offered as incentive to return the survey by December 15.
Figure 3.1. Counties selected to receive the 1997 Group Drainage Survey.
As a follow-up to the November 18 survey mailing, a postcard was mailed December 8 to all agencies reminding them of the survey and the return date. This reminder postcard was sent about one week later than that recommended by Dillman (1978), because of the length of the survey and the intervening Thanksgiving Day holiday. On January 5, 1998, a reminder letter, which included a second copy of the survey instrument and a new self-addressed, stamped return envelope, was mailed to all non-respondents. In February and March, all remaining non-respondents were contacted by phone to request completion of the survey.

During this phone contact, if it appeared that the recipient would not complete the survey, they were asked to answer selected questions in order to obtain a limited amount of the information that was requested in the survey. In two cases, visits by the author were arranged to gather information, especially for Sections I and II. On the basis of these two visits it was determined that extensive time would have to be spent reviewing many agency records to obtain complete information from those agencies that did not provide complete information in response to the questions in Sections I and II. While obtaining this information would be valuable, the author felt unable to make this time commitment for extensive field visits, and no further visits were made.

A database was created in Microsoft Access to record the answers from the surveys. To meet objective 1, the appropriate questions in Section IV were summarized and assessment methods listed by the respondents were identified. The documentation for these assessment methods was reviewed in order to identify the parcel characteristics used in each method, and a list of these characteristics was compiled. Similar characteristics were grouped together, and variables were assigned to represent these
characteristics. Each assessment method was then rewritten in a common format using these variables and the resulting formulae were grouped into three classes based on the complexity of the each formula.

Counties that provided documentation of their assessment methods were asked to review and comment on the formula representing their method. A copy of the rewritten formula was sent to the appropriate county by fax, and the responsible agency person was asked to review the formula and return it with his comments, if any.

To evaluate the extent to which agencies calculated benefits for drainage projects in Ohio (objective 2), the data on individual projects provided by the agencies in Section III was summarized and evaluated. These projects were organized by legal authority and the characteristics of the projects were summarized. The factors used to estimate benefits and the amount of benefits estimated by the agencies were summarized.

To meet objective 3, the parcel characteristics used in each of the assessment methods reported were summarized, and the values used by the agencies in applying the assessment methods were evaluated. A comparison of assessments was performed for four of the assessment methods using a simulated set of parcels.

Finally, to meet the fourth objective, the responses to the questions regarding the process, changes made or suggested, unique aspects of the agencies’ drainage program, and the agencies “willingness to change” were summarized. These responses were categorized by agency to evaluate agency specific trends.
3.3 Results and Discussion

A mail survey of both County Engineers and Soil and Water Conservation Districts (SWCDs) in 50 Ohio counties was conducted from November 1997 through April 1998. Table 3.2 provides basic information about the number of surveys returned by each agency group, and lists the time frame the surveys were received. The response rate was very good with 79 surveys returned by 34 county engineers and 45 SWCDs. In addition, one county engineer and two SWCDs took the initiative to either send a letter or phone to indicate their activity, for an overall response rate of 82%. Phone calls were made to the agencies that did not respond to the survey, resulting in partial information obtained from 16 agencies, and site visits were made by the author to two county engineers. Overall, information relating to Section III of the survey was obtained from 67 agencies (67%), while information relating to Section IV was obtained from 78 agencies (78%). Twenty five agencies (25%) provided some written documentation on the assessment method(s) used by their agency for group projects. A more detailed review of the response rate is found in Chapter 2 of this document.
Table 3.2. Time period in which surveys were returned by the County Engineers and SWCDs, and the number of agencies for which data was obtained by other means.

<table>
<thead>
<tr>
<th>Date</th>
<th>Engineer</th>
<th></th>
<th>SWCD</th>
<th></th>
<th>Overall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>November 18, 1997 –</td>
<td>16</td>
<td>32</td>
<td>31</td>
<td>62</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>December 15, 1997</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December 16, 1997 –</td>
<td>6</td>
<td>12</td>
<td>5</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>January 8, 1998</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>12</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>January 22, 1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February 2, 1998 –</td>
<td>7</td>
<td>14</td>
<td>5</td>
<td>10</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>February 28, 1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 4, 1998 –</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>April 30, 1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No survey returned, partial data obtained by phone</td>
<td>12</td>
<td>24</td>
<td>3</td>
<td>6</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>No survey returned, partial data obtained by a site visit</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Several factors may have contributed to limited or no response from several of the agencies. First, agency personnel reported that they were busier than normal because the winter of 1997-1998 was mild, with little snowfall, allowing field work to continue throughout the winter. Several respondents with large ditch maintenance programs commented that the ability to work in the field interfered with their ability to take time to complete the survey.

Second, many agencies do not have computerized records, thus requiring a substantial investment in time to review individual project files to obtain the information requested in Section III. This was a factor that prevented obtaining complete information from several of the agencies with large workloads. Where complete information was not provided, limited information was usually obtained through follow-up phone calls or visits.
However, the author believes that information about all major assessment methods and formulae in use by county engineers and SWCDs in Ohio was obtained. Overall, 25 agencies provided sufficiently detailed information about their assessment methods for group drainage projects to identify 17 fairly distinct methods or formulae used to assess group project drainage costs to individual landowners. The documentation of these methods and formulae provided by the agencies can be found in Appendix C.

For this part of the overall study, the survey recipients were asked to enclose documentation of the assessment method used to allocate costs among parcels benefiting from group drainage projects. Documentation provided by the respondents for the methods was often brief, and contained little or no justification for the development of these methods. The lack of extensive documentation for these methods is surprising, given the level of group drainage activity occurring in Ohio discussed in Chapter 2. Based on the respondents’ documentation, the agencies appear to depend on institutional memory to explain and justify their methods. It may be that agencies do have better written justifications for some of the methods, but if so, they were not evident from the survey or the materials returned by the agencies.

In the discussion which follows, the various assessment methods are summarized and formulae presented to show how the assessment calculations are made. Although the various agencies often use unique terminology to describe their methodology, the methods and formulae are presented here using common terms as much as possible. The specific usage of the individual terms by individual agencies is explained more fully in the discussion. Several of the terms used in the discussion will be defined in the following paragraphs.
Area Benefited - The amount of land that benefits from the construction of the project, usually the land contributing surface and/or subsurface drainage water. The term area as used in a formula denotes benefited area unless otherwise noted.

Direct Assessments - An extraordinary assessment charged directly to a parcel for an item associated with the project that benefits only that parcel. The direct assessment is added to the parcel assessment determined by formula. These direct assessments vary by county and/or project and may be levied for such items as brush removal, outlet pipes, ditch crossings, junk pile removal, etc. Decisions on how to assess these items is often based on negotiation with the group of landowners or custom of the county.

CAUV - Current Agricultural Use Valuation, a procedure used to calculate property taxes based on a parcel's agricultural use, rather than its market value.

Hydrologic Soil Group - A grouping of soils according to their tendency to produce runoff (Soil Survey Division Staff, 1993). There are four groups, 'A' soils having a low runoff potential and 'D' soils having a high runoff potential, with 'B' and 'C' having intermediate runoff potential.

Lateral - A ditch or subsurface drain that drains a sub-watershed of the main watershed.

Reach - A length of a stream or ditch, usually based on a point where water from a lateral enters the project, thus substantially changing the volume of water flowing in the channel.

Remoteness Factor - A measure of the distance a parcel of land is from the project. Sometimes this factor is a combination of distance and elevation above the
project, often using the ditch bank at the point the parcel’s water enters the project as datum.

Runoff Coefficient - A measure of the land’s contribution to runoff for a given storm. Usually based on the SCS curve number concept (Soil Survey Division Staff, 1993), it takes into account land cover, land use and soil type.

Volume of Runoff - The volume of runoff from a parcel of land during a storm event, often measured as a depth, and usually calculated using the curve number method (SCS, 1972).

3.3.1 Assessment methods and formulae used in Ohio

This study found 17 identifiable methods and formulae which are applied to surface water drainage projects such as open ditches by agencies in the Ohio counties that responded to the survey. The county responses relating to assessment methods and assistance provided to group projects using these methods are presented in Table 3.3 using a common naming convention developed by the author. There were several inconsistencies in the way respondents completed this part of the survey. For example, some agencies indicated they did not provide assistance, yet listed a method and a indicated that a number of projects had been completed using the listed method. Except for changing the names of the methods to reflect the convention used by the author, and to provide consistency, other information in Table 3.3 is presented as received.

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6 Projects other than open ditches, such as subsurface mains or grassed waterways use assessment formulae very specific to these applications. Assessments for subsurface drainage mains are usually based only on the area drained by contributing subsurface drains, unless significant surface water is allowed to enter the system.
In this study, the formulae and narrative provided by the agencies were rewritten as formulae in a common format for presentation and to ease comparison among methods. By using the same variables in the formulae, similarities between methods were identified and a classification scheme was developed. This scheme places these methods or formulae in one of three general categories based on how the assessments are calculated for parcels of land benefiting by the project’s construction:

1. Methods which use a simple multiplicative index;
2. Methods which use a complex multiplicative index; and
3. Methods which base assessments on some form of derived financial benefits.

The first two categories are similar, in that an index value, hereafter called a benefit index, is determined for each parcel of land as a function of one or more characteristics of
Table 3.3. Summary of assessment methods used by agencies in 50 Ohio counties with group drainage projects.

<table>
<thead>
<tr>
<th>County</th>
<th>Agency</th>
<th>Assist Groups</th>
<th>Name of Assessment Method</th>
<th>Authority for Assistance</th>
<th>Year First Used</th>
<th>Number of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen</td>
<td>Engineer Yes</td>
<td>Yes</td>
<td>Parcel Benefit Factor</td>
<td>CP</td>
<td>1970</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>SWCD Yes</td>
<td>Yes</td>
<td>Parcel Benefit Factor</td>
<td>MA</td>
<td>1973</td>
<td>NR++</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Parcel Benefit Factor</td>
<td>SB</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Ashtabula</td>
<td>Engineer No</td>
<td>No</td>
<td>None reported</td>
<td>--++</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>SWCD Yes</td>
<td>Yes</td>
<td>None reported</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Auglaize</td>
<td>Engineer Yes</td>
<td>Yes</td>
<td>Benefit Acres</td>
<td>CP</td>
<td>1974</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>SWCD No</td>
<td>--</td>
<td>Benefit Acres</td>
<td>MA</td>
<td>1980</td>
<td>9</td>
</tr>
<tr>
<td>Butler</td>
<td>Engineer Yes</td>
<td>Yes</td>
<td>Butler County</td>
<td>MA</td>
<td>1988</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>SWCD No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Champaign</td>
<td>Engineer Yes</td>
<td>Yes</td>
<td>None reported</td>
<td>CP</td>
<td>1960</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>SWCD Yes</td>
<td>Yes</td>
<td>None reported</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Clark</td>
<td>Engineer No</td>
<td>--</td>
<td>Benefit Acres</td>
<td>CP</td>
<td>1986</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SWCD Yes</td>
<td>Yes</td>
<td>Benefit Acres</td>
<td>SB</td>
<td>--</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Montgomery County</td>
<td>MA</td>
<td>1989</td>
<td>NR</td>
</tr>
<tr>
<td>Clinton</td>
<td>Engineer No</td>
<td>No</td>
<td>None reported</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>SWCD No</td>
<td>--</td>
<td>Acre Equal</td>
<td>SB</td>
<td>1972</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Acre Equal</td>
<td>MA</td>
<td>1972</td>
<td>NR</td>
</tr>
<tr>
<td>Crawford</td>
<td>Engineer Yes</td>
<td>Yes</td>
<td>Benefit Adjustment Formula</td>
<td>CP</td>
<td>1984</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SWCD Yes</td>
<td>Yes</td>
<td>None reported</td>
<td>MA</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>Darke</td>
<td>Engineer No</td>
<td>No</td>
<td>None reported</td>
<td>--</td>
<td>--</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>SWCD Yes</td>
<td>Yes</td>
<td>None reported</td>
<td>CP</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>--</td>
<td>SB</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Defiance</td>
<td>Engineer Yes</td>
<td>Yes</td>
<td>Defiance County</td>
<td>CP</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>SWCD Yes</td>
<td>Yes</td>
<td>Defiance County</td>
<td>SB</td>
<td>1966</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group decides</td>
<td>MA</td>
<td>1964</td>
<td>NR</td>
</tr>
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^Engineer indicates the County Engineer; SWCD indicates the local Soil and Water Conservation District.

Yes indicates that the agency provides assistance to landowners for group drainage improvement projects.

Based on agency's response and author's naming convention.

CP is County Petition; MA is Mutual Agreement; SB is Senate Bill 160.

The year this assessment method was first used by this agency, based on agency's response.

Agency's estimate of number of projects constructed/assessed using this assessment method.

^ Not reported.

# No response expected.

## Respondent indicated that he did not know.

the parcel. Assessment methods in the third category, while utilizing calculations similar to the benefit indices of the first two categories, also include factors that reflect an estimation of benefits for the parcels of land benefiting from the project.

In the simplest form, the general formula for determining a benefit index for the assessment methods identified in this study can be expressed as:

\[
B_n = f(X_1, X_2, \ldots X_m)
\]  

where \(B_n\) is the benefit index of the \(n\)th parcel in the project area, and \(X_1, X_2, \ldots X_m\) represent values assigned to \(m\) characteristics related to the \(n\)th parcel. The characteristics used in the assessment methods and formulae presented in this paper are represented by the variables shown in Table 3.4.

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Table 3.4. Definition of variables used in assessment formula equations.

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<td>Area in a parcel benefited by the project</td>
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<td>B</td>
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<td>Bd</td>
<td>Drainage benefit; often a measure of increased productivity</td>
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<td>Bo</td>
<td>Obligation benefit; a benefit by reason of law</td>
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<td>Ca</td>
<td>Assessable cost of a project; the total cost less any direct assessments</td>
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<td>Drainage class factor</td>
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</tr>
<tr>
<td>M</td>
<td>Degree of problem correction factor</td>
</tr>
<tr>
<td>N</td>
<td>Need for problem correction factor</td>
</tr>
<tr>
<td>P&lt;sub&gt;n&lt;/sub&gt;</td>
<td>Assessment for the n&lt;sup&gt;th&lt;/sup&gt; parcel</td>
</tr>
<tr>
<td>R</td>
<td>Remoteness factor; usually a function of the distance a parcel is from the ditch project</td>
</tr>
<tr>
<td>S</td>
<td>Subsurface drainage adjustment factor</td>
</tr>
<tr>
<td>T</td>
<td>Topography factor or slope factor</td>
</tr>
<tr>
<td>U</td>
<td>Land use factor</td>
</tr>
<tr>
<td>V</td>
<td>Volume of runoff factor; related to runoff contributed by a parcel, often expressed as a depth</td>
</tr>
<tr>
<td>V&lt;sub&gt;c&lt;/sub&gt;</td>
<td>Volume of runoff under current conditions</td>
</tr>
<tr>
<td>V&lt;sub&gt;o&lt;/sub&gt;</td>
<td>Volume of runoff under natural or original conditions</td>
</tr>
<tr>
<td>X</td>
<td>Percentage of an area planted to a crop</td>
</tr>
<tr>
<td>Y&lt;sub&gt;a&lt;/sub&gt;</td>
<td>Average county yield</td>
</tr>
<tr>
<td>Z</td>
<td>Crop net return to land</td>
</tr>
</tbody>
</table>

Some parcel characteristics, such as land use, can vary within a parcel. For example, a parcel may have an area devoted to woodland, another area for pasture, and a third area devoted to cropland. Each of these land uses may have a different value in a particular assessment method or formula, and how the calculations are made in these situations may vary among the counties and assessment methods. How these situations affect the benefit index calculation will be addressed as each assessment method is described.
After the benefit index is calculated for all benefiting parcels, the assessment for an individual parcel is calculated as a simple ratio of the parcel's benefit index value to the sum of the benefit index values for the entire project, multiplied by the assessable cost of the project. This procedure is presented as Eq. 4:

\[ P_n = \frac{B_n}{\sum B_n} \times C_o \]  \[4\]

where:

- \( P_n \) is the assessment for the \( n \)th parcel;
- \( B_n \) is the index value for the \( n \)th parcel; and
- \( C_o \) is the assessable cost of the project.

The assessable cost of a project is the total cost less any costs that will be charged as direct assessments against individual parcels.

Often a project may contain two or more reaches. In such cases, parcel assessments are often calculated separately for each reach. The sum of the reach assessments for each parcel is its total project assessment. Whether assessments are calculated by reaches depends on the size of the project and local custom.

In this study, each method or formula was assigned a name, either one used by the agency providing the description of the method, or a name that represents the county involved or the procedure used. Each of the assessment methods was placed in one of the previously mentioned categories. One or more equations are presented illustrating how each method or formula is applied, the range of values given the variables, and additional narrative as needed. Discussion of the assessment methods follows. Within each of these categories, the related assessment methods are presented, roughly in order of increasing complexity.
3.3.2 Assessment methods which use a simple multiplicative index

Fifteen agencies, 28% of the 54 agencies reporting about their methods, use one of the eight assessment methods placed in this category. The application of these methods is straightforward. The methods in this category derive the benefit index by first assigning a value to one or more characteristics of a parcel of land, such as the land use, then multiplying each of these values together to produce the benefit index, \( B_n \). The values assigned are often, but not always, a value between 0 and 1, as the decimal representation of a percentage.

Although these assessment methods are similar, each uses a different combination of characteristics to determine the benefit index value assigned to each of the benefiting parcels. The specific characteristics used by each of the nine assessment methods in this category are shown in Table 3.5.

<table>
<thead>
<tr>
<th>Assessment Method</th>
<th>Agency Using Method</th>
<th>Variable Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acre Equal</td>
<td>Fayette Co. Engr.</td>
<td>A U L R D E H S</td>
</tr>
<tr>
<td></td>
<td>Fulton SWCD</td>
<td>X X X X -- -- --</td>
</tr>
<tr>
<td>Benefit Acres</td>
<td>Auglaize Co. Engr.</td>
<td>X X X X -- -- --</td>
</tr>
<tr>
<td></td>
<td>Clark Co. Engr.</td>
<td>X X X X -- -- --</td>
</tr>
<tr>
<td></td>
<td>Henry SWCD</td>
<td>X X X X -- -- --</td>
</tr>
<tr>
<td>Benefit Units</td>
<td>Huron SWCD</td>
<td>X X -- -- -- -- --</td>
</tr>
<tr>
<td></td>
<td>Seneca SWCD</td>
<td>X X -- -- -- -- --</td>
</tr>
<tr>
<td></td>
<td>Wayne Co. Engr.</td>
<td>X X -- -- -- -- --</td>
</tr>
<tr>
<td>Defiance County</td>
<td>Defiance Co. Engr.</td>
<td>X X -- -- -- X X X</td>
</tr>
<tr>
<td>Fairfield County</td>
<td>Fairfield SWCD</td>
<td>X X X X -- -- -- X</td>
</tr>
<tr>
<td>Preble SWCD</td>
<td>Logan SWCD</td>
<td>X X -- -- -- X X --</td>
</tr>
<tr>
<td>Putnam County</td>
<td>Putnam Co. Engr.</td>
<td>X X X -- -- -- -- --</td>
</tr>
<tr>
<td></td>
<td>Putnam SWCD</td>
<td>X X X -- -- -- -- --</td>
</tr>
<tr>
<td></td>
<td>Van Wert Co. Engr.</td>
<td>X X X -- -- -- -- --</td>
</tr>
<tr>
<td>Sandusky County</td>
<td>Sandusky Co. Engr.</td>
<td>X X X X -- -- --</td>
</tr>
</tbody>
</table>

*Indicates this variable is used in the method.
† Indicates this variable is not used in the method.
Except for the Sandusky County Assessment Procedure, none of the methods in this category assigns an estimate of benefits to individual parcels. Rather, the assumption is made that parcel benefits are proportional to the indices developed by the multiplicative functions. No justification for this assumption has been found in the literature or provided by the agencies participating in this study.

In the remainder of this section, the nine assessment methods assigned to this category are presented in equation form. The equations presented illustrate how each method or formula is applied to create the benefit index. These assessment methods are presented roughly in order of increasing complexity.

3.3.2.1. Acre Equal Method

This method is used by the Fayette County Engineer and the Fulton SWCD, and is the simplest of the assessment methods reviewed. The Acre Equal Method assumes that the per acre benefits are equal for all land uses in the project area, which may be a reasonable assumption for a small watershed having a dominant land use such as cropland. Often small mutual agreement projects use this method. The formula used in this method is of the same form as Eq. 4, and is presented as Eq. 5:

\[ P_n = \left( A_n / \sum A_n \right) \times C_a \]  \[ \text{[5]} \]

where:

- \( P_n \) is the assessment for the nth parcel;
- \( A_n \) is the benefited area of the nth parcel; and
- \( C_a \) is the assessable cost of the project.
3.3.2.2. Benefit Units Method

The Benefit Units Method is used by the Huron and Seneca SWCDs, and the Wayne County Engineer. The assumption behind the Benefit Units Method is that benefits vary according to land use. The area of a parcel is multiplied by a land use factor to produce the parcel’s benefit index. This assessment formula for this method is presented as Eq. 6:

\[ B_n = A_n \times U_n \]  

where \( A_n \) is the area of a parcel in the \( n \)th land use classification, in acres, and \( U_n \) is the factor value for the \( n \)th land use classification. Land use factors used by the Huron SWCD, Seneca SWCD, and the Wayne County Engineer are shown in Table 3.6. A noteworthy point is the disparity in factor values among the three counties.

<table>
<thead>
<tr>
<th>Land Use Classification</th>
<th>Huron SWCD</th>
<th>Seneca SWCD</th>
<th>Wayne Co. Engr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural land</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Commercial, village and utility parcels</td>
<td>--</td>
<td>--</td>
<td>2.0</td>
</tr>
<tr>
<td>Residential</td>
<td>4.0</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Roads (right of way)</td>
<td>2.0</td>
<td>2.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Undeveloped parcels (vacant lots)</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* Indicates that this factor is not used by this agency.

3.3.2.3. Putnam County Method

The Putnam County Engineer, the Putnam SWCD, and the Van Wert County Engineer use the Putnam County Method. This method builds on the Benefit Units
Method with the addition of a factor, herein called the location factor, \( L_n \), that accounts for the portion of the project a parcel's runoff uses. The assumption is that the more of a project the water from a parcel uses, the greater the benefit to the parcel. This method is presented as Eq. 7:

\[
B_n = A_e \times U_n \times L_n
\]  

[7]

where \( L_n \) is the location factor, or percent of use factor, for the \( n \)th parcel, and the other variables are defined as before. The value of the location factor is calculated as the ratio of the length between the project outlet and the point where the water from the \( n \)th parcel enters the project, to the length of the entire project. Thus the value of \( L_n \) varies from 0.0 for a parcel at the project outlet to 1.0 for a parcel at the end of the project farthest away from the outlet. The land use factors used in the Putnam County Method are shown in Table 3.7.

<table>
<thead>
<tr>
<th>Land Use Classification</th>
<th>Land Use Factor ((U_n)) (units/acre)</th>
<th>Putnam Co. Engineer and SWCD</th>
<th>Van Wert Co. Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woods, waste and pasture land</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Agricultural cropland</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Residential and Commercial</td>
<td>2.0</td>
<td>2.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Historically, the location factor, \( L_n \), was the only factor used in the assessment method in Putnam county. However, in 1985, the land use factor, \( U_n \), was added to the formula to address concerns that benefits vary with land use as well as with the percentage of project used.
3.3.2.4. Benefit Acres Method

The Benefit Acres Method, known as the Benefited Acres Method in Henry County, is used by the Auglaize County Engineer, the Clark County Engineer, and the Henry SWCD. It introduces a remoteness factor, $R_n$, to the benefit index calculation. The value for $R_n$ is based on the distance from the project, with more distant land having a lower value, assuming that a parcel more remote from the project derives less benefit from its construction. Eq. 8 illustrates the calculation of the benefit index for the Benefit Acres Method:

$$B_n = A_n * U_n * L_n * R_n$$  \[8\]

where $R_n$ is the remoteness factor for the $n$th parcel, and the other variables are defined as before. The factors $U_n$, $L_n$, and $R_n$ can have values between 0.0 and 1.0. The land use factors are shown in Table 3.8. Land Use Factor ($U_n$)

<table>
<thead>
<tr>
<th>Land Use Classification</th>
<th>Auglaize Co. Engineer</th>
<th>Clark Co. Engineer</th>
<th>Henry SWCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woods</td>
<td>0.3</td>
<td>.15</td>
<td>0.5</td>
</tr>
<tr>
<td>Pasture</td>
<td>--</td>
<td>.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Agricultural / cultivated</td>
<td>0.4</td>
<td>.25</td>
<td>1.0</td>
</tr>
<tr>
<td>Recreational</td>
<td>--</td>
<td>.3</td>
<td>--</td>
</tr>
<tr>
<td>Residential</td>
<td>0.6</td>
<td>.4</td>
<td>--</td>
</tr>
<tr>
<td>Road right of way</td>
<td>0.7</td>
<td>.9</td>
<td>--</td>
</tr>
<tr>
<td>Commercial</td>
<td>--</td>
<td>.8</td>
<td>--</td>
</tr>
<tr>
<td>Impervious</td>
<td>1.0</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

-- indicates that this factor is not used in the method.

The Henry SWCD calculates the remoteness factor, $R_n$, by measuring the distance along the flow path from the main project to the parcel, then dividing this distance by the length of the entire flow path in that reach, and subtracting the quotient from 1.0. The
Clark County Engineer uses a similar calculation to determine the value of $R_n$. A somewhat different approach is used by the Auglaize County Engineer who calculates the value of $R_n$ by drawing equidistant arcs around the parcel’s water entry point. The parcels inside the first arc are assigned a value of $R_n$ equal to 1.0, and the value in each succeeding arc is decreased by 0.1 For some projects with enough topographic relief, the Auglaize County Engineer uses an elevation factor in place of the length based remoteness factor. In these cases, contour intervals from a USGS 7.5' topographic map are used in place of the concentric arcs to determine the factor value. The elevation factor is formally introduced later in this section in the Preble SWCD Method.

3.3.2.5. Sandusky County Assessment Procedure

This method is used by the Sandusky and Wood County Engineers and is apparently the oldest method in Ohio that uses financial benefits in assessment calculation. Other methods which estimate financial benefits are presented later in the paper, but this method is presented here because its operation is exactly like the methods in this section. The Sandusky County Assessment Procedure is very similar to the Benefit Acres. However, instead of using a unitless number for a factor value as is done in all of the other methods in this section, the Sandusky County Assessment Procedure assigns a dollar value to a drainage factor, $D_n$. The calculation of the benefit index, $B_n$, and the parcel’s assessment, $P_n$, is exactly the same as for the other index methods. This method is presented as Eq. 9:

$$B_n = A_n \times L_n \times R_n \times D_n$$ [9]
where $D_n$ is the financial benefit assigned to the drainage class of the $n$th parcel, and the other factors are defined as before. The descriptions of the seven drainage classes and the estimated benefits used by the Sandusky County Engineer for each class are given in Table 3.9.

<table>
<thead>
<tr>
<th>Drainage Classification</th>
<th>Drainage Benefit Per Acre</th>
<th>Class Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$160</td>
<td>Land which has both surface and subsurface drainage flowing into the project.</td>
</tr>
<tr>
<td>II</td>
<td>$120</td>
<td>Land which has only surface drainage flowing into the project, but which could be subsurface drained to discharge into the project.</td>
</tr>
<tr>
<td>III</td>
<td>$100</td>
<td>Tillable land with surface drainage only into project. No existing subsurface drains and none can be installed which would drain into the project.</td>
</tr>
<tr>
<td>IV</td>
<td>$100</td>
<td>Land which has only subsurface drainage emptying into the project and for which the surface drainage flows into another watershed.</td>
</tr>
<tr>
<td>V</td>
<td>$60</td>
<td>Land which has only surface drainage flowing into the project and for which subsurface drainage discharges into another watershed.</td>
</tr>
<tr>
<td>VI</td>
<td>$60</td>
<td>Land which has only surface drainage flowing into the project and for which subsurface drainage is impractical or not feasible to drain into the project; e.g., woods, permanent pastures because of stone near surface, etc.</td>
</tr>
<tr>
<td>VII</td>
<td>None</td>
<td>Land which has no natural or subsurface drainage, for which drainage is not practical or feasible, and land which has not been removed from its natural state.</td>
</tr>
</tbody>
</table>

According to the narrative accompanying the Sandusky County Assessment Procedure, the drainage benefit assigned to parcels used for purposes other than cropland is adjusted to proportionately reflect the estimated benefit received. In addition, the benefit assigned to a parcel subject to flooding would be adjusted by an amount reflecting the benefit received because of decreased flooding resulting from the project.
The location factor is proportional to the amount of the project used by the parcel’s drainage, and is calculated as in previous methods. It may assume a value between 0.0 and 1.0. The remoteness factor is based on the distance of the parcel from the project, and is taken from Table 3.10. Its value is also between 0.0 and 1.0. The remoteness values may be refined for small streams using one-half mile increments with proportional remoteness factors.

Table 3.10. Values used for the remoteness factor, $R_m$, by the Sandusky County Engineer for the Sandusky County Assessment Procedure.

<table>
<thead>
<tr>
<th>Distance From Main Channel (mi)</th>
<th>Remoteness Factor ($R_m$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>1.0</td>
</tr>
<tr>
<td>1 - 2</td>
<td>0.9</td>
</tr>
<tr>
<td>2 - 3</td>
<td>0.8</td>
</tr>
<tr>
<td>3 - 4</td>
<td>0.6</td>
</tr>
<tr>
<td>4 - 5</td>
<td>0.4</td>
</tr>
<tr>
<td>5 - 6</td>
<td>0.25</td>
</tr>
<tr>
<td>&gt; 6</td>
<td>0.15</td>
</tr>
</tbody>
</table>

3.3.2.6. Fairfield County Method

The Fairfield County Method introduces a factor called the drainage benefit, or hydrologic soil group factor, $H_m$, which is based on the four NRCS hydrologic soil groups, A, B, C, and D. At present this formula is used for maintenance assessments only. The formula used in this method is presented as Eq. 10:
\[ B_n = A_n \times U_n \times L_n \times R_n \times H_n \]  

where \( H_n \) represents the hydrologic soil group factor for the \( n \)th parcel, and the other variables are used as previously defined. The factors \( L_n \) and \( R_n \) can have values between 0.0 and 1.0 as in previous methods. Only two land use classifications are identified; the value assigned to \( U_n \) is 1.0 for cropland, and 3.0 for urban land. The values for \( H_n \) are given in Table 3.11.

<table>
<thead>
<tr>
<th>NRCS Hydrologic Soil Group</th>
<th>Hydrologic Soil Group Factor (( H_n ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.25</td>
</tr>
<tr>
<td>B</td>
<td>0.50</td>
</tr>
<tr>
<td>C</td>
<td>0.75</td>
</tr>
<tr>
<td>D</td>
<td>1.00</td>
</tr>
</tbody>
</table>

### 3.3.2.7. Preble SWCD Method

Developed at the Preble SWCD, the Preble SWCD Method is not used by that agency. However, the Preble SWCD Method is used by the Logan SWCD and was used in the past by the Huron SWCD. An extension of this method is used by the Defiance County Engineer and is presented in 3.3.2.8.

The Preble SWCD method introduces an elevation factor, \( E_n \), which is based on the area of the parcel within an elevation range relative to the point where the parcel's water enters the project. Elevations are estimated from USGS 7.5' quadrangle maps. The use of the elevation factor is based on the assumption that land at higher relative elevations benefits less than land at an elevation lower relative to the project outlet. This method is presented as Eq. 11:
\[ B_n = A_n \cdot U_n \cdot L_n \cdot H_n \cdot E_n \]

where \( E_n \) is the elevation factor for the \( n \)th parcel, and the other variables are used as previously defined. The calculations for each of the factors involve an area-weighting calculation. For instance, the \( E_n \) value used for a parcel is the area-weighted average of the values for each elevation range in that parcel.

Table 3.12 shows the base factor values used by the Logan SWCD and the Defiance County Engineer for implementation of the Preble SWCD Method. The values included in Table 3.12 for the subsurface drainage factor will be explained in the next section. In some cases, breaks for the elevation factor are at 5 foot intervals instead of 10 feet. The Huron SWCD has used this method, modified so that there are more elevation categories with different category values.

3.3.2.8. Defiance County Method

The Defiance County Method used by the Defiance County Engineer, extends the Preble SWCD method by adding a subsurface drainage factor, \( S_n \), and the location factor, \( L_n \). The subsurface drainage factor adjusts the benefit index by considering the drainage class of the soil series found on the parcel and whether the subsurface drainage is routed towards or away from the project. The assumption behind this factor is that land with subsurface drainage that outlets into the project receives more benefits than land with no subsurface drainage, or subsurface drainage that outlets elsewhere. This equation is presented as Eq. 12:

\[ B_n = A_n \cdot U_n \cdot L_n \cdot H_n \cdot E_n \cdot S_n \]
where $S_n$ is the subsurface drainage factor, and the other variables are used as previously defined. The subsurface drainage factor ranges in value from 1.0 – 1.2 when the subsurface drainage outlets to the project, and from 0.8 – 1.0 when the subsurface drainage outlets to another location. No explanation or justification was provided as to the selection of the specific values for $S_n$ in the Defiance County Method. Values for the other factors range between 0.0 and 1.0, except for the land use factor value for buildings, which is set at 10.0.

All factor values for a parcel, except for the location factor, are determined by the area-weighting procedure described for the Preble SWCD Method. A single location factor value is assigned for the entire parcel, and is calculated based on the percent of project use, as described in earlier methods.
Table 3.12. Land use, soil group, elevation, and subsurface drainage factor values used for the Preble SWCD Method (Logan SWCD) and the Defiance County Method.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Logan SWCD</th>
<th>Defiance County Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use Classification</td>
<td>Land Use Factor (U&lt;sub&gt;u&lt;/sub&gt;)</td>
<td></td>
</tr>
<tr>
<td>Woods</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Agricultural / cultivated</td>
<td>0.2</td>
<td>0.25</td>
</tr>
<tr>
<td>Recreational</td>
<td>--</td>
<td>0.4</td>
</tr>
<tr>
<td>Residential</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Roads</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Industrial</td>
<td>--</td>
<td>0.7</td>
</tr>
<tr>
<td>Buildings</td>
<td>--</td>
<td>10.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydrologic Soil Group</th>
<th>Soil Group Factor (H&lt;sub&gt;s&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>0.1</td>
</tr>
<tr>
<td>Group B</td>
<td>0.4</td>
</tr>
<tr>
<td>Group C</td>
<td>0.7</td>
</tr>
<tr>
<td>Group D</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elevation Range</th>
<th>Elevation Factor (E&lt;sub&gt;e&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10 ft</td>
<td>1.0</td>
</tr>
<tr>
<td>11 - 20 ft</td>
<td>0.8</td>
</tr>
<tr>
<td>21 - 30 ft</td>
<td>0.5</td>
</tr>
<tr>
<td>31 - 40 ft</td>
<td>0.3</td>
</tr>
<tr>
<td>41 - 50 ft</td>
<td>0.2</td>
</tr>
<tr>
<td>51+ ft</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsurface Drainage Classification</th>
<th>Subsurface Drainage Factor (S&lt;sub&gt;n&lt;/sub&gt;) To Factor</th>
<th>Away Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic Soil Group A</td>
<td>--</td>
<td>1.20</td>
</tr>
<tr>
<td>Hydrologic Soil Group B</td>
<td>--</td>
<td>1.13</td>
</tr>
<tr>
<td>Hydrologic Soil Group C</td>
<td>--</td>
<td>1.07</td>
</tr>
<tr>
<td>Hydrologic Soil Group D</td>
<td>--</td>
<td>1.01</td>
</tr>
<tr>
<td>No subsurface drainage</td>
<td>--</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* Used when subsurface drainage from a parcel is routed to the project.
† Used when subsurface drainage from a parcel is routed away from the project.
3.3.3 Assessment methods which use a more complex multiplicative index

Six of the assessment methods use a multiplicative index which is more complex than those presented in the preceding section. These six methods are used in some form by 15 agencies. In each of these methods, at least one of the multiplicative factors used to derive the benefit index is a function of two or more characteristics of the parcel.

The six methods use equations similar to Eq. 3 and Eq. 4 to derive the benefit index values for each parcel are shown in Table 3.13 along with the variables used in each method.

<table>
<thead>
<tr>
<th>Assessment Method</th>
<th>Agencies Using Method</th>
<th>A</th>
<th>G</th>
<th>L</th>
<th>R</th>
<th>U</th>
<th>S</th>
<th>H</th>
<th>T</th>
<th>N</th>
<th>M</th>
<th>I</th>
<th>E</th>
<th>V</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit Adjustment Formula</td>
<td>Crawford Co. Engr.</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Preble Co. Engr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Richland Co. Engr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montgomery County</td>
<td>Greene SWCD</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Miami SWCD</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Montgomery SWCD</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickaway SWCD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preble SWCD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parcel Benefit Factor</td>
<td>Allen Co. Engr.</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Paulding County Target</td>
<td>Paulding Co. Engr.</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Hancock Co. Engr.</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Hardin Co. Engr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Varied</td>
<td>Ottawa Co. Engr.</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Ottawa SWCD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Indicates this variable is used in the method.
† Indicates this variable is not used in the method.
3.3.3.1. Target Method

The Target Method, also known as the 100% Ring Method, is used by the Hancock County Engineer and the Hardin County Engineer, and introduces the concept of the ring. The ‘ring’ is an area in the project watershed enclosed by a boundary within which the benefits are assumed to be equal. In practice, an area of land near the center of the improvement is assumed to receive the maximum benefits from the drainage project, and is assessed at a rate of 100%. Concentric rings are then drawn around the 100% area, and the area within each succeeding ring is assessed at decreasing rates, each 10% less than the one before. The area of 100% acres is determined by the engineer after review of the project plans, based on his experience. Factors used in the determination of the 100% ring area include sub-watershed areas, lateral ditches and watershed subsurface drains, soil types, areas of increased siltation, topography, and frequently flooded areas. In practice, the 100% area is assigned to the land that will benefit the most from reduced flooding.

The formula representing the 100% Ring Method is presented as Eq. 13:

\[ B_n = A_n \cdot G_n \]  

[13]

where \( G_n \) is the percentage of benefits estimated to be received by the land within the \( n \)th ring, and the other variables are defined as before. A value between 0.1 and 1.0 is assigned to \( G_n \). Although conceptually a simple percentage method, it is placed in this category because a number of factors are taken into account when determining where the rings are drawn.
3.3.3.2. Varied Assessment Method

The Varied Assessment Method is used by the Ottawa County Engineer and the Ottawa SWCD, and is also known as the 100% Acres Method\textsuperscript{7}. This method is a fairly simple assessment distribution using only two components, the benefiting acres and a single factor that combines the parcel's location on the project, \( L_n \), and remoteness from the project, \( R_n \). As before, it is assumed that a parcel more remote from the project receives fewer benefits than one closer to the project, and that benefits increase according to the amount of the project used. The benefit index used in determining assessments by the Varied Assessment Method is presented as Eq. 14:

\[
B_n = A_n \times f(L_n, R_n) \\
\text{[14]}
\]

where the variables are defined as before. The factor \( f(L_n, R_n) \) generally can assume a value between 0.4 and 1.0 except for special situations when a value lower than 0.4 may be assigned. A value of 1.0 is assigned to parcels at the upper end and 0.4 to 0.5 assigned to parcels at the lower end of the project.

Although similar to the Benefit Acres Method, this method differs in that the two factors \( L_n \) and \( R_n \) are not multiplied together. Also, rather than having fixed schedules or a formula for determining the value of the individual factors \( L_n \) and \( R_n \), or the value of the combined factor, a value is assigned to each parcel by the technician or engineer, based

\textsuperscript{7} In the 1919 revision of the Ohio drainage laws, the engineer was required to prepare a schedule of lands benefiting from the project, the number of acres believed to benefit and "the percentage of such benefit on the basis of 100% benefit to the land or lands subject to assessment and receiving the highest benefit from the improvement at the least probable additional cost to make it available" (Schwartz, 1955). This provision may be the basis for the term "100% acres" we find in use here and in several other methods.
on his experience and knowledge of the area. The values assigned are very much at the
discretion of the person making the assessments.

3.3.3.3. Parcel Benefit Factor Method

The Parcel Benefit Factor Method, used by the Allen County Engineer, differs
from the Varied Assessment Method only by the addition of a factor based on land use.
The location/remoteness factor, \( f(L_n, R_n) \), is determined by the technician doing the
assessment calculations, based on his experience, as is the case with the Varied
Assessment method. The Parcel Benefit Factor Method is presented as Eq. 15:

\[
B_n = A_n \times U_n \times f(L_n, R_n)
\]  

[15]

where the variables are defined as before. The land use factors are shown in Table 3.14.
The location/remoteness factor can assume a value between 0.0 and 1.0.

This method is very similar to the Benefit Acres Method and the Benefited Acres
Method of the previous section, in that they use the same factors in the determination of
the benefit index. However, these methods use an established formula or table to assign
the values to the individual factors \( L_n \) and \( R_n \), while the Parcel Benefit Factor Method
utilizes a factor that combines the location and remoteness concepts into one value, which
is assigned by a technician without reference to a formula or table. This distinction is
rather artificial, and serves only to point out the slight difference in the methods. In
operation, these methods would be expected to produce very similar assessments.

To establish the location/remoteness factor, the parcel is first located with respect
to its location on the project; i.e., how much of the ditch the parcel’s runoff uses. This
value is then reduced based on the distance the center of the parcel is from the main
channel of the project. The location/elevation factor can assume a value between 0.0 at
the outlet of the project, and 1.0 at the upstream end of the project.

Table 3.14. Land use factors, based on runoff values, used with the Parcel Benefit Factor Method.

<table>
<thead>
<tr>
<th>Land Use Classification</th>
<th>Land Use Factor ( (U_r) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woods</td>
<td>0.10</td>
</tr>
<tr>
<td>Agricultural</td>
<td>0.15</td>
</tr>
<tr>
<td>Grass (parks, etc.)</td>
<td>0.20</td>
</tr>
<tr>
<td>Residential, 2.0 acres or greater</td>
<td>0.25</td>
</tr>
<tr>
<td>Residential, between 1.0-2.0 ac</td>
<td>0.30</td>
</tr>
<tr>
<td>Residential, less than 1.0 ac</td>
<td>0.35</td>
</tr>
<tr>
<td>Railroad right-of-way</td>
<td>0.45</td>
</tr>
<tr>
<td>Road right-of-way</td>
<td>0.60</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.65</td>
</tr>
<tr>
<td>Commercial (mall)</td>
<td>0.85 – 1.00</td>
</tr>
</tbody>
</table>

3.3.3.4. Paulding County Method

The Paulding County Engineer and the Paulding SWCD use the Paulding County Method, which incorporates the remoteness factor in a manner different from the methods presented previously. In this percentage method, the remoteness adjustment is made by subtracting the remoteness factor, \( R_n \), from the location factor, \( L_n \), rather than incorporating the remoteness factor into the formula as a multiplicative factor as in done in previously described methods. The effect of implementing a remoteness adjustment in this way is to reduce the impact of remoteness on a parcel's assessment, compared with other methods. The Paulding County Method is presented as Eq. 16:

\[
B_n = A_n \times U_n \times (L_n - R_n) \times S_n
\]  

[16]
where the variables are defined as before. The value of the subsurface drainage
adjustment factor, $S_n$, is usually 0.5 for situations when the surface water drains to the
project under consideration, but the subsurface drainage outlet is in another project. The
remoteness adjustment factor, $R_m$, is based on the distance from the main channel of the
project along a lateral, or overland, often 2% per quarter mile.

The land use factor values used with the Paulding County Method are shown in
Table 3.15. Apparently the land use factor was only added to the Paulding County
Assessment Method in the last 10 to 15 years, or since the early to mid 1980s.

<table>
<thead>
<tr>
<th>Land use classification</th>
<th>Land Use Factor ($U_u$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woods</td>
<td>0.50</td>
</tr>
<tr>
<td>Agricultural</td>
<td>1.0</td>
</tr>
<tr>
<td>Roads</td>
<td>1.5</td>
</tr>
<tr>
<td>Residential</td>
<td>2.0</td>
</tr>
<tr>
<td>Commercial</td>
<td>4.0</td>
</tr>
</tbody>
</table>

3.3.3.5. Benefit Adjustment Formula

The Benefit Adjustment Formula was developed by former Preble County
Engineer Kenneth J. Yost so that the cost of a ditch project to property owners could be
"rationally explained in simple terms...(Yost, 1979;1980). This method is also called
the Yost Method and the Preble County Method. The use of the latter term has caused
this method to be confused with the Preble SWCD Method described earlier. The
Crawford, Erie, Preble, and Richland County Engineers use this method.

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Yost (1979;1980) used many of the factors listed in Section 6131 of the Ohio Revised Code in his formula. However, rather than a straightforward multiplication, some of the factor values are combined as a sum prior to the multiplication step. Since the factor values being combined are of similar magnitude, this practice has the effect of making the combined factor more important in the overall equation than those that appear singly. For example, the sum of $T_n$ and $H_n$ has the potential to have a value twice as great at the individual factors $U_n$ and $L_n$. The reasons for doing the calculations in this manner were not addressed by Yost (1979;1980).

The Benefit Adjustment Formula is shown as Eq. 17:

$$B_n = A_n \times U_n \times L_n \times (H_n + T_n) \times (N_n + M_n + I_n)$$  \[17\]

where:

$T_n$ is a surface drainage factor based on topography or slope of the land. A factor value from 1 (25-35% slopes) to 10 (depressional areas) is assigned based on need for artificial drainage.

$N_n$ is a factor assigned to the parcel based on the degree of need for correction of a drainage problem, determined by the engineer or technician based on an evaluation of the parcel's characteristics. Factor values range from 0.1 (no new drainage benefits, but a legal obligation) to 10 (area is inundated with a severe threat to property or health).

$M_n$ is a factor assigned to the parcel based on the degree of problem correction by the project as determined by the engineer or technician. This factor value ranges
from 0 to 10 based on an estimation of the percentage of the drainage needs that will be corrected by the project.

$I_n$ is a factor assigned to the parcel and determined by the engineer or technician, based on the degree of productivity and value enhancement of the parcel by the project. Values range from 0 to 10 (10 is a 100% increase) based on an estimation of the increase in productivity and increase in intrinsic value a parcel derives from the project.

The other factors are used as previously defined.

Table 3.16 shows the range in values for each of the factors used by the four county engineers who use the Benefit Adjustment Formula. In this method, the location factor, $L_n$, each parcel in the watershed of a project is assigned one of 10 values based on the proportion of the improvement used by the parcel’s drainage water and the actual cost per foot of ditch. A schedule of values for the hydrologic soil group factor values, $H_n$, is developed for each county based on the soils mapped in the county soil survey.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Crawford County Engineer</th>
<th>Erie County Engineer</th>
<th>Preble County Engineer</th>
<th>Richland County Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_n$</td>
<td>0.1 - 10</td>
<td>0.1 - 10</td>
<td>0.1 - 10</td>
<td>0.1 - 10</td>
</tr>
<tr>
<td>$L_n$</td>
<td>1 - 10</td>
<td>1 - 10</td>
<td>1 - 10</td>
<td>1 - 10</td>
</tr>
<tr>
<td>$T_n$</td>
<td>1 - 10</td>
<td>1 - 10</td>
<td>1 - 10</td>
<td>1 - 10</td>
</tr>
<tr>
<td>$H_n$</td>
<td>1 - 10</td>
<td>1 - 5</td>
<td>1 - 10</td>
<td>1 - 10</td>
</tr>
<tr>
<td>$N_n$</td>
<td>0.1 - 10</td>
<td>0.1 - 10</td>
<td>0.1 - 10</td>
<td>0.1 - 10</td>
</tr>
<tr>
<td>$M_n$</td>
<td>0 - 10</td>
<td>0 - 10</td>
<td>0 - 10</td>
<td>0 - 10</td>
</tr>
<tr>
<td>$I_n$</td>
<td>--</td>
<td>--</td>
<td>0 - 10</td>
<td>0 - 10</td>
</tr>
</tbody>
</table>

* Denotes that the factor is not used by this agency.
In applying this method, each engineer has adjusted the individual factor values, or has made certain assumptions when estimating these values. For example, the Preble County Engineer usually gives the factors $N_n$, $M_n$, and $L_n$ the same value for each parcel. The Crawford and Erie County Engineers do not use the improvement factor $L_n$. However, the Crawford County Engineer applies a direct assessment of $\$50$ to the calculated assessment for parcels under five acres. The Erie County Engineer calculates the watershed location factor, $L_n$, by dividing the cost of the portion of the improvement each parcel uses by the cost of the entire project, multiplying by 10 and rounding to the nearest whole number. Also, in addition to factor values for the four hydrologic soil groups, which range from 1.0 to 4.0, the Erie County Engineer includes a value of 5.0 for residential parcels.

3.3.3.6. Montgomery County Drainage Assessment Procedure

The Montgomery County Drainage Assessment Procedure, hereafter called the Montgomery County Method, is very popular in several counties in southwest Ohio, and is used by the Greene, Miami, Montgomery, Pickaway and Preble SWCDs. This method introduces a flooding factor, $F_n$, which is described as a measure of the value of property enhancement because of relief from flooding because of the project. The assumption is that a parcel will benefit from reduced flooding with an increased property value. Other factors described previously are calculated in new ways. For example, the increased production factor, $L_n$, is similar to that used in the Benefit Adjustment Formula, but its value is based on the current agricultural use valuation (CAUV) of the parcel. The apparent assumption here is that the project will provide a parcel with increased
production in proportion to the ratio of the parcel's CAUV to the highest CAUV for any parcel in the area.

Another difference in the Montgomery County Method compared with others previously presented is in the calculation of the value for the elevation/remoteness factor, \( f(E_n, R_n) \). In this method, a combination of the relative elevation of the parcel and its distance from the main channel of the project is used to reduce the assessments of parcels away from the main channel. The Montgomery County Method is represented by Eq. 18:

\[
B_n = A_n * L_n * f(E_n, R_n) * S_n * I_n * V_n * F_n
\]

where \( V_n \) is a volume of runoff factor, \( F_n \) is a potential or actual reduction in flooding factor, and the other factors are defined as before.

The location factor, \( L_n \), is based on the percentage of the improvement used, similar to several methods previously presented. The range in values is shown in Table 3.17, which also shows the differences in values used by the Montgomery and Preble SWCDs.

<table>
<thead>
<tr>
<th>Percentage of Project Used (%)</th>
<th>Location Factor (( L_n ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Montgomery County</td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>10</td>
<td>1.0</td>
</tr>
<tr>
<td>50</td>
<td>5.0</td>
</tr>
<tr>
<td>100</td>
<td>10.0</td>
</tr>
</tbody>
</table>

The elevation/remoteness factor, \( f(E_n, R_n) \), is determined from a matrix and can assume values from 1.0 to 10.0. An abbreviated matrix is shown in Table 3.18.
Table 3.18. Example of the matrix used by the Montgomery SWCD to calculate the elevation/remoteness value for the Montgomery County Method.

<table>
<thead>
<tr>
<th>Elevation of Parcel Relative to Hydraulic Grade Line (ft)</th>
<th>Distance of Parcel from Point where the Parcel's Runoff Enters the Main Channel of the Project (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>0 – 5</td>
<td>10.0</td>
</tr>
<tr>
<td>5 – 10</td>
<td>7.0</td>
</tr>
<tr>
<td>10 – 15</td>
<td>5.0</td>
</tr>
<tr>
<td>15 – 20</td>
<td>4.0</td>
</tr>
<tr>
<td>20+</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The subsurface drainage reduction factor, $S_n$, can assume a value of 0.8 if the subsurface drainage from a parcel outlets to a channel outside of the project watershed. Although the narrative describing the method states that this reduction is implemented by reducing the volume of runoff factor, $V_n$, by 20%, that statement is mathematically equivalent to using $S_n$ as a separate factor in Eq. 20 as is presented here.

The value for the potential increase in productivity factor, $I_n$, is calculated as shown by Eq. 19:

$$I_n = (CAUV_n / CAUV_{max}) * 10.0$$  \[19\]

where $I_n$ is the potential increase in productivity factor, $CAUV_n$ is the current agricultural use valuation of the $n$th parcel, and $CAUV_{max}$ is the highest CAUV in the area. Non-agricultural land is given a $I_n$ value of 1.0. No justification for this procedure was provided by any of the counties using this method.

The volume of runoff factor, $V_n$, is calculated by the NRCS Curve Number Method (SCS, 1972), using Eq. 20:
\[ V_n = \left( \frac{ROV_n}{ROV_{(100CN)}} \right) \times 10 \]  

where:

- \( V_n \) is the volume of runoff factor;
- \( ROV_n \) is the runoff volume of the \( n \)th parcel for the design storm; and
- \( ROV_{(100CN)} \) is the runoff volume for a land use with a curve number of 100.

Table 3.19 illustrates the values of \( V_n \) for several curve numbers, and also shows the difference in runoff volumes calculated by the Montgomery and Preble because of differences in the design storm rainfall. The volume of runoff factor may be reduced by 20% if the subsurface drainage is routed outside the watershed.

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Montgomery, Piskaway SWCDs</th>
<th>Preble SWCD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-year storm runoff (in)</td>
<td>10-year storm runoff (in)</td>
</tr>
<tr>
<td>100</td>
<td>4.00</td>
<td>10.0</td>
</tr>
<tr>
<td>95</td>
<td>3.43</td>
<td>8.6</td>
</tr>
<tr>
<td>90</td>
<td>2.92</td>
<td>7.3</td>
</tr>
<tr>
<td>85</td>
<td>2.46</td>
<td>6.2</td>
</tr>
<tr>
<td>80</td>
<td>2.04</td>
<td>5.1</td>
</tr>
<tr>
<td>75</td>
<td>1.67</td>
<td>4.2</td>
</tr>
<tr>
<td>70</td>
<td>1.33</td>
<td>3.3</td>
</tr>
</tbody>
</table>

The value of the flooding factor, \( F_n \), is determined by reference to a schedule (Table 3.20). The value of 10.0 is assigned if the project provides relief from potentially severe flooding or a substantial increase in property value. A value of 1.0 is assigned to parcels with little need for improved drainage from the project. Since the benefit to agricultural parcels from a project is considered in the potential increase in productivity...
factor, $L_m$, a value of 1.0 is generally assigned to agricultural parcels, unless they are subject to ponded surface water or seasonal flooding.

Table 3.20. Description of flooding factor values used by Montgomery and Preble SWCDs for the Montgomery County Method.

<table>
<thead>
<tr>
<th>Description</th>
<th>Flooding Factor Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief from potential or actual severe flooding with inundated structures, and health and safety hazards. Substantial increase in property value.</td>
<td>7 – 10 Montgomery SWCD 4 – 5 Preble SWCD</td>
</tr>
<tr>
<td>Relief from potential or actual flooding, such as water in basement or garage, including flooding which causes crop damage or erosion of the land. Moderate increase in property value.</td>
<td>5 – 7 Montgomery SWCD 3 – 4 Preble SWCD</td>
</tr>
<tr>
<td>Relief from potential or actual ponding of water near structures or on cropland. Better use of property because of improvement. Increase in property value because of improved neighborhood reputation.</td>
<td>3 – 5 Montgomery SWCD 2 – 3 Preble SWCD</td>
</tr>
<tr>
<td>Little need for improved drainage. Small effect on property value.</td>
<td>1 – 3 Montgomery SWCD 1 – 2 Preble SWCD</td>
</tr>
</tbody>
</table>

The Pickaway SWCD has simplified the elevation/remoteness factor matrix. Using an aerial photograph and a USGS 7.5’ quad sheet, zones are determined by the technician, and values are assigned to each parcel based on its location and elevation. A value of 10.0 is assigned to parcels in the lower portion of the project watershed. As the distance increases from the main channel of the project, the values are reduced until the parcels in the upper portion of the project watershed are assigned a value of 1.0.

The Preble SWCD established a minimum assessment of $50, and modified the values used for the location factor, $L_m$, the elevation/remoteness factor, $f(E_n, R_n)$, and the flood protection/property enhancement factor, $F_r$. The value for the location factor, $L_m$, is calculated by multiplying the decimal percentage of the improvement used by 5.0 rather than by 10.0 as done by the Montgomery SWCD. The matrix used for calculating
the value of the elevation/remoteness factor, \( f(E_n, R_n) \), is simplified, with fewer elevation and distance classes (Table 3.21), and the highest value for \( f(E_n, R_n) \) is 5.0. The maximum value for the flood protection/property enhancement factor, \( F_n \), is also 5.0.

The Preble SWCD made no change in the subsurface drainage factor, \( S_n \), or in the calculation of the potential increase in productivity factor, \( I_n \), which retains a maximum value of 10.0. The values of the volume of runoff factor, also retain a maximum value of 10.0. The effect of these changes is to make the potential increase in productivity factor, \( f(E_n, R_n) \), and the volume of runoff factor, \( V_n \), relatively more important in the formula than the other factors.

<table>
<thead>
<tr>
<th>Table 3.21. Matrix used by the Preble SWCD to calculate the elevation/remoteness values for the Montgomery County Method.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elevation Above Hydraulic Grade Line or Ditch Bank (ft)</strong></td>
</tr>
<tr>
<td>0 – 10</td>
</tr>
<tr>
<td>11 – 20</td>
</tr>
<tr>
<td>20+</td>
</tr>
</tbody>
</table>

### 3.3.4 Assessment methods which use derived financial benefits

Three methods attempt to estimate the benefits of a drainage project in financial terms. These methods have been developed fairly recently, evidently in response to a perceived need to make a better correlation between assessments and the benefits of a project. The three methods summarized here attempt to evaluate the increased
productivity to cropland from the improvement of a drainage ditch. Other land uses are not addressed from the standpoint of improved valuation resulting from the project. As before, the three methods in this category are summarized and represented as equations in the following section.

3.3.4.1. Moran Method

The Moran Method is used by the Delaware County Engineer, and has also been used by the Huron SWCD. This method was developed by Kyle Moran (Moran, 1983), an engineer with ODNR and former SCS engineer. The main difference between the Moran Method, and those presented earlier, is that two categories of benefits are calculated, and these are measured in dollars. The calculations are quite similar to the preceding methods, and the same factors are used in these calculations.

Moran (1983) proposed that two general classes of benefits would be derived from a drainage project, an obligation benefit and a drainage benefit. The obligation benefit is related to the legal obligation a parcel has for the increased or accelerated runoff brought on by development of the parcel from its natural state, as expressed in 6131.01(F) of the Ohio Revised Code. In the Moran Method, the accelerated runoff is defined as the difference between predicted runoff volume under natural conditions (e.g., woods or grass) and predicted runoff under current land use conditions.

The calculation of the obligation benefits involves a benefit index much like previous methods such as the Putnam County Method, the Benefit Acres Method, and the Sandusky County Method. A parcel’s benefited area is multiplied by the accelerated runoff and the percent of the project used to determine the benefit index. The obligation
benefit of the parcel is the ratio of the parcel’s benefit index to the sum of all benefit indices, multiplied by the assessable cost. An interesting point here is that the sum of the obligation benefits for all parcels is defined as equal to the assessable cost of the project, which implies that if any other benefits are identified, the project will have a benefit:cost ratio greater than 1.0. The equations for calculating the obligation benefits are presented as Eq. 21 and Eq. 22:

\[ B_n = A_n \times L_n \times (Vc_n - Vo_n) \]  \[ \text{[21]} \]

\[ Bo_n = \left( B_n / \sum B_n \right) \times C_n \]  \[ \text{[22]} \]

where:

- \( Vc_n \) is the runoff volume of the \( n \)th parcel under current conditions;
- \( Vo_n \) is the runoff volume of the \( n \)th parcel under natural conditions;
- \( Bo_n \) is the obligation benefit for the \( n \)th parcel in dollars; and
- the other variables are defined as before.

The second category of benefits is the drainage benefit, defined as the result of providing or improving outlets for surface and subsurface drainage systems, such as the increase or potential increase in crop production. Moran (1983) does not address drainage benefits for land used for purposes other than crop production, although this method allows for these to be calculated and included in the method.

The drainage benefit is calculated for each parcel by multiplying the per acre benefit by the benefited area and an elevation/remoteness factor that is a function of the parcel’s elevation above the project and the distance away from the project, similar to the
matrix used in the Montgomery County Method. Eq. 23 is used to calculate the drainage benefits:

$$Bd_n = A_n \cdot f(E, R) \cdot I_n$$  \[23\]

where $Bd_n$ is the drainage benefit for the $n$th parcel in dollars, and the other factors are defined as before. An example matrix for calculating the elevation/remoteeness factor value is shown in Table 3.22. This matrix differs from that used in the Montgomery County Method by having minimum values of 0.0. The assumption here is that parcels beyond a certain distance, or above a certain elevation, receive no drainage benefit from the project.

<table>
<thead>
<tr>
<th>Elevation Above Hydraulic Grade Line or Ditch Bank (ft)</th>
<th>Distance of Parcel from Point where the Parcel's Runoff Enters the Main Channel of the Project (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0  2000 4000 6000 8000 8000+</td>
</tr>
<tr>
<td>0 – 5</td>
<td>1.0 0.7 0.4 0.1 0.0 0.0</td>
</tr>
<tr>
<td>5 – 10</td>
<td>0.7 0.4 0.1 0.0 0.0 0.0</td>
</tr>
<tr>
<td>10 – 15</td>
<td>0.4 0.1 0.0 0.0 0.0 0.0</td>
</tr>
<tr>
<td>15 – 20</td>
<td>0.1 0.0 0.0 0.0 0.0 0.0</td>
</tr>
<tr>
<td>20+</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0</td>
</tr>
</tbody>
</table>

The increased productivity factor, $I_n$, is measured in dollars. Moran (1983) does not specify how the value for $I_n$ should be calculated, but in his example he created classifications for parcels having certain characteristics and assigned benefit values to each classification, as is done in the Sandusky County Method. Moran (1983) states that
applicable values for this factor must be determined for each county. Table 3.23 shows a
set of values and class descriptions that could be used for the factor $I_n$.

Table 3.23. Example table showing the drainage benefit values, $I_n$ for five classes of cropland in a corn,
soybean, small grain cropping system, for use in the Moran Method (from Moran, 1983).

<table>
<thead>
<tr>
<th>Parcel Classification</th>
<th>Increased Value Per Acre</th>
<th>Class Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$115</td>
<td>Cropland that is or needs to be surface and subsurface drained.</td>
</tr>
<tr>
<td>II</td>
<td>$45</td>
<td>Cropland that is or needs to be surface and subsurface drained, but has subsurface drain outlets outside the project boundary.</td>
</tr>
<tr>
<td>III</td>
<td>$80</td>
<td>Cropland that is or needs to be surface and subsurface drained, but has surface drainage outlets outside the project boundary.</td>
</tr>
<tr>
<td>IV</td>
<td>$0</td>
<td>Cropland or other land that does not need or cannot be surface or subsurface drained.</td>
</tr>
<tr>
<td>V</td>
<td>$10</td>
<td>Other land that is or can be benefited from surface or subsurface drainage.</td>
</tr>
</tbody>
</table>

Once the obligation and drainage benefits have been calculated, the parcel
assessments can be determined. A parcel’s assessment is the ratio of its benefits to the
sum of individual parcel benefits for the project, multiplied by the assessable cost. The
parcel assessment calculation is presented here as Eq. 24:

$$P_n = \frac{(Bo_n + Bd_n)}{\sum (Bo_n + Bd_n)} \times C_a$$  \quad [24]$$

where the variables are defined as before.

3.3.4.2. Sectionalized Method of Ditch Assessments

The Sectionalized Method of Ditch Assessments was developed by Keith Early,
Mercer County Engineer, and is used by the Mercer and Miami County Engineers. The
Sectionalized Method is an extension of the Moran Method (Moran, 1983), and uses the
concept of obligation and drainage benefits. However, Early (1990) argues that
calculating costs and benefits over the entire project, as is done in the Moran Method,
may produce flawed assessments because of differing costs for various sections of the
project. In the Sectionalized Method, costs and benefits are calculated on short sections, or reaches, of the improvement. A parcel’s assessment for each section of the ditch is calculated, then the parcel’s total assessment for the entire project is obtained by summing the individual section assessments.

A second change from the Moran Method is in the calculation of obligation benefits. In the Moran Method, the obligation benefits are defined as being equal to the assessable cost of the project, giving a benefit:cost ratio of 1.0 without considering other benefits to the project. On the other hand, in the Sectionalized Method, only a portion of the assessable cost is assigned as the obligation benefit. The remaining amount of assessable cost is assigned to the drainage benefits. The amount of assessable cost considered as the obligation benefit is in proportion to the ratio of the accelerated runoff, $V_0_n$, to the total runoff, $V_c_n$. For example, if 40% of the total runoff in a section is accelerated runoff, then 40% of the cost of improving that section would be assessed as an obligation benefit. In practice, the obligation benefit for a parcel is calculated for each section by multiplying the parcel’s benefited area by the parcel’s accelerated runoff, times the assessable cost per unit of runoff volume. The obligation assessment is equal to the obligation benefit for all benefited parcels. This calculation is presented as Eq. 25:

$$B_{o_n} = A_n \times (V_{c_n} - V_{0_n}) \times \left\{ C_d / \sum (A_n \times V_{c_n}) \right\}$$  \hspace{1cm} [25]

where the variables are defined as before. In contrast to the Moran method, the obligation benefits do not equal the assessable costs in each section, because the assumed runoff under original conditions is assessed part of the cost of improving the ditch. Thus, a certain amount of drainage benefit will be required before a project achieves a benefit:cost ratio greater than 1.0.
A parcel’s drainage benefit for a section is calculated based on an estimate of the increased value that parcel receives from the improvement of that section. While Early (1990) bases the drainage benefit on the improved productivity because of drainage as Moran does, Early (1990) limits the drainage benefit to a certain length of the project, arguing that improvements farther downstream than this distance have no effect on the drainage of a parcel. In other words, after a certain point, subsurface drainage water could get away without further drainage improvement. This concept is implemented as a subsurface drainage adjustment factor, $Sd$. The drainage benefit calculation is similar to Moran (1983), with the addition of the drainage adjustment factor. This calculation is presented as Eq. 26:

$$Bd_n = A_n \cdot f(E_n, R_n, Sf_n) \cdot l_n \cdot Sd_n$$

where $Sd_n$ is a subsurface drainage adjustment factor for the $n$th parcel expressed as a decimal percentage, $Sf_n$ is the freeboard\(^8\) of the subsurface drain outlet for the $n$th parcel, and the other factors are defined as before. The function $f(E_n, R_n, S_{dc})$ is a remoteness factor used to reduce the drainage benefit because of the parcel’s elevation above the main channel of the project, its distance away from the main channel of the project, and the freeboard on the subsurface drain outlet serving the parcel. The values of the parameters in this function are assigned by the engineer based on his experience and not taken from a set schedule. The parameter $Sd_n$ is based on the percentage of length of the section of ditch under consideration which is needed to provide drainage benefits for the

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\(^8\) Freeboard is defined as the distance of a drain pipe outlet above the bottom of the channel, or above the level of water in the channel under low flow conditions.
Values for the parameter $Sd_n$ are calculated using either Eq. 27, Eq. 28, or Eq. 29, depending on the relation of the parcel to the project section:

$$Sd_n = 1.0, \text{ if } Ld_n - Lr_n \geq Ls$$  \hspace{1cm} [27]$$

$$Sd_n = (Ld_n - Lr_n) / Ls, \text{ if } (Ld_n - Lr_n) < Ls$$ \hspace{1cm} [28]$$

$$Sd_n = 0, \text{ if } (Ld_n - Lr_n) < 0$$ \hspace{1cm} [29]$$

where

$Ld_n$ is the length of the project that must be improved to obtain full drainage benefit for the $n$th parcel;

$Lr_n$ is the length drainage water from the subsurface drainage outlet of the $n$th parcel travels to reach the project section under consideration;

$Ls$ is the length of the project in the section under consideration; and

the other variables are defined as before.

Therefore, for each section, a parcel’s drainage assessment is the ratio of the parcel’s drainage benefit to the sum of the section’s drainage benefits, multiplied by the remaining cost of construction for the section, which is the assessable cost less the obligation assessment. The parcel’s section assessment is then the sum of the obligation assessment and the drainage assessment for the section. These calculations are combined and presented as Eq. 30:

$$P_n = Bo_n + \left\{ (Bd_n / \sum Bd_n) \times (C_o - \sum Bo_n) \right\}$$ \hspace{1cm} [30]$$

where the variables are defined as before. The last term on the right side of Eq. 30 represents the portion of the drainage benefits that are needed to cover the costs of the
project. A parcel's assessment for the entire project is the sum of the individual section assessments.

3.3.4.3. Miami County Benefit Cost Procedure

The Miami County Benefit Cost Procedure, hereafter referred to as the Miami County Method, is used by the Greene SWCD, and is similar to methods described in the previous section. The Miami County Method is based on the assumption that the agricultural benefits for each parcel are related to the parcel's location in the watershed, distance from the improvement, soil drainage characteristics, percent of land area on which subsurface drainage is installed, and the percent of land area where these drains are impaired. The latter two characteristics are not used in any other method.

Drainage benefits for cropland are determined for each of three drainage classes using the following procedure.

The increase in productivity for the jth drainage class is given by Eq. 31:

\[ I_j = \sum_i (N_i \ast Y_i \ast X_i \ast Y_r) \]  

[31]

where:

- \( I_j \) is increase in productivity for the jth drainage class;
- \( N \) is the estimated net return per bushel for the ith crop;
- \( Y_i \) is the county average yield of the ith crop;
- \( X_i \) is the percentage of the watershed planted to the ith crop; and
- \( Y_r \) is the yield reduction factor for the ith cropland the jth drainage class.
The value for Ni is determined for each crop by subtracting the variable production cost for the crop from the five-year average price for that crop. The variable production cost is taken from the NRCS Field Office Technical Guide (FOTG) while the crop price is taken from the Ohio Crop Reporting Service.

The factor $X_i$ is an estimate of the percentage of each crop planted in the watershed. For instance, assuming that a two-year corn-soybean cropping system is used in the project watershed, the value of $X_i$ would be 0.5 (50%) for each crop. This value is estimated from the Ohio Crop Reporting Service, as is the average crop yield, $Y_i$, for each crop.

The improvement in productivity factor value, $I_j$, is next adjusted by two factors: one based on an elevation/remoteeness factor, and the second based on an estimate of the percent of land area on which subsurface drainage is installed, $S_j$. The elevation remoteness factor is a matrix similar to the matrix used in the Montgomery County Method, and is shown in Table 3.24. The subsurface drainage installed factor values are estimated from Table 3.25, unless the actual area of land having subsurface drainage is known.
Table 3.24. Matrix to determine elevation/remoteeness factor values for the Miami County Method.

| Elevation of the Center of the Parcel Relative to the Ditch Bank Elevation where the Parcel's Runoff Enters the Main Channel (ft) | Distance of the Center of the Parcel from the Point where the Parcel's Runoff Enters the Main Channel of the Project (ft) | 499 | 500 | 1999 | 2000 | 3499 | 3500 | 4999 | 5000 | 6999 | 7000 | 8999 | 9000 | 11,999 | 12,000 | 14,999 | 15,000 | 17,000 |
| 0 – 4 | 1.00 | .85 | .70 | .55 | .40 | .35 | .30 | .25 | .20 | 10 |
| 5 – 9 | .85 | .70 | .55 | .40 | .35 | .30 | .25 | .20 | .15 | 10 |
| 10 – 14 | .70 | .55 | .40 | .35 | .30 | .25 | .20 | .15 | .10 | 10 |
| 15 – 19 | .55 | .40 | .35 | .30 | .25 | .20 | .15 | .10 | .10 | 10 |
| 20+ | .40 | .35 | .30 | .25 | .20 | .15 | .10 | .10 | .10 | 10 |

Table 3.25. Values for the subsurface drainage installed factor used in the Miami County Method.

<table>
<thead>
<tr>
<th>USDA Drainage Class</th>
<th>Subsurface Drainage Installed Factor, $S_j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well drained</td>
<td>0.0</td>
</tr>
<tr>
<td>Moderately well drained</td>
<td>0.25</td>
</tr>
<tr>
<td>Somewhat poorly drained</td>
<td>0.50</td>
</tr>
<tr>
<td>Very poorly drained</td>
<td>0.75</td>
</tr>
</tbody>
</table>

For each drainage class, the cropland drainage benefits are adjusted by multiplying the value of the benefits by a subsurface drainage impairment factor, which is equivalent to the remoteness factor used in previous methods, as it is derived from a matrix based on elevation and distance from the ditch. Once the remoteness adjustment is made, the value is further reduced by subtracting a value determined by multiplying the cost of subsurface drain installation by an adjustment factor which is based on the percentage of subsurface drainage completed in this drainage class. This procedure is presented as Eq. 32:

$$Z_j = (I_j * f(E_n, R_p)) - (Cs * (1.0 - S_j))$$  \[32\]
where $Z_j$ is the adjusted agricultural benefit for the $j$th drainage class, $C_a$ is the annualized per acre cost of subsurface drainage installation, and the other factors are defined as before. The total agricultural drainage benefit for a parcel is found by multiplying the adjusted agricultural benefits for each drainage class in the parcel by the area of the parcel in each drainage class. This calculation is presented as Eq. 33:

$$B_n = \sum (A_{n,j} \cdot Z_j)$$  \[33\]

where $A_{n,j}$ is the area of land in the $n$th parcel in the $j$th drainage class, and the other factors are defined as before. If drainage benefits for other land uses are defined, they can be added to the agricultural benefits for each parcel. The parcel assessment is then a ratio of the parcel benefit to the sum of all parcel benefits, multiplied by the assessable cost. This procedure is presented as Eq. 34:

$$P_n = \frac{B_n}{\sum B_j} \cdot C_a$$  \[34\]

where the variables are as previously defined.

3.3.5 **Detailed information about individual ditch projects in Ohio**

The previous section discussed in general the assessment methods in use in Ohio. In this section we will look at detailed information provided on several individual drainage improvement projects, in order to examine how assessments are performed in practice.

The 100 agencies surveyed were asked to provide detailed information on one open ditch project for which they had provided assistance between 1988 and 1992.
During this time period, 53 agencies reported assisting with the construction of 265 group drainage improvements. Thirty-eight agencies responded with detailed information about 38 separate projects (Table 3.26). These agencies alone reported assisting with 253 improvements from 1988-1992, which verifies that the most active agencies were the ones responding to these questions.

Fifteen of these 38 projects were organized using the county petition (CP) process, 11 were organized under the Senate Bill 160 (SB) process, and 12 were organized under the mutual agreement process (MA). As expected, on average the mutual agreement projects (580 ac/project) were smaller than the Senate Bill 160 projects (944 ac/project), which in turn were smaller than the county petition projects (2131 ac/project). The size of the improvements was quite variable, ranging from a low of 13 acres to a high of 8184 acres benefited. In addition to one project of 8184 acres, three other projects each benefited over 4000 acres. The low average size of the mutual agreement improvements likely reflects the need for agreement among all benefiting landowners, which is more difficult to achieve for larger size improvements. The larger average size of the county petition improvements over the Senate Bill 160 improvements may reflect the older heritage of the county petition process, and perhaps its better defined legal environment. Individual improvement length ranged from 460 feet to 32,460 feet (data not shown).
Table 3.26. Reasons why a particular legal authority was used by 38 agencies in Ohio during 1988-1992 to construct individual group drainage improvement projects.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Legal Authority</th>
<th>Reason Why This Authority Was Used</th>
<th>Acres Benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>CP</td>
</tr>
<tr>
<td>E22D1</td>
<td>SB</td>
<td>Most agricultural watershed use SB-160 petitions to save cost of engineering expenses</td>
<td>--</td>
</tr>
<tr>
<td>E23D1</td>
<td>MA</td>
<td>Mutual agreement between developer and county.</td>
<td>--</td>
</tr>
<tr>
<td>E29D84-1</td>
<td>CP</td>
<td>Method customarily used at the time</td>
<td>3014</td>
</tr>
<tr>
<td>E31D1</td>
<td>CP</td>
<td>Property owners felt it would be the quickest and most binding on objecting property owners</td>
<td>71</td>
</tr>
<tr>
<td>E35D1</td>
<td>CP</td>
<td>SB160 and Mutual Agreement projects are not promoted locally</td>
<td>4251</td>
</tr>
<tr>
<td>E38D1</td>
<td>CP</td>
<td>Some landowners protested cleaning</td>
<td>2444</td>
</tr>
<tr>
<td>E39D1</td>
<td>CP</td>
<td>Landowner came in office and requested to begin petition procedure</td>
<td>8184</td>
</tr>
<tr>
<td>E47D1</td>
<td>MA</td>
<td>SCS worked with group</td>
<td>--</td>
</tr>
<tr>
<td>E49D1</td>
<td>CP</td>
<td>Most expedients</td>
<td>735</td>
</tr>
<tr>
<td>E50D1</td>
<td>CP</td>
<td>Landowner file petition</td>
<td>215</td>
</tr>
<tr>
<td>E51D1</td>
<td>CP</td>
<td>Landowners could not agree to do the project together</td>
<td>4440</td>
</tr>
<tr>
<td>E53D1</td>
<td>SB</td>
<td>This legal authority offers the least cost to property owners. It is also the preferred method by memo of understanding between the board of city commissionors, city engineer and SWCD.</td>
<td>--</td>
</tr>
<tr>
<td>E55D1</td>
<td>CP</td>
<td>Too many contentious owners for private agreement</td>
<td>855</td>
</tr>
<tr>
<td>E59D1</td>
<td>CP</td>
<td>Landowners choice</td>
<td>532</td>
</tr>
<tr>
<td>E60D1</td>
<td>CP</td>
<td>No other authority could be found to assist with what would otherwise have been a township problem</td>
<td>27</td>
</tr>
<tr>
<td>E61D1</td>
<td>CP</td>
<td>Preferred method of landowners in Sandusky county</td>
<td>950</td>
</tr>
<tr>
<td>E63D1</td>
<td>CP</td>
<td>Petitioned by landowner</td>
<td>429</td>
</tr>
<tr>
<td>S65D1</td>
<td>CP</td>
<td>Only method available at the time</td>
<td>4315</td>
</tr>
<tr>
<td>E67D1</td>
<td>CP</td>
<td>There was no other legal action the property owner could use at that time &amp; the project involve [sic] work along a RR</td>
<td>507</td>
</tr>
<tr>
<td>S20D1</td>
<td>SB</td>
<td>Too large to get voluntary cooperation</td>
<td>--</td>
</tr>
<tr>
<td>S22D1</td>
<td>SB</td>
<td>Large number of landowners along with large number of acres drained</td>
<td>--</td>
</tr>
<tr>
<td>S29D1</td>
<td>SB</td>
<td>It started as Mutual agreement but went to 160 in order to collect from State Hwy and one landowner</td>
<td>--</td>
</tr>
<tr>
<td>S31D1</td>
<td>SB</td>
<td>County - Petitioner was told SB-160 method would be cheaper (Co. Eng.). Mutual - requires all landowners to be in agreement (Prosecutor’s view)</td>
<td>--</td>
</tr>
<tr>
<td>S33D1</td>
<td>MA</td>
<td>Landowners request</td>
<td>--</td>
</tr>
<tr>
<td>S37D1</td>
<td>MA</td>
<td>Landowners decided to do some of work themselves and hired rest of work done according to SWCD plans then petitioned for maintenance</td>
<td>--</td>
</tr>
<tr>
<td>S38D1</td>
<td>MA</td>
<td>Quickest and most economical</td>
<td>--</td>
</tr>
<tr>
<td>S42D1</td>
<td>MA</td>
<td>Promotes cooperation between neighbors; easy to understand; less expensive; fewer legalities/lawsuits; protects district image as cooperative, not regulatory agency</td>
<td>--</td>
</tr>
</tbody>
</table>

Continued
Table 3.26 (continued) Reasons why a particular legal authority was used by 38 agencies in Ohio during 1988-1992 to construct individual group drainage improvement projects.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Legal Authority</th>
<th>Why was this authority used?</th>
<th>Acres Benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td>S46D1</td>
<td>MA</td>
<td>The landowners all agreed that the improvement was necessary and they all paid their assessment upfront</td>
<td>--</td>
</tr>
<tr>
<td>S47D1</td>
<td>SB</td>
<td>One objecting landowner</td>
<td>198</td>
</tr>
<tr>
<td>S53D1</td>
<td>SB</td>
<td>Memo of understanding between the county engineer and the co. commission and the SWCD</td>
<td>350</td>
</tr>
<tr>
<td>S55D1</td>
<td>SB</td>
<td>Could not get 100% agreement and landowners did not want to petition through the county commissioners</td>
<td>1370</td>
</tr>
<tr>
<td>S56D1</td>
<td>SB</td>
<td>County Petition was backed up. Farmers could use SB160 to get done sooner</td>
<td>800</td>
</tr>
<tr>
<td>S57D1</td>
<td>MA</td>
<td>At that time, the majority of landowners were in agreement, on or two key landowners helped to push project through</td>
<td>291</td>
</tr>
<tr>
<td>S58D1</td>
<td>MA</td>
<td>Landowners were amicable. No dissension as to cost allocation. Saved time and expense compared to SB-160 process</td>
<td>338</td>
</tr>
<tr>
<td>S62D1</td>
<td>MA</td>
<td></td>
<td>~</td>
</tr>
<tr>
<td>S64D1</td>
<td>MA</td>
<td></td>
<td>~</td>
</tr>
<tr>
<td>S67D1</td>
<td>SB</td>
<td>Not all landowners agreed to project and SB160 is cheaper than the county petition</td>
<td>960</td>
</tr>
<tr>
<td>S68D1</td>
<td>MA</td>
<td>Because 90% of all group project are mutual agreements here in Wyandot County</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of projects</th>
<th>15</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average area benefited per project</td>
<td>2131</td>
<td>944</td>
<td>580</td>
</tr>
</tbody>
</table>

Table 3.26 also shows the reasons given by the agencies for choosing the particular legal authority. Use of the mutual agreement (MA) process requires the landowners all reach agreement. If agreement occurs, it can result in a project being accomplished in a quick and economical manner. Most counties promote this process where feasible, but as projects increase in size and benefited acres, either the SB-160 or county petition methods are used.

The SB-160 process was used for 11 improvements. In two counties it is the preferred authority, with a memo of understanding between the board of county commissioners, the county engineer and the soil and water conservation district to
implement the SB-160 process as the preferred legal authority. This process is perceived by four agencies as being less expensive than the county petition process, probably because the SWCD and the Natural Resources Conservation Service provide engineering services at no cost to the group. However, we noted in Chapter 2 that this perception may not always be valid.

In some counties, the county petition process is traditionally used, and the SB-160 and mutual agreement processes are not promoted. One agency reported that the CP process was perceived to be the most expeditious process. In at least two instances, it was felt to provide the only viable option. Four responses indicated that the CP process was used by choice of the landowners, or because a landowner had filed a petition. In four instances, respondents indicated that the CP process was used to force unwilling landowners to participate.

The agencies were next asked if benefits were estimated and what factors were used to estimate the benefits. As shown in Table 3.27, most agencies merely listed the factors used in their assessment methods. Only 13 agencies claimed that any dollar benefits were estimated, and of these, only six provided dollar benefits for their improvements. Clearly there is a gap between the agencies' intentions and the reality of computing benefits in financial terms. The survey did not explore the reasons why drainage benefits were calculated for so few projects. It may be that agency personnel do not understand how benefits can be calculated, or perhaps they do not have a satisfactory method for doing so. Further exploration of this issue could be and should be addressed.
Table 3.27. Factors used by 38 agencies to estimate benefits for selected ditch improvement projects in Ohio (1988-1992).

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Project Name</th>
<th>Factors Used to Estimate Benefits</th>
<th>Benefits Estimated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>E22D1</td>
<td>Aiers Ditch</td>
<td>(1) Watershed acres drained; (2) Remoteness coeff.; (3) Runoff coeff.; (4) Use of ditch; (5) Direct assessments.</td>
<td>No</td>
</tr>
<tr>
<td>E23D1</td>
<td>Schul Estates, Sec. 7A</td>
<td>None</td>
<td>No</td>
</tr>
<tr>
<td>E29D84-1</td>
<td>Prairie Ditch 84-1</td>
<td>None</td>
<td>No</td>
</tr>
<tr>
<td>E31D1</td>
<td>B &amp; O Ditch #31</td>
<td>See attached assessment procedure</td>
<td>Yes</td>
</tr>
<tr>
<td>E35D1</td>
<td>Ditch No. 2064 South Branch</td>
<td>Area drained, length of project used the distance from the project and any special benefits.</td>
<td>No</td>
</tr>
<tr>
<td>E38D1</td>
<td>Silver Creek</td>
<td>See Engineer’s report.</td>
<td>No</td>
</tr>
<tr>
<td>E39D1</td>
<td>Silver Creek Ditch No. 1021</td>
<td>Length of project, proximity to project, amount of project landowner will use and we determine the area that will receive the most benefit or relief from the project.</td>
<td>No</td>
</tr>
<tr>
<td>E47D1</td>
<td>Collins Ditch Pet 911</td>
<td>Ac Benefited, reach, land use was all the same for this project</td>
<td>No</td>
</tr>
<tr>
<td>E49D1</td>
<td>#127 Children’s Home Ditch</td>
<td>Equal Benefit at and above headwall – reestablished subsurface outlets</td>
<td>Yes</td>
</tr>
<tr>
<td>E50D1</td>
<td>Beaver-Seckel Ditch</td>
<td>Reduce flooding of subdivision, increase agricultural drainage</td>
<td>Yes</td>
</tr>
<tr>
<td>E51D1</td>
<td>Kyle Prairie Dr. No. 90-99</td>
<td>--</td>
<td>No</td>
</tr>
<tr>
<td>E53D1</td>
<td>Horning Group Drainage Project</td>
<td>Six factors: benefited acres, reach factor, volume runoff factor, location/elevation factor, potential increase in productivity factor, flood protection/property enhancement factor</td>
<td>No</td>
</tr>
<tr>
<td>E56D1</td>
<td>Harry Delact Ditch No. 150</td>
<td>Acreage drained, land use, location on ditch, proximity to ditch, public safety, improvement of road shoulder, improvement of lot (enclosure of ditch)</td>
<td>Yes</td>
</tr>
<tr>
<td>E59D1</td>
<td>Richard Fairchild Ditch #811</td>
<td>Benefited acres, percent of ditch used, land use.</td>
<td>No</td>
</tr>
<tr>
<td>E60D1</td>
<td>Annfield Drive (Baumberger Acres)</td>
<td>By determining the amount of local flooding impacting private property.</td>
<td>Yes</td>
</tr>
<tr>
<td>E61D1</td>
<td>Israel Waggoner ditch, project #902</td>
<td>Number of acres benefited, percent of project used, drainage classifications, overland distance to channel</td>
<td>No</td>
</tr>
<tr>
<td>E63D1</td>
<td>Beamon Ditch</td>
<td>Acres benefited/real/land use/elevation/soils/need/correction</td>
<td>No</td>
</tr>
<tr>
<td>S65D1</td>
<td>North Spice Run</td>
<td>We use number of acres draining, location on ditch and distance from improvement.</td>
<td>No</td>
</tr>
<tr>
<td>E67D1</td>
<td>Richard Carpenter</td>
<td>Cost to Benefit</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>Project ID</th>
<th>Project Name</th>
<th>Factors Used to Estimate Benefits</th>
<th>Estimated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>S26D1</td>
<td>Cranberry Creek</td>
<td>Location, land use</td>
<td>No</td>
</tr>
<tr>
<td>S22D1</td>
<td>Kuest Ditch</td>
<td>Improved agricultural drainage, control and reduce soil erosion, improve water quality, reduce flooding of cropland, improve the economic base see attached papers</td>
<td>Yes</td>
</tr>
<tr>
<td>S29D1</td>
<td>Behm #89-l</td>
<td>Land use, soils hydrologic group, topographic elevation above outlet, acreage.</td>
<td>Yes</td>
</tr>
<tr>
<td>S31D1</td>
<td>Tommas Ditch</td>
<td>Landowners all agreed to an equal per acre assessment</td>
<td>No</td>
</tr>
<tr>
<td>S37D1</td>
<td>Paullin Group Open Ditch</td>
<td>Group Determined their own benefits</td>
<td>No</td>
</tr>
<tr>
<td>S38D1</td>
<td>Rothlisberger Group Ditch</td>
<td>Surface and subsurface drainage - equal acre for benefits.</td>
<td>No</td>
</tr>
<tr>
<td>S42D1</td>
<td>Burras Ditch #186</td>
<td>Acres and land use.</td>
<td>No</td>
</tr>
<tr>
<td>S46D1</td>
<td>Cummins No.769</td>
<td>None</td>
<td>No</td>
</tr>
<tr>
<td>S47D1</td>
<td>Collins Group Ditch</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>S52D1</td>
<td>Horning Group Drainage Project</td>
<td>None used</td>
<td>No</td>
</tr>
<tr>
<td>S55D1</td>
<td>LaCarpe Creek - Gaeth</td>
<td>OSU Fact Sheets - Drainage effects on corn and soybean yields, figured increase over 20 yrs of interest on money invested. If cost did not exceed benefit, then OK.</td>
<td>Yes</td>
</tr>
<tr>
<td>S56D1</td>
<td>Simpson Joint County Ditch</td>
<td>Benefitted acres, Reach factor volume of runoff, location, elevation, potential increase in productivity, flood protection/property enhancement.</td>
<td>Yes</td>
</tr>
<tr>
<td>S57D1</td>
<td>Braskett Group County Ditch</td>
<td>Acres, reach (location), runoff, relative elevation, potential increase in productivity, flood protection/property enhancement.</td>
<td>No</td>
</tr>
<tr>
<td>S58D1</td>
<td>Vanzant Group</td>
<td>Maintenance base are the same as construction cost.</td>
<td>No</td>
</tr>
<tr>
<td>S62D1</td>
<td>SC #289 Attica Work Ditch</td>
<td>Enclosed in appraisal Benefits Roll</td>
<td>Yes</td>
</tr>
<tr>
<td>S64D1</td>
<td>Rapid Run Group</td>
<td>None used - only cost/acre.</td>
<td>No</td>
</tr>
</tbody>
</table>
The projects for which financial benefits are provided, and the dollar amount of the benefits, are listed in Table 3.28. One of the six agencies provided only limited information for the B&O Ditch project and stated that they only made a general determination that costs exceeded benefits. The other agencies apparently made a more extensive effort at estimating benefits, and provided values in one or more categories. Improved crop production is the category most often used, which is probably because cropland is likely the predominant land use in most drainage improvements. Still, one would expect that benefits in other categories could be calculated. The survey did not question the agencies about their selection of benefit categories, so we cannot determine exactly why these categories were chosen. We can speculate that the agencies do not have a procedure for calculating benefits in other categories, or that it is more difficult to do so.

Survey participants were also not asked to provide the details of the calculations since the main objective of these questions was to determine how many agencies were actually calculating benefits. Thus the validity of the calculations cannot be assessed. However, we can compare the benefits with the cost of each of these projects. The question of the validity of the benefit estimates remains, however.

The comparison of costs and benefits for these six projects is shown in Table 3.29. To create this table, construction and maintenance costs provided by the agencies were converted to annual costs as explained in the table footnotes. The benefits provided by the agencies were already expressed as annual amounts. Except for the B&O Ditch project, all projects show benefit amounts that substantially exceed the costs. We can conclude that it is easy to justify these types of projects. It may be that the agencies only
calculate benefits to show that the project benefits exceed the costs, and don’t worry about doing a complete benefit calculation. Or they may only create enough benefits to exceed the costs.

Table 3.28. Estimated annual benefits in dollars by category reported for six group drainage improvements.

<table>
<thead>
<tr>
<th>Name</th>
<th>Estimated Annual Benefits in Each Benefit Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improved Crop Production</td>
</tr>
<tr>
<td>B&amp;G Ditch</td>
<td></td>
</tr>
<tr>
<td>Children's Home</td>
<td>$27,000†</td>
</tr>
<tr>
<td>Harry Delact</td>
<td>$24,351.54</td>
</tr>
<tr>
<td>Behm</td>
<td>$9,000.00</td>
</tr>
<tr>
<td>Tommas</td>
<td>-</td>
</tr>
<tr>
<td>Simpson Joint Co.</td>
<td>$12,000.00</td>
</tr>
</tbody>
</table>

† Agency made a general determination that benefits exceeded costs.

† Values provided are on a per acre basis.
Table 3.29. Comparison of annual costs and annual benefits for six drainage improvements.

<table>
<thead>
<tr>
<th></th>
<th>Total Construction Cost</th>
<th>Annual Construction Cost</th>
<th>Total Annual Maintenance Cost</th>
<th>Total Annual Cost</th>
<th>Total Annual Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>B &amp; O Ditch #31</td>
<td>$26,615.00</td>
<td>$2,610.72</td>
<td>$563.03</td>
<td>$2,618.65</td>
<td>$645.00</td>
</tr>
<tr>
<td>#127 Children's Home Ditch</td>
<td>$13,835.00</td>
<td>$1,357.11</td>
<td>$683.55</td>
<td>$1,358.04</td>
<td>$23,520.00</td>
</tr>
<tr>
<td>Harry Delacot Ditch No. 150</td>
<td>$39,055.79</td>
<td>$3,831.07</td>
<td>$267.65</td>
<td>$3,939.05</td>
<td>$41,305.79</td>
</tr>
<tr>
<td>Behm #59-1</td>
<td>$16,917.95</td>
<td>$1,659.52</td>
<td>-#</td>
<td>$1,659.52</td>
<td>$9,001.76</td>
</tr>
<tr>
<td>Tommas Ditch</td>
<td>$2,241.00</td>
<td>$219.82</td>
<td>-#</td>
<td>$219.82</td>
<td>$2,780.88</td>
</tr>
<tr>
<td>Simpson Joint County Ditch</td>
<td>$46,094.00</td>
<td>$4,521.46</td>
<td>$328.00</td>
<td>$4,821.80</td>
<td>$12,000.00</td>
</tr>
</tbody>
</table>

* Total cost provided by agency from Chapter 2.
† Annual construction cost was calculated by amortizing the total cost over 20 years at an interest rate of 7.5%.
‡ Total annual maintenance cost taken from Chapter 2. Annual expenditures provided by agencies were converted to a present value at the time of construction, and then annualized over the number of years since project construction, using an interest rate of 7.5%.
§ Total annual benefits is the sum of the values provided by the agency in Table 3.29.

It is apparent from this analysis that agencies could do a more thorough job of estimating benefits while planning ditch projects. Only 6 of 38 projects (16%) had quantified benefits, and then usually for only one or two categories of benefits. The reasons for this are not clear from the survey, but may be related to a need to have better knowledge of how to estimate benefits. These issues should be explored in subsequent studies.

3.3.6 Attitudes of respondents

Three open-ended questions, Q-51, Q-52, and Q-53, were asked to determine changes that have been made or that were being considered in the methods and procedures used in calculating assessments for drainage improvements. In question Q-51, respondents were asked to “Please describe any changes you have made in your
methods of calculating assessments or allocating costs for group drainage improvement projects since 1985.” Sixteen county engineers and twenty SWCDs provided a response to this question. A listing of non-negative responses – those for which a response other than “none” was given – is presented in Table 3.31 (all responses are listed in Appendix B).

There apparently have not been many substantial changes made in methods by the agencies responding. Of those responding to question Q-51, 63% of the county engineers and 70% of the SWCDs indicated no changes had been made in methods since 1985. On the other hand, 37% of the county engineers and 25% of the SWCDs indicated that changes had been made or were being considered either in the factors evaluated or the methodology used in determining assessments. One county engineer reported he is leaning toward using the Rational Method (Benefit Adjustment Formula), while one SWCD has changed to the Montgomery county procedure and another SWCD has switched to a varied method from the Acre Equal Method.

Six agencies (16%) have made changes in the use of factors. At least one county engineer and one SWCD have added land use categories or increased the number of land use categories in their formulae. One SWCD has added factors such as distance from the outlet, need for improvement based on soil types, and the percentage correction of the problem. The Montgomery County Engineer indicated that they “are currently reviewing their method and comparing it with other counties. This survey and subsequent report is very timely and important to Montgomery County.”

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Table 3.30. Non-negative responses, by agency, to question Q-51: “Please describe any changes you have made in your methods of calculating assessments or allocating costs for group drainage improvement projects since 1985.”

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Changes made in assessment methods for group drainage improvement projects since 1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>E22</td>
<td>All projects assessed all vary according to the characteristics of the project, but all use the same basis used (see question Q-28)</td>
</tr>
<tr>
<td>E29</td>
<td>On a small urban type project was done successfully on a per unit basis on approximately equal sized lots.</td>
</tr>
<tr>
<td>E30</td>
<td>We do not consider runoff.</td>
</tr>
<tr>
<td>E45</td>
<td>Generally we assess at flat rate per acre, varies with each individual ditch.</td>
</tr>
<tr>
<td>E50</td>
<td>Each project is unique and although, in general, methods of assessment are tailored to each project.</td>
</tr>
<tr>
<td>E53</td>
<td>None so far however we are currently reviewing the method and comparing it with other counties. This survey and subsequent report is very timely and important to Montgomery County.</td>
</tr>
<tr>
<td>E56</td>
<td>Classification of land according to use (more categories) Direct assessment for tile and pipe repair or replacement (1998 projects)</td>
</tr>
<tr>
<td>E60</td>
<td>We are leaning toward the Rational Determination method of determining assessments, having used the prorata by area method in the past.</td>
</tr>
<tr>
<td>E63</td>
<td>Established a 2 ac. minimum building site for use factor, Whether Agricultural or Residential.</td>
</tr>
<tr>
<td>E65</td>
<td>We charge 50% of cost of brushing to the parcel of land it was on.</td>
</tr>
<tr>
<td>E69</td>
<td>We don’t require a mutual agreement from a developer for a subdivision if the estimated cost of improvements outside the right of way will be less than $5,000 and the average lot assessment will be less than $5 per year.</td>
</tr>
<tr>
<td>S21</td>
<td>This district has worked on two group ditches and 2 SB 160’s in the early to mid 80’s. Both SB 160 assessment calc. were performed by Co. Engineer. Neither project was constructed.</td>
</tr>
<tr>
<td>S31</td>
<td>Added factors: distance from outlet, need for improvement based on soil types, % correction of problem. Using combination of benefit units and acreage to divide costs.</td>
</tr>
<tr>
<td>S33</td>
<td>Use an agent for the group to represent landowners more. Make that agent more active in the project.</td>
</tr>
<tr>
<td>S37</td>
<td>Have added Miami County-Montgomery county procedures</td>
</tr>
<tr>
<td>S38</td>
<td>Assessment method determined on case by case basis. Long narrow watersheds usually pay based on % of stream used. Small projects usually go equal acre basis. Group votes on which method is used.</td>
</tr>
<tr>
<td>S39</td>
<td>Most mutual projects are done with equal assessment. Since ‘85 we tried 1 SB project w/equal assessment and switched it to varied. All SB 160 projects are varied now.</td>
</tr>
<tr>
<td>S40</td>
<td>The method has not been changed although we have purchased a computer program that runs the calculations for us.</td>
</tr>
<tr>
<td>S41</td>
<td>Don’t do enough projects to make a good assessment.</td>
</tr>
<tr>
<td>S52</td>
<td>None. The method now used was adopted in 1985.</td>
</tr>
<tr>
<td>S57</td>
<td>Drainage assessment used previously was cost per acres benefited. Several methods can be used now, present current assessment schedule, then let the group decide with SWCD input.</td>
</tr>
<tr>
<td>S58</td>
<td>Have set minimum assessments for small residential lots.</td>
</tr>
</tbody>
</table>
In question Q-52, respondents were asked to “Please describe any changes in law, procedures, etc., that could be made to improve the group drainage improvement process.” Fourteen county engineers and twenty SWCDs provided a response to this question. A listing of non-negative responses is presented in Table 3.31 (all responses are listed in Appendix B).

Several issues surfaced in response to this question. Reducing the regulatory burden by eliminating 401 and 404 permitting on drainage projects was mentioned by 18% (6 responses) of those responding to this question. Fifteen percent (5) indicated a desire for better methods, and 9% (3) felt that all counties should use the same methods for assessment. One respondent felt that if agencies used the same method, it would be easier to justify assessments to landowners in different counties, which could be an issue in multi-county projects.

While eight (24%) of the responses expressed a desire for consistent methods around the state or for improved methods for making assessments, only two responses (6%) mentioned benefits. One county engineer specifically expressed the need to develop a “more defined method to justify benefit over cost for these projects.” One SWCD mentioned a need for an improved method for determining benefits to residential property from the construction of group drainage projects.

Twelve percent (4) of the responses were related to ditch maintenance issues, and another 9% (3) were related to easement concerns.
Table 3.31. Non-negative responses, by agency, to question Q-52: “Please describe any changes in law, procedures, etc., that could be made to improve the group drainage improvement process.”

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Suggested changes in law, procedures, etc. to improve process</th>
</tr>
</thead>
<tbody>
<tr>
<td>E20</td>
<td>Eliminate the 401 Certification (OEPA) and 404 Permit (Army Corps of Engineers)</td>
</tr>
<tr>
<td>E22</td>
<td>It would be nice if all 88 counties could agree to a standard assessment procedure to provide consistency from county to county.</td>
</tr>
<tr>
<td>E39</td>
<td>Eliminate the need for a 401 EPA and 404 Army Corps of Engineers permits for drainage projects</td>
</tr>
<tr>
<td>E49</td>
<td>Address Easement Rights for maintenance — in particular when ag land is sold for lots; i.e. temporary easement for spoil spreading is not adequate</td>
</tr>
<tr>
<td>E51</td>
<td>Make all counties use the same method</td>
</tr>
<tr>
<td>E53</td>
<td>Improve language in ORC 1515 regarding temporary and permanent easements; Improve ORC 6131 language regarding temp &amp; perm easements on plat of survey.</td>
</tr>
<tr>
<td>E59</td>
<td>Make review and permit procedure by other gov't agencies easier. Less paper work/more timely response.</td>
</tr>
<tr>
<td>E60</td>
<td>Simplify the process and give the Board of county Commissioners more authority in all ditch matters.</td>
</tr>
<tr>
<td>E63</td>
<td>Cost/Benefit ratio. Develop a more defined method to justify benefit over cost for these projects.</td>
</tr>
<tr>
<td>E65</td>
<td>Have interest from ditch maintenance fund put back into ditch maintenance fund, not general fund. Also streamline permit process thru army corps of Eng and Ohio EPA.</td>
</tr>
<tr>
<td>E69</td>
<td>(1) Publication of a guidebook of &quot;accepted&quot; assessment methods; (2) allow commissioners to levy &amp; collect assessments based on estimated project costs, and allow them to place any leftover contingency amounts into maintenance account (ORC 6131.43); (3) indicate if outside funding (e.g., Issue 2) monies can be subtracted from &quot;cost&quot; for cost/benefit calcs.</td>
</tr>
<tr>
<td>S21</td>
<td>Can't answer. Haven't seen a petition ditch go from petition to construction maintenance. All have died in the process</td>
</tr>
<tr>
<td>S25</td>
<td>Since Montgomery County method has been through the courts. This method should be adopted state wide to eliminate confusion.</td>
</tr>
<tr>
<td>S30</td>
<td>State approved guidelines for cost allocation that could be provided to mutual groups would be very beneficial.</td>
</tr>
<tr>
<td>S31</td>
<td>Change 6131 to accept 1515 projects onto county maintenance.</td>
</tr>
<tr>
<td>S32</td>
<td>Prevailing wage laws for 6131</td>
</tr>
<tr>
<td>S35</td>
<td>Our board said we would assist with project if group installed &quot;min&quot; 10' filter strip both sides of open ditch.</td>
</tr>
<tr>
<td>S37</td>
<td>Adapting the 160 process to urban and storm water controls. Need to improve method for determining benefits of drainage improvement values for residential acreages.</td>
</tr>
<tr>
<td>S40</td>
<td>Assessment process is too complicated, but I don't have a better answer.</td>
</tr>
<tr>
<td>S41</td>
<td>Don't do enough projects to do a good assessment.</td>
</tr>
<tr>
<td>S42</td>
<td>ORC 1515 should be maintained according to ORC 6137. Cost share $ for erosion control to replace lost ACP monies.</td>
</tr>
<tr>
<td>S46</td>
<td>There should be a consistent method of assessment across the state. This would make it easier to justify assessment methods to landowners in more than one county</td>
</tr>
<tr>
<td>S52</td>
<td>A method to collect assessments from benefiting landowners within an established drainage area of a previous county petitioned drainage project that was completed before 1958. The funds collected would be used for future maintenance or replacement.</td>
</tr>
</tbody>
</table>

Continued
Table 3.31. (continued) Non-negative responses, by agency, to question Q-52: “Please describe any changes in law, procedures, etc. that could be made to improve the group drainage improvement process.”

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Suggested changes in law, procedures, etc. to improve process</th>
</tr>
</thead>
<tbody>
<tr>
<td>S55</td>
<td>Provide law Temp. Const. easements and permanent maintenance language for SWCD with out using the 6131 Language.</td>
</tr>
<tr>
<td>S55</td>
<td>The laws could be made easier to understand. Different counties interpret the wording different.</td>
</tr>
<tr>
<td>S56</td>
<td>Find fair way to charge for brush removal.</td>
</tr>
<tr>
<td>S57</td>
<td>Allow government agencies such as Seabees - Mobil Naval Construction battalion, bid or work free gratis on group drainage projects.</td>
</tr>
<tr>
<td>S59</td>
<td>Remove DPA and C.O.E. from all projects with less than 10,000 acre watershed, especially if no public funds are used.</td>
</tr>
<tr>
<td>S68</td>
<td>Working well.</td>
</tr>
</tbody>
</table>

One respondent felt that since the Montgomery County Drainage Assessment Procedure has been “through the courts,” it should be adopted statewide. However, as noted earlier, several of the methods in use have been through the courts, so the experience is not unique to the Montgomery County Method. Each case is tried on its merits, thus providing a particular court case no special precedence. Also, the burden of proof on appeal is upon the plaintiff to show that the assessments are not proportional to the benefits, a burden that is hard to fulfill.

One engineer asked for an indication “if outside funding (e.g., Issue 2) monies can be subtracted from ‘cost’ for cost/benefit calcs [sic].” This suggestion is obviously an attempt to secure a more favorable benefit:cost ratio, and would not be good practice if one wanted to achieve a true financial picture of the projects. A suggestion was also made for cost-share monies to replace those previously provided through the Agriculture Conservation Program of the USDA-Farm Service Agency. Cost-share funding makes a project more financially attractive to the landowners, but doesn’t change the overall benefit:cost analysis.
In question Q-53, respondents were asked to “Please describe any unique, unusual or different aspects of your group drainage improvement program that you are aware of with respect to other counties in Ohio.” Thirteen county engineers and fourteen SWCDs provided a response to this question. A listing of non-negative responses is presented in Table 3.32 (all responses are listed in Appendix B). A summary of the responses to questions 51, 52 and 53 is provided in Table 3.33.

Many agencies, 41% of those responding, indicated they were unaware of any differences. The remaining responses show divergent experiences and methods of operation. One SWCD bragged “We are damned good at what we do...Our [SB]160 program is growing & succeeding.” On the other hand, one SWCD indicated that “It is a horrible and confusing mess...” and another stated that their “system is slowly breaking down.” These divergent experiences indicate a need for inter-county assistance, education and training, to help improve things for counties that are having problems.

How agencies approach ditch maintenance varies considerably. Auglaize County performs 100% of ditch maintenance in-house, while another county contracts out all work except record keeping and inspections, and are considering contracting out the inspection. Another agency uses prisoner details to reduce expenses. This indicates that the agencies are responding to local efficiencies and experiences to find the procedures that work best in their situation.
Table 3.32. Responses to question Q-53: “Please describe any unique, unusual or different aspects of your group drainage improvement program that you are aware of with respect to other counties in Ohio.”

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Program differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>E20</td>
<td>Allen County—watershed based on surface drainage; Putnam County—Watershed based on Sub-surface drainage.</td>
</tr>
<tr>
<td>E22</td>
<td>Auglaize county performs 100% of all maintenance work on 162 projects. No contracts are let for maintenance.</td>
</tr>
<tr>
<td>E49</td>
<td>We mow all open ditches since 1972.</td>
</tr>
<tr>
<td>E53</td>
<td>Through a memo of understanding between board of city comm., city engineer and MSWCD the district will maintain ORC 1515 Improvements. We also use prisoner details to reduce expenses.</td>
</tr>
<tr>
<td>E56</td>
<td>The spirit of rugged individualism causes many problems with group projects in Paulding County. Neighbors cannot agree so they are forced into the petition or SB-160 route.</td>
</tr>
<tr>
<td>E58</td>
<td>Repair ditches; old county petition projects fixed by authority of commissioners on request of landowners. These ditches are not on the maintenance program.</td>
</tr>
<tr>
<td>E61</td>
<td>Seems that most counties determine their final watershed from topo maps. We send our initial mailings based on topo maps, but determine final watershed from personal interviews w/ all owners. This is very time consuming, but priceless when it comes to having an informed watershed at hearings!</td>
</tr>
<tr>
<td>E69</td>
<td>None that I’m aware of.</td>
</tr>
<tr>
<td>S20</td>
<td>EPA has effectively stopped work on any projects that need deepening.</td>
</tr>
<tr>
<td>S31</td>
<td>We’re all different.</td>
</tr>
<tr>
<td>S32</td>
<td>It is a horrible and confusing mess because it relies on too many people/ departments to make it work. We only have 1 on maintenance and every year it is a disaster.</td>
</tr>
<tr>
<td>S42</td>
<td>Excessive grades in unstable soils.</td>
</tr>
<tr>
<td>S43</td>
<td>Last group project in county was in 1980.</td>
</tr>
<tr>
<td>S52</td>
<td>The Miami SWCD works very close with the Miami Co. Engineer. The first step in all drainage improvement projects is the use of the mutual agreement. If that procedure fails then the petition method is used.</td>
</tr>
<tr>
<td>S53</td>
<td>We have a solid team—Co. Commissioner, Co. Eng., Prosecutor, Health department, Twp. Trustees and sheriffs office. Are system is slowly breaking down.</td>
</tr>
<tr>
<td>S59</td>
<td>We are damned good at what we do! Since 1990 our office has been involved with a total of 53 group projects, ranging in size from 1 mile to 29 miles. Our 160 program is growing &amp; succeeding.</td>
</tr>
<tr>
<td>S68</td>
<td>We contract out all work except record keeps and inspection. We are considering having a contractor do inspection in the future.</td>
</tr>
</tbody>
</table>
Table 3.33. Summary of responses to questions Q-51, Q-52 and Q-53:

**Question Q-51:** Please describe any changes you have made in your methods of calculating assessments or allocating costs for group drainage improvement projects since 1985.

<table>
<thead>
<tr>
<th>Category of response</th>
<th>Number of County Engineers with this response</th>
<th>Number of Soil and Water Conservation Districts with this response</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Response indicated no change</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Response indicated changes in factors used</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Response indicated change in methodology used</td>
<td>--</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total responses**                                        | **16**                                        | **20**                                                          |

**Question Q-52:** Please describe any changes in law, procedures, etc. that could be made to improve the group drainage improvement process.

| No response                                                                                                      | 2 |
| No experience with group drainage projects                                                                    | -- |
| Response indicated a desire to reduce the regulatory burden on agencies and landowners                      | 4 |
| Response indicated all counties should use the same assessment methods or procedures                         | 2 |
| Response indicated a need for better methods                                                                  | 2 |
| Response indicated a need to address easements                                                               | 2 |
| Response related to project maintenance                                                                      | -- |
| Response indicated no change needed                                                                         | 4 |
| Other                                                        | 1 |

**Total responses**                                        | **14**                                        | **20**                                                          |

**Question Q-53:** Please describe any unique, unusual or different aspects of your group drainage improvement program that you are aware of with respect to other counties in Ohio.

| No Response                                                                                                      | 5 |
| Response indicated none known                                                                                  | 6 |
| Response cited differences                                                                                       | 6 |
| Response made general comments unrelated to program differences                                               | 1 |

**Total responses**                                        | **13**                                        | **14**                                                          |

Two SWCDs mention that teamwork among the agencies is very important for successful programs. Working closely with landowners to keep them informed of the process is also important, as is the ability of landowners to work together. One agency
indicates that the “spirit of rugged individualism” causes problems, and often causes projects to be constructed using the petition or SB-160 procedures, which often results in more out-of-pocket expense and a more lengthy process than using the mutual agreement procedures.

After answering the open-ended questions, the participants were asked to indicate the willingness of their agencies to change from the current assessment procedures. A Likert scale from 1 to 5 was used, and the responses are summarized in Table 3.34. Fifty-two responses to this question were received. Overall, on average the responses were neutral, with as many unwilling to change as were willing to change. However, when the responses are separated by agency type, as shown in Table 3.34, a difference in opinions is observed.

The county engineers (mean score 3.17) appear to be more willing to change assessment methods than SWCDs (mean score 2.76). A plurality of county engineers, 39%, indicated they were willing to change methods, and another 30% were neutral. On the other hand, while nearly 52% of the responding SWCDs were neutral, only 17% stated that they were willing to change. Over 20% were somewhat unwilling and 10% were unwilling to change assessment methods. The nine SWCDs in these last two categories have by far the most active group drainage programs of the SWCDs responding, with an average of more than 40 requests for project assistance per county and a completion rate during 1994-1996 of 45 per county for the ‘unwilling’ respondents and 29 per county for the ‘somewhat unwilling’ respondents. The SWCDs which were

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9 Because of an error in the survey, this question was also numbered Q-53.
neutral received an average of only 6 requests per county and completed only four per county in the same time period. Obviously, the more active SWCDs are happy with their methods, and are unwilling to change a successful process.

This trend is not found in the responses of the county engineers. Discounting the single response in the ‘somewhat unwilling’ category, the average project requests per county was similar for all response categories, ranging from 17 to 21. The counties that responded in the 'unwilling' and 'somewhat unwilling' categories did complete more projects than the counties responding in the other categories, but the contrast was not nearly as great as with the SWCD responses.

Although explanations or comments regarding the willingness to change were not solicited, a few respondents made comments. These comments are shown in Table 3.35.
### Table 3.34. Willingness of respondents to change assessment or cost allocation methods, and project summary data.

<table>
<thead>
<tr>
<th>Score</th>
<th>Number Responses</th>
<th>Percent of Responses</th>
<th>Number of Requests Filed 1994-1996</th>
<th>Average Requests per County</th>
<th>Number of Projects Completed 1994-1996</th>
<th>Average Completed Per County</th>
<th>Soil and Water Conservation Districts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>17.4%</td>
<td>83</td>
<td>21</td>
<td>70</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>4.3%</td>
<td>36</td>
<td>36</td>
<td>18</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>30.4%</td>
<td>132</td>
<td>19</td>
<td>68</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>39.1%</td>
<td>192</td>
<td>21</td>
<td>131</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>8.7%</td>
<td>33</td>
<td>17</td>
<td>25</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>23</strong></td>
<td></td>
<td><strong>476</strong></td>
<td></td>
<td><strong>312</strong></td>
<td>14</td>
<td><strong>29</strong></td>
</tr>
</tbody>
</table>

- Average score: 3.20
- Standard deviation: 1.23
- Average: 2.76
- Standard deviation: 0.87

\(^1\) Responses were measured using a Likert scale with 1 = Unwilling, 2 = Somewhat unwilling, 3 = Neutral, 4 = Willing and 5 = Very willing
Table 3.35. Comments by respondents relating to their willingness to change cost allocation methods.

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Response</th>
<th>Comment offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-20</td>
<td>4</td>
<td>I am willing; of course, this would be dependent on the county commissioners and auditor.</td>
</tr>
<tr>
<td>S-26</td>
<td>2</td>
<td>Unless you have a better way.</td>
</tr>
<tr>
<td>E-40/S-40</td>
<td>3</td>
<td>If simple, equitable method can be found, I am sure that it would be given consideration. Our present assessment procedure is complicated and difficult for some people to understand.</td>
</tr>
<tr>
<td>S-42</td>
<td>2</td>
<td>Up to landowners.</td>
</tr>
<tr>
<td>S-51</td>
<td>3</td>
<td>Would be interested in assessment method for SB 160 projects.</td>
</tr>
<tr>
<td>E-56</td>
<td>3</td>
<td>Depends on too many unknown elements at present. If it can be shown to be better, we might change.</td>
</tr>
<tr>
<td>E-61</td>
<td>1</td>
<td>To having an informed watershed a hearings.</td>
</tr>
<tr>
<td>S-21</td>
<td>--</td>
<td>County Engineer is acting on a very recent petition. Past projects have been done using acre equal. This current project is being looked at with Montgomery County’s method. We will see next year how it worked.</td>
</tr>
<tr>
<td>S-35</td>
<td>1</td>
<td>Our cost allocation methods work great only pay what you have drained.</td>
</tr>
</tbody>
</table>

3.4 Discussion of assessment methods and formulae

Seventeen distinct assessment methods or formulae have been presented. These were placed in three groups reflecting the similarities among the formulae. Overall, the agencies seem to be neutral on their willingness to change methods, yet 24% of the respondents to question Q-52 indicated a desire for either better assessment methods or for a method that could be used statewide. In this section we will discuss the formulae used by these agencies in Ohio and the factors used in the formula in order to clarify issues that need to be addressed in a statewide assessment method.

Very little narrative and justification was provided by the agencies regarding the 17 assessment formulae in use. Often, only the formula was provided. Many of these formulae have been in use a long time, and the original justification may have been lost, forgotten or perhaps was never developed. In some cases, it is claimed the basic procedure has been in use for over 100 years. Many of the formulae were probably
developed for use under older laws, and have continued to be used although some of the laws have changed. Custom of the counties and agencies involved plays a large part in how projects are assessed.

The lack of justification for the various assessment methods indicates a need for training in benefit cost analysis for the agency personnel involved in assessments. With the large number of new and completed group drainage projects found in Chapter 2, there is also an opportunity to conduct ex ante and ex post studies of costs and benefits of drainage projects.

3.4.1 Relation of variables used to benefit factors

As we have seen, various characteristics, or factors, of a parcel are used to calculate assessments. Table 3.36 lists the various factors used as variables in the formulae presented, and shows the frequency of use in the different formula categories used. Aside from the variable \( A \) (area), which is used in all formulae, variables \( L \) (percent of project used) and \( R \) (remoteness from the project) are the most frequently used. Variable \( U \) (land use) is used in nine formulae, \( E \) (elevation) is used in six formulae, while variables \( S \) (subsurface drainage adjustment) and \( I \) (increased value or productivity) are each used in five formulae. The variable \( H \) (hydrology) is used in four formulae, the variable \( V \) (volume of runoff) is used in three formulae, and the remaining variables are used in less than three formulae each. Variable \( U \) is not used in the financial benefit methods, while variable \( I \) is not used in simple index methods.
Table 3.36. Frequency that each variable is used in the various assessment methods.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviated Description</th>
<th>Simple Index Methods (8 methods)</th>
<th>Complex Index Methods (6 methods)</th>
<th>Financial Benefit Methods (3 methods)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Area</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>D</td>
<td>Drainage class</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>Elevation</td>
<td>2</td>
<td>-</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>F</td>
<td>Flooding factor</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>Ring class</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Hydrology</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>I</td>
<td>Increased productivity</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>L</td>
<td>Length; percent use</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>M</td>
<td>Problem correction</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>Need for project</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>Remoteness</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>S</td>
<td>Subsurface drainage</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>T</td>
<td>Topography</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>U</td>
<td>Land use</td>
<td>6</td>
<td>3</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>V</td>
<td>Volume of runoff</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>X</td>
<td>Percent of crop</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ya</td>
<td>Crop yield</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Agricultural benefit</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Some of the factors represented by these variables are explicitly mentioned in paragraph 6131.01(F) of the Ohio Revised Code which defines benefits resulting from drainage improvements. Others are listed in section 6131.15 of the revised code. The first factor mentioned as being relevant is the “watershed or entire land area drained or affected by the improvement” (6131.01(F)(1)). This is represented by variable A, and is the only factor used in all formulae.

Variable L, used in 11 of the formulae, represents the portion of the improvement through which drainage water from a parcel flows (6131.15 Revised Code). In practice, a parcel is expected to bear the cost of any part, and only those parts, of the improvement through which his drainage water travels.
Variable R, also used in 11 of the formulae, represents a "remoteness" factor, or distance from the improvement. This is analogous to the provision that the engineer take into consideration the relative location of the parcel to the improvement (6131.15 Revised Code). This value is usually based on distance. The intent may be to recognize that owners of parcels away from the improvement may need to make an investment, to recognize the full benefit of the improvement, thus the parcel's assessment is reduced to account for this.

The variable, V, represents "the total volume of water draining into or through the improvement and the amount of water contributed by each landowner" (6131.01(F)(2) Revised Code) or the accelerated runoff (6131.01(F) Revised Code). However, the variable V is only used in four formulae. The variable U is also used to represent this factor in several of the formulae. The Wayne County Engineer indicated that the land use variables were based on relative runoff volumes. The Allen County Engineer created a table of land use values for the Parcel Benefit Factor Method based on runoff volume. It appears that land use serves as a proxy for runoff volume in all of the formulae in which it is used.

If this is so, the values used for the various land uses should be relatively the same for each of the formulae, but this is not the case. Table 3.37 shows the relative values used for various land use categories in the formulae. This table was created by normalizing the values to the value used for agricultural land, and setting the agricultural land use value equal to 1.0. We can then see how the other land use values compare to the value used for agricultural land among the various formulae, even though the actual values used may different for each of the formulae.
As seen in Table 3.27, the relative values are not consistent among the various formulae. For example, residential land use values vary from a low of 30% of the value for agricultural land in the Paulding County Method, to a high of 400-600% of the value used for agricultural land in the Benefit Adjustment Formula used by the Preble Engineer. Similar ranges in values exist for other land uses. While differing soil types and farming systems may account for some variation in runoff volume, the values shown in Table 3.27 indicate a variance inconsistent with the premise that the land use variable is a proxy for runoff volume in all of these formulae.

The use of the land is also a factor to be considered (6131.01(F)(3) Revised Code). The use could be considered in ways other than from the standpoint of its effect on runoff volume. For instance, cropland may have increased productivity because of improved drainage, while productivity would be irrelevant for residential and commercial land. There may be a benefit for improved surface drainage for many land uses. However, there is no indication of the basis for land use values in the formulae, other than as a proxy for runoff volume.

The variable I is used in six formulae, and represents the potential increase in productivity resulting from the improvement. This factor is mentioned in section 6131.15 of the Revised Code. All four of the financial benefit (Class III) formulae use this factor. This factor is a recognition of the benefit of improved drainage to cropland.
Table 3.37. Normalized land use factor values used by several agencies, grouped by similar assessment formulae.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Agricultural Cropland</th>
<th>Woods</th>
<th>Pasture/Grass</th>
<th>Roads</th>
<th>Road ROW</th>
<th>Residential</th>
<th>Commercial</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
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</table>

* Some formulas use values within a range. The high and low columns represent the range of values used in the formula.

† Blank cells indicate that the land use is not considered in the formula.
The variable $E$ is also used in six formulae. This variable represents an elevation difference between the parcel and the improvement. Elevation difference is not explicitly mentioned in the revised code as a factor relating to benefits. The variable $E$ is used in these formula in combination with distance from the improvement as a remoteness factor.

The variable $H$ represents a hydrologic soil group factor in three of the formulae. As the hydrologic soil group is related to volume of runoff, it serves as a proxy for the volume of runoff variable, $V$.

The variable $S$, representing an adjustment factor for subsurface drainage, is used in five formulae. This factor also is not explicitly mentioned in the revised code, but represents various adjustments for the amount of subsurface drainage in a parcel, or whether or not the subsurface drainage enters the improvement.

The variable $D$ is based on the soil drainage class. Better drained soils receive less benefit from a drainage improvement that do poorly drained soils, and the values assigned reflect this. This variable is used by one formulae.

The variable $F$ is used by the Montgomery County Drainage Assessment Procedure and represents the reduction or elimination of damage from flooding. This factor is listed in 6131.01(F) of the revised code.

The variables $M$ and $N$ are used in the Benefit Adjustment Formula and represent an assessment of the need for problem correction and the amount of protection provided by the improvement. The values used for these variables are determined by the technician based on his experience and descriptive value ranges.
3.4.2 Discussion of assessment formulae

Only four of the 19 formulae presented here attempt to assign benefit values to each parcel of land in a watershed served by a drainage improvement: The Sandusky County Method, the Moran Method, the Sectionalized Method and the Miami County Method. The others make the assumption that benefits are proportional to a combination of various parcel characteristics. However, no financial benefits are defined. No evidence was presented, such as the regression analysis done by Bengston et al. (1969), to justify these assumptions. Also, each characteristic is usually equally weighted in the formula. This is in contrast to Bengston et al. (1969), who used three physical characteristics in their equation: (a) distance, in feet, from the tract of land to the main drain, (b) distance, in feet, from the tract of land to the main outlet and (c) permeability of the soil on the tract of land. The correlation coefficients found were 0.3476, 0.4680 and 0.4434 respectively, indicating that the factors, while close to the same value, are not necessarily of equal importance. Of course, to conduct a regression analysis, the benefits for each parcel would need to be determined.

Formulae are used instead of estimating actual benefits from a drainage improvement for several reasons: the lack of accepted methods of estimating benefits, a lack of understanding of benefit cost analysis, a desire for a procedure that is easy to use, a desire for a procedure that is easy to explain to affected landowners and government officials, and the desire for a procedure that is repeatable; that is, one that will give the same results when performed by different persons. So long as the formula produces assessments that are proportional to benefits, all is well. However, the formulae in use in Ohio have not been shown to be proportional to the benefits. This has not been a major
concern, since in case law there is an assumption that the assessments are valid (H. Nolan Meyer v. Joint Board of County Commissioners, 1996 Ohio App. LEXIS 4330). Thus, so long as the Board of County Commissioners and/or the Court of Common Pleas have confidence in their formula, it is likely to withstand appeal. However, a study showing that a formula resulted in assessments that were proportional to the benefits would be very helpful.

Earlier we placed the assessment formulae in use in Ohio in one of three classes based on their complexity or the estimation of benefits. We will review the development of these formulae and evaluate strong and weak points.

The first two classes of formula are very similar, and could in fact be combined into one class. All formulae in these classes develop an index value for each parcel that results in an assessment that purports to be proportional to the benefits received by that parcel from the construction of the improvement.

Each of the formulae in these two classes can be thought of as extensions of the most simple formula, which is used for the Acre Equal Method, where the parcel assessments are proportional to the acres in each parcel. Thus, use of this formula assumes that the benefits are proportional to the area benefited. This assumption is valid only for improvements benefiting small areas having a similar land use. For larger projects, with substantial areas in more than one land use, this assumption may not hold, and the engineers calculating assessments began to look at other factors to use in the formulae to make the assessments better approximate the benefits. However, no instance of a comparison of assessments with benefits has been found, so the assumptions made as
the additional factors were added have not been rigorously tested. The only test has been
the acceptance of the additional factors by the landowners themselves.

The Benefit Units Method adds a land use factor to the basic formula to account
for the differences in benefits resulting from different land uses. Three agencies use the
Benefit Units Method, but the factor values used appear to be quite different. The Wayne
County Engineer indicated that their values were based on runoff volume calculations.

The Putnam County Method adds the percent of use factor to the basic formula as
variable L in the formula (Eq. 9). This factor is mentioned in section 6131.15 of the
Revised Code as relating to benefits.

The Benefited Acres Method used by the Henry SWCD adds a remoteness factor,
R, to the Putnam County Method. This is analogous to the provision that the engineer
take into consideration the relative location of the parcel to the improvement (6131.15
Revised Code). This value is usually based on distance. The intent may be to recognize
that owners of parcels away from the improvement may need to make an investment, to
recognize the full benefit of the improvement, thus the parcel's assessment is reduced to
account for this.

Table 3.38 demonstrates the results of these alternative assessment methods, using
invented parcel characteristics. We can see that there are some large differences among
the assessments of each of the parcels under the different methods, with assessments for
some parcels as much as ten times the assessments of other parcels in the same project.
Table 3.38. The effect of four different methods on assessments using assumed parcel characteristics.

<table>
<thead>
<tr>
<th>Parcel</th>
<th>Cropland Acres</th>
<th>Residential Acres</th>
<th>Total Acres</th>
<th>% of Ditch Used</th>
<th>Remoteness Value</th>
<th>Benefit Units Index Value</th>
<th>Putnam County Index Value</th>
<th>Henry County Index Value</th>
<th>Acre Equal</th>
<th>Calculated assessments</th>
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<td>A</td>
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<td>11</td>
<td>11</td>
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</tr>
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<td>9</td>
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<td>$76.92</td>
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<td>10</td>
<td>70%</td>
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<tr>
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<td>50%</td>
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<td>1</td>
<td>10</td>
<td>20%</td>
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<td>11</td>
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<td>$76.92</td>
<td>$80.29</td>
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<tr>
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<td>1</td>
<td>10</td>
<td>20%</td>
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<td>11</td>
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<td>10%</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>$76.92</td>
<td>$72.99</td>
</tr>
</tbody>
</table>

| Total  | 130           | 137               | 73.7        | 64.6            |                  |                          |                          |                          | $999.96    | $999.97  | $1,000.00 | $1,000.01 |

Assessable cost per unit $7.69 $7.30 $13.57 $15.48
It is evident that the percentage of ditch used factor drastically changes the assessments of parcels at opposite ends of the improvement. The assessment for parcel A almost doubles when this factor is added, while the assessment for parcel M is reduced to about 20% of the acre equal value. While all four of these methods are acceptable methods in Ohio, they can’t all result in assessments that are proportional to the benefits from a drainage improvement. One of these methods may, in fact, produce assessments that are proportional to these benefits, but this has not been shown to be the case.

The Fairfield County Assessment Method adds a factor representing the soil drainage class to the previous formula. The result of this is that a parcel having better drained soil would have a lower assessment than a parcel with more poorly drained soil.

In the Preble SWCD Method elevation is used instead of distance to reduce assessments for parcels away from the ditch. (Parcels bordering the ditch would have no reduction.) The hydrologic soil group is also used as a factor, representing the decreased infiltration, and increased runoff, for D group soils compared to A group soils.

A subsurface drainage factor was added in Defiance County to account for the presence of subsurface drainage in the parcel. The factor value varies with the hydrologic soil group and whether the subsurface drainage is routed to or away from the improvement. While a reduction in assessments for subsurface drains using another improvement as an outlet is understandable, it is unclear why different values are assigned for the different hydrologic soil groups.

The Target Method is unique among the methods in that a boundary is drawn on a map enclosing an area of land, called the 100% area, determined to have the highest benefits from the project, and the remainder of land in the project area is assessed at
decreasing rates the farther away they are from the 100% area. The weakness of this method is that the boundaries appear to be arbitrarily drawn. It appears that there are always 10 areas, with equally spaced values assigned to each area. It is unlikely that this would provide assessments that are proportional to benefits. Determining the area of 100% benefits is a good approach, if done well, and with a less arbitrary means of determining the values assigned to other rings, this method could work well.

A different approach to reducing assessments because of a parcel's location away from the improvement is taken in the Paulding County Assessment Method. Here a set percentage value is subtracted from the percent of use factor prior to the calculation of the benefit index. This approach generally results in less reduction for remoteness than occurs in methods that use the remoteness factor as a multiplier in the index formula.

The Benefit Adjustment Formula developed by Yost (1979; 1980) is another benefit index formula which adds certain of the factors prior to the multiplication step. Factors for topography and soils hydrologic function are added together as a composite factor, as are factors relating to the need, the correction of the problem, and the increased productivity resulting from the improvement. It is unclear why these factors are combined in these ways. The result is to make the combination of factors somewhat more important that the other individual factors used in the formula. This formula is relatively easy to use, but depends on the experience of the technician making the assessments to determine the factor values. It is unlikely different technicians would come up with the same assessments, although they could be similar. This method does address several of the factors mentioned in the Ohio Revised Code as relating to benefits.
However, there is no justification for the values ranges used in the formula, nor for the formula itself.

The Montgomery County Drainage Assessment Procedure is used by several counties in southwest Ohio. In operation, it is very similar to the Benefit Adjustment Method and the other benefit index formulae. It uses a function of distance and elevation to calculate the remoteness factor. The elevation values for parcels are obtained from a USGS 7.5' quadrangle, and are difficult to measure accurately. The improvement in productivity factor is calculated as a ratio of the CAUV of the parcel to the maximum CAUV found in the area of the improvement. The rationale is that parcels with higher CAUV values get greater benefit from the improvement than parcels with low CAUV. No justification for this assumption has been provided. This method has been modified by agencies that have adopted it.

This brings us to the methods that assign a value to the benefits received by a parcel. The three methods in this group and the Sandusky County Method from the first group do this in various ways, which we will explore.

The Sandusky County Assessment Procedure uses a simple approach to calculating assessments. Parcels are first assigned to drainage classes with each class having a predetermined per acre dollar benefit assigned to it. A benefit value is then obtained and assessments calculated exactly as in the case of any of the benefit index methods. A concern with this procedure is that the same values appear to be assigned to each of the drainage classes for all projects in the county. In reality, one would expect that the class values might change from project to project. Also, these values have apparently been used without adjustment for a number of years.
The Miami County Benefit Cost Procedure is a relatively recent development, a joint effort of several agency personnel in Miami County. This method is very complicated, deriving an adjusted agricultural benefit that is a function of a net agricultural benefit, subsurface drain installation cost, and distance from and elevation above the project. The net agricultural benefit is a function of crops grown, county yield averages, and county average prices. One concern about the methodology is that the costs of drain installation are subtracted from the benefits. Boyd and Hart (1924) argue that the benefits of the subsurface drain installation should be subtracted from the benefits of the drainage improvement; that is, for the purposes of determining net benefits, benefits should be subtracted from benefits, not costs from benefits. While this is a good attempt to calculate true benefits for a drainage improvement, it is very complicated and would be hard for people to understand.

The Moran Method defines two classes of benefits to be derived from a drainage improvement: obligation benefits and drainage benefits. Obligation benefits are related to the amount of runoff produced by parcels as a result of changing land use from woods or grassland, which Moran terms accelerated runoff. Moran based the obligation benefit on the cost of the improvement, and the amount of accelerated flow contributed by the watershed, with each parcel responsible for its share of the accelerated flow. The drainage benefits were based on improved crop yields because of the drainage improvement. A major concern with Moran’s implementation is that the obligation benefits were equal to the cost of construction. Thus, if an improvement had any drainage benefits whatsoever, it would have a benefit-cost ratio greater than one. This seems unlikely to be the case in all situations.
The Sectionalized Method of Ditch Assessments was developed by Early (1990) based on the Moran Method. The Sectionalized Method retains the concept of obligation and drainage benefits, but calculated these based on several sections of the improvement. The obligation benefit is based on the accelerated runoff, but it only assumes its share of the cost based on its share of the total runoff. Thus, substantial drainage benefits are needed to create benefit-cost ratio greater than 1.0. The drainage benefits for cropland are limited to a set length of ditch downstream from the parcel, the assumption being that improvement farther downstream would provide no benefit to the subsurface drainage from a parcel.

The benefit index or percentage methods would be improved if the benefits were determined for the parcel receiving the greatest benefits, and the benefits received by the other parcels could be shown to be related to the most-benefited parcel by the reach/remoteness factor.

There does seem to be increased interest in determining the benefits of the improvement as a whole in financial terms, in order to justify its construction. Jim Bishop, Program Administrator at the Montgomery SWCD, related that the Board of Montgomery County Commissioners are seeking assurance that a project's benefits exceeded it's cost (Jim Bishop, personal communication, March, 1998). The method currently in use, only provides a means of distributing the assessments, and does not address the issue of benefits. In some cases, agencies are calculating project benefits separately for the whole project, in order to show that the project is worthwhile. However, these calculations are usually unrelated to the assessment procedure. Certainly it would be better to have the same benefit calculation used for assessments as well.
Financial analysis does not appear to be well understood by some agency personnel. In one example, the annual cost of the construction was calculated by taking the sum of the construction cost plus interest costs for a 5-year loan and dividing by an estimated life of 25 years. This was added to a charge of 5% of the construction cost as a maintenance charge to represent the annual cost of the project, which was then compared with the estimated annual benefits. In this example, the result was a benefit-cost ratio of 4.62:1. Another way to calculate the annual cost would be to amortize the $45,000 construction cost over the 25 year life span to derive an annual cost of construction, which when added to the annual maintenance cost, could then be compared to the estimated annual benefits. Doing the calculation this way results in a benefit-cost ratio of 1.98:1. While this ratio is still greater than 1.0, the much lower true benefit-cost ratio might cause the planners to examine their assumptions more carefully than would the higher benefit-cost ratio shown in the original calculation. The presentation of a flawed analysis would reduce confidence in other calculations made in support of the improvement.

Volume of runoff is a factor mentioned in the Ohio Revised Code as relating to benefits and is used in several of the formulae. Typically, the runoff volume is estimated for each parcel and the proportion of the parcel's runoff volume to the total runoff volume is used as a determining factor in making assessments or, in the case of Moran and the Sectionalized Method, used to determine obligation benefits. However, in open ditch design, the size or capacity of the ditch is based on peak flows, not the total volume of runoff. Therefore, it seems that a parcel's contribution to the peak flow at a design point should be considered, not the volume of runoff. This is especially important when
runoff mitigating factors such as wetlands, detention and retention basins, controlled drainage and subirrigation are present. Computer hydrologic models could be used to evaluate a parcel's contribution to peak flow.

A remoteness factor is considered in many of the formulae. This factor is used to reduce a parcel's benefit because of the distance it is from the ditch, and/or the elevation the parcel is above the ditch. If a landowner has to pay for a lateral ditch or subsurface main to get his water to the ditch, it seems fair to assume his benefits from the construction of the ditch are less than a landowner whose land abuts the ditch. Most formulae use a percentage reduction factor to reduce the assumed benefits, often based on distance, but sometimes based on elevation as well. While this approach is simple, it probably does not relate well to the actual difference in benefits. The reduction in benefits should be related to the cost of the lateral ditch or main, not merely distance. Boyd and Hart (1924) argue that this reduction should not be only the cost, but should account for the return to the investment in the lateral ditch or main. One way to do this would be to determine benefits as if the optimal improvement in drainage were made, and proportion those benefits according to the cost of each component of the system, whether installed or not. The benefits because of the main ditch could then be determined according to the investment required for the ditch, while the benefits because of the installation of subsurface drainage or the installation of a lateral ditch would be determined by the return to the investment of those individual components.

Using elevation as a factor is questionable in practice, as it is difficult to measure elevation differences with any degree of accuracy with current information and technology. Relating elevation to individual parcels of land requires that parcel
boundaries be transferred from a large scale parcel map, often 1:7980, to a USGS 7.5' quad sheet which is at a scale of 1:24,000.

The subsurface drainage impairment calculation is very similar to the location/remoteness factor found in the Montgomery County method. Subtracting the cost of subsurface drain installation from the benefits is a way to give credit for a landowner's investment, but Boyd and Hart (1924) argue that the benefits achieved by the investment in subsurface drainage by the landowner should be subtracted, rather than just the costs.

3.5 Summary and Conclusions

A mail survey of both County Engineers and Soil and Water Conservation Districts (SWCDs) in 50 Ohio counties was conducted from November 1997 through April 1998. The response rate was very good with 79 surveys returned by 34 county engineers and 45 SWCDs. In addition, one county engineer and two SWCDs took the initiative to either send a letter or phone to indicate their activity, for an overall response rate of 82%. Phone calls were made to the agencies that did not respond to the survey, resulting in partial information obtained from 16 agencies, and site visits were made by the author to two county engineers. Overall, information relating to Section III of the survey was obtained from 67 agencies (67%), while information relating to Section IV was obtained from 78 agencies (78%). Twenty five agencies (25%) provided some written documentation on the assessment method(s) used by their agency for group projects.
Agencies in general are not determining benefits resulting from improved drainage for group drainage improvement projects. Training in benefit cost analysis is needed for agency personnel. A procedure is needed that will allow agencies to calculate benefits for individual parcels and different land uses. Off-site effects are usually ignored. The individual parcel benefits could then be totaled for the whole project and could be compared to the costs to assess the viability of the project. The sectionalized method appears to come the closest to meeting this need, but improvements can be made.

Agriculture is the predominant land use in most of the projects and, in most of Ohio, improved drainage is a benefit to agricultural productivity. In-field yield increases have been documented through research. There is need to determine what proportion of increased yield may be the result of the group drainage project, and what proportion results from the subsurface drainage system, or other components of the entire drainage system.

Computer modeling can be used to provide insight into the relationship among drainage benefits and soil types, distance from a project, etc. We can easily do the calculations based on assumed relationships; we need to develop justifiable relationships based on modeling or field data collected from on-the-go yield monitors. This might entail collecting stage data on the ditches adjacent to fields in which the operator will collect on-the-go yields. The farmer would have to be agreeable to sharing his data.

With the large number of projects being completed, there is opportunity to conduct cost benefit studies in many areas of the state. Ex ante and ex post hedonic price studies would be very useful. The study by Palmquist and Danielson (1989) in North Carolina showed that drainage is a differentiated component of land pricing. Will a
properly designed study be able to show the same for a drainage outlet on a county
maintenance program? Such knowledge would be very helpful in evaluating existing or
proposed assessment methods.

Knowledge on how other land uses benefit from drainage is lacking at the county
level. As the population increases, other land uses will become more important in areas
benefited by group drainage improvements. There is a need to compile the benefits of
drainage to these other land uses, such as roads, residences, commercial land, etc. The
use of stormwater management by landowners may reduce the benefits of improved
drainage. These relationships need to be established.

The financial consequences of off-site impacts must be established. It is widely
agreed that there are both positive and negative effects of drainage projects beyond those
that are currently measured.

In conclusion, although there are many deficiencies in the methods used by the
county agencies to assess land for drainage improvements, most of the counties have
developed systems that work well and are accepted by the public and the public officials
involved in their application.

3.6 References


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Schwartz, A.A. 1955. A history of the ditch and drainage laws of Ohio, with special emphasis on the levying of assessments according to the benefits derived. Columbus, Ohio: Legislative Reference Bureau.


CHAPTER 4

USING STEADY-STATE DRAINAGE EQUATIONS TO CALCULATE DRAIN SPACINGS FOR OHIO SOILS

4.1 Introduction

Subsurface drainage is important for optimal crop production in many soils in Ohio. Long-term studies in Ohio have shown that subsurface drainage can substantially improve corn and soybean yields and reduce year-to-year variability on Toledo and Hoytville soils (Schwab et al., 1985; Brown et al., 1998). On-farm use of on-the-go yield monitors is showing farmers the benefits of good drainage on these and other soils (Finck, 1998). With over 10 million meters of subsurface drain pipe being installed in Ohio annually (see next chapter), producers are making a substantial capital investment in improved drainage.

It may cost over $1,236 per ha ($500 per acre) to install a complete subsurface drainage system, so it is important that the system be properly designed. In a 5 county study in Ohio, Shafer (1940) attributed 28% of the failures of 30 to 40 year old subsurface drainage mains to improper design. Skaggs and Nassehzadeh-Tabrizi (1986) studied 28 North Carolina fields mapped as Rains sandy loam, and estimated that the present worth of optimizing the design of subsurface drains was $440 per ha ($178 per ac), less engineering design costs. Skaggs (1987) reviewed the progress of drainage research and development of methods for determining optimum spacing and depth of
drains in terms of soil properties, site parameters, crop requirements and climatic conditions, and noted that most drainage systems in the U.S. are not designed using these methods; many systems are installed with a constant drain spacing for an area or using general soil characteristics. Skaggs (1987) suggested that drainage design remained more art than science.

The most important design problem is the determination of optimum spacing (Schwab, 1969). Many equations have been developed to describe the flow of groundwater to drains, usually classified as either steady-state or unsteady-state. Steady-state drain spacing equations can be used when rainfall or irrigation is nearly constant. Unsteady-state equations are preferred when rainfall or irrigation is variable.

Several studies have been done to evaluate the performance of steady-state equations. Raadsma (1974) reported that Mueller (1967) compared the results of 40 steady-state formulae with the optimal drain spacings determined at 35 experimental fields, and that he concluded that only the formulae of Hooghoudt (1940), Ernst (1956), and Toksoz and Kirkam (1961) were suitable for general application.

Lucas (1982) compared drain spacing values obtained using observed drain performance in 14 Illinois and Ohio soils to spacing values obtained using the Hooghoudt equation and high and low permeability values from the soil interpretation record (SIR). He found that drain spacing estimates were acceptable for 4 soils, under-designed for 2 soils, and over-designed for 8 soils.

Bjorneberg et al. (1994) measured drain tile discharge and water table height on two 0.4 ha Iowa plots and used three drain spacing equations - the steady-state Hooghoudt, van Schilfgaarde, and integrated Hooghoudt – to calculate saturated
hydraulic conductivity. Using limited data, they found that the steady state Hooghoudt
provided the best results.

Skaggs and Nassehzadeh-Tabrizi (1986) simulated corn yields for 12 North
Carolina soils. Economic analyses were then conducted to determine the drain spacing
that would give maximum return to land and management for each drain depth and
surface drainage treatment. These spacings were then used in the Hooghoudt equation to
calculate a design drainage rate (DDR), also referred to as the drainage coefficient, when
the water table is at the surface. The average DDR values were 11 mm/d for good
surface drainage, and 13 mm/d for poor subsurface drainage. They found that using these
rates with the Hooghoudt equation would give a good first approximation of the optimum
drain spacing, but would tend to predict spacings that are somewhat too narrow for soils
with low hydraulic conductivity values, and spacings that are too wide for soils with high
conductivity values. They stress that the DDR values for North Carolina soils should not
be used in other regions.

To provide assistance to drainage contractors and designers, Nolte et al. (1987)
reported that state drainage guides have been developed which present guidelines for
drainage practices suitable to particular soils. In Ohio, the most recent drainage guide
was published in 1976 (USDA, 1976). The guide lists 22 drainage groups with a range of
surface and subsurface drainage recommendations for each group.

The Ohio Drainage Guide is currently being updated using computer simulations
(Atherton et al., 1998). Over 475 soils series have been mapped in Ohio, and drain
spacing recommendations will be made for each of these, based on the high and low
permeability values found in the soil interpretation record (SIR) of the central concept of
the soil series. Drain spacing equations will be used to calculate the drain spacings for each soil. A set of 53 “benchmark” soils has been established to represent the range of characteristics found in Ohio soils and test the computer program.

The objectives of this study are to:

1. Develop a computer program that will generate a range in spacing values for 53 benchmark Ohio soils using three steady-state drain spacing equations; and
2. Evaluate the results obtained using four drain spacing equations.

This chapter presents the results of this study.

4.2 Methods

Raadsma (1974), Ritzema (1994) and others have discussed the application of steady-state flow equations to drainage design. These equations are used for parallel drains, and are based on the assumption that drain discharge equals the recharge to the groundwater, so that the water table remains at a constant level (Ritzema, 1994). This situation is applicable to areas with a humid climate, and periods of fairly uniform, low intensity rainfall, such as exist in late winter and early spring in Ohio. In irrigated areas, or when rainfall is highly variable, unsteady-state equations are sometimes more appropriate. Figure 4.1 shows a typical cross-section of the steady-state system for parallel, subsurface drains.
Figure 4.1  Schematic of water table position and system parameters used for steady-state drainage equations.
Hooghoudt (1940) and Donnan (1946) developed similar equations to describe steady-state flow to drains, based on the Dupuit-Forsheimer assumptions. The flow pattern is assumed to be horizontal and parallel to an impervious layer near the drain. Further assumptions made include the existence of two-dimensional flow, uniform distribution of recharge, and homogeneous, isotropic soils.

The Donnan equation is the simplest case of the Hooghoudt equation, and is expressed as Equation 1:

\[ L^2 = 4 \times \frac{K(H^2 - D^2)}{q} \]  \[1\]

where:

- \( q \) is the drain discharge \((\text{m/d})\);
- \( K \) is the saturated hydraulic conductivity of the soil \((\text{m/d})\);
- \( H \) is the height of the water table above the impermeable layer \((\text{m})\);
- \( D \) is the height of the water in the drain above the impermeable layer \((\text{m})\); and
- \( L \) is the distance between parallel drains \((\text{m})\).

When the impermeable layer is below the drain depth, the assumptions of parallel and horizontal flow do not apply, because of radial flow into the drain from the soil below the drain. Hooghoudt accounted for this by reducing the depth of the flow layer below the drain to a hypothetical "equivalent depth", \( d_e \), which depends on \( D, L \), and the radius of the drain. The head loss of flow in this equivalent layer is considered equal to the horizontal and radial head loss in the actual soil layer down to the impermeable layer. The Hooghoudt equation can be written as shown in Equation 2:

\[ L^2 = \left[ \left( 8 \times K_h \times d_e \times H \right) + \left( 4 \times K_r \times H^2 \right) \right] / q \]  \[2\]
where:

$L$ is the distance between parallel drains (m)

$K_t$ and $K_b$ are the horizontal hydraulic conductivity of the layers above and below the drain, respectively (m/d);

$d_e$ is the Hooghoudt’s equivalent depth (m); and

$q$ is the drainage coefficient or the design drainage rate (m).

For homogeneous soils, $K_t = K_b$. For soil layers with different $K$ values above the drain, a depth-weighted average is calculated for $K_t$ (Raadsma, 1974).

If the soil below the drain consists of two layers with different $K$ values, the Ernst equation is used (Ritzema, 1994; van Beers, 1979). The Ernst equation is most often used when a layer of high saturated hydraulic conductivity underlies a layer of low hydraulic conductivity.

To obtain his solution for saturated flow to a drain, Ernst (1956) divided the flow into vertical, horizontal and radial components, and the available head ($h$) into head loss caused by the vertical flow ($h_v$), horizontal flow ($h_b$), and radial flow ($h_r$). The derivation of the Ernst equation is described in detail in Ritzema (1994). In its general form, the Ernst equation is written as:

$$h = q \left[ D_v / K_v + \left( L^2 / \left\{ 8 \times \sum (KD)_h \right\} \right) + \left( L / \pi K_v \right) \times \ln \left( a \times D_v / u \right) \right]$$  \hspace{1cm} [3]

where:

$h$ is the total hydraulic head, or height of the water table above the water level in the drain;

$q$ is the design discharge rate (m/d);

$D_v$ is the thickness of the layer in which vertical flow is considered (m);
$K_v$ is the vertical hydraulic conductivity (m/d);

$(KD)_h$ is the transmissivity of the soil layers through which the water flows horizontally (m$^2$/d);

$K_r$ is the radial hydraulic conductivity (m/d);

$a$ is the geometry factor of the radial resistance;

$D_r$ is the thickness of the layer in which radial flow is considered;

$u$ is the wetted perimeter of the drain (m); and

$L$ is the distance between drains (m).

If the drain is in the bottom layer, $a = 1$; if the drain is in the top layer, the value of $a$ depends on the ratio of $K_b$ and $K_r$. Ritzema (1994) provides a table from which the values of $a$ can be derived. Use of the Ernst equation is limited to cases where $D < \frac{1}{4} L$.

Computer modeling is being used extensively in the development of the Ohio Agricultural Water Management Guide (Atherton et al., 1998). A range of drain spacing values for each of the 475+ soil series mapped in Ohio will be calculated with steady-state drain spacing equations using the high and low permeability values listed in the soil interpretation (SIR) record for the central concept of each soil series. A subset containing 53 of these soils, called benchmark soils in this paper, was identified by a group of soil scientists to represent the range in characteristics found in the full set of mapped soils. In a separate study, DRAINMOD (Skaggs, 1980) will be used to further evaluate the response of these 53 soils to improved drainage.

Desmond (1989) wrote a FORTRAN program to solve the ellipse equation for soils based on information derived from the SOIL-5 database. For the purposes of this study, Desmond’s program was modified to provide additional input and output options;
to carry through descriptive variables such as soil texture; to provide for interactive input of user selected values for the drainage coefficient and depth of drain; and to provide for English or SI output. Subroutines were added to incorporate the Hooghoudt and Ernst equations as options.

Desmond's program assumed a single homogeneous soil profile by calculating a weighted average hydraulic conductivity based on the permeability values from the SSSD. For this study, a 2-layer option was created, with the layer interface coinciding with the drain depth.

The equivalent depth, \( d_e \), is based on a relationship between the equivalent depth (\( d_e \)), the drain spacing (\( L \)), the depth to the restrictive layer (\( D \)), and the radius of the drain (\( r_0 \)) derived by Hooghoudt. For this study, the Hooghoudt equivalent depth is calculated using the equation of Moody (1966), as presented in Skaggs and Nassehzadeh - Tabrizi (1986):

\[
d_e = D / \{1.0 + (D / L) \times [(8.0 / \pi) \times \ln(D / r) - a]\}, \quad 0 < D / L \leq 0.3
\]  

or

\[
d_e = L \pi / [8 \times (\ln(L / r) - 1.15)], \quad D / L > 0.3
\]

where \( r \) is the drain pipe radius and

\[
a = 3.55 - 1.6 \times D / L + 2(D / L)^2
\]

These equations assume that the drain pipe is completely open and there is no head loss as water enters the pipe. An equivalent radius, \( r_e \), can be substituted for \( r \) in Eq. 3 and Eq. 4 to account for the head loss associated with a finite number of openings in the pipe. An \( r_e \) value of 0.51 has been assumed for the drain pipe in this study, which is appropriate for
10 cm diameter pipe with 68 cm$^2$ open area per meter (Skaggs and Nassehzadeh–Tabrizi, 1986).

In order to perform a preliminary study of the feasibility of this approach for estimating drain spacing, a list of 53 soil series was developed by soil scientists to represent the more than 475 soil series that have been mapped in Ohio. Characteristics for these soils, including layer depths, layer textures, and high and low permeability estimates for each layer were obtained from the State Soil Survey Database (SSSD) for Ohio. Soil scientists with the USDA-Natural Resources Conservation Service provided a file in ASCII format that included the soil series name and Soil Interpretation Record (SIR) number, layer depths and textures, and minimum and maximum permeability values from the State Soil Survey Database (SSSD) for all soil series in Ohio. Each line in the file contained data for one layer of one soil/surface texture combination. A FORTRAN program, SIR2ELPS, was written to reformat this information, placing all data for one soil/surface texture combination on one line for input to a drain spacing equation program.

For each soil series, the program reads the minimum and maximum permeability values for each soil layer. A loop is begun which determines the weighted permeability above each layer interface below the water table. This weighted permeability is compared with the permeability of the next lower layer. If the permeability of the next layer is less than 20% of the weighted permeability of the profile above, it is defined as a restricting layer (Fausey, 1977; U.S. Department of Interior, 1993). Otherwise, the calculation of the weighted permeability of the profile continues until the lowest layer,
and the restricting layer is taken to be the depth of the soil profile described in the SOIL-5, typically 1.5 - 2.0 m.

Since the equivalent depth used in the Hooghoudt equation depends on the spacing of the drains, the spacing solution is an iterative process. An iterative loop is entered to determine the drain spacing, unless the impermeable layer is above the depth of the drain. A drain spacing of 10 m is used as the initial estimate. A drain spacing is calculated and compared with the previous estimate. If the spacing estimates are not within 0.5 cm, the program calculates a new equivalent depth based on the revised spacing and then calculates a new drain spacing. These are then compared and the iteration continues until the spacing estimates are within 0.5 cm.

Once the drain spacing is determined for the minimum permeability values, the program loops back and repeats the process for the maximum permeability values for that soil. After drain spacing estimates are calculated for both minimum and maximum permeability of a soil/surface texture combination, the values are written to an output file and the program then proceeds to repeat the process for the next soil, continuing until all soils in the input file are completed.

Drain spacing calculations were performed for all soils in Ohio using four equations and four soil profile scenarios:

1. Donnan's equation with a homogeneous profile;
2. Hooghoudt's equation with a homogeneous profile;
3. Hooghoudt's equation with a 2-layer profile with drain at layer interface; and
4. Ernst's equation with drain either above or below layer interface.
4.3 Results and Discussion

The source code for the FORTRAN program is provided in Appendix E. The characteristics of the 53 soils used in this study are given in Table G.1 in Appendix G, and a listing of the input file is provided in Table G.2. Program runs were completed for all 53 soil series using each of the four drain spacing equations and each of the parameter values listed in Table 4.1. Results of all program runs are summarized in Appendix F.

Table 4.1. Values used in the drain spacing computer program to calculate drain spacing values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain depth</td>
<td>60 cm; 75 cm; 90 cm; 120 cm</td>
</tr>
<tr>
<td>Design drainage rate (DDR)</td>
<td>0.95 cm/d; 1.27 cm/d</td>
</tr>
<tr>
<td>Depth to restrictive layer</td>
<td>Bottom of profile found in SIR, 1.5 – 2.0 m, depending on soil series; 3.05 m</td>
</tr>
<tr>
<td>Permeability</td>
<td>High and low values found in SIR</td>
</tr>
<tr>
<td>Steady-state water table depth</td>
<td>30 cm</td>
</tr>
</tbody>
</table>

For presentation of the results in this section, these soils are grouped into four categories based on the change in hydraulic conductivity (K) with depth. These classifications also relate to the use of the each equation, as presented by Ritzema (1994).

Class 1 soils have a restrictive layer at or near drain depth. For Class 1 soils, the drain will be placed at the depth of the impermeable layer, and the Donnan equation is appropriate. Soils having a homogeneous profile are placed in Class 2. For these soils, the Hooghoudt equation is appropriate. The Hooghoudt equation is also used for Class 3 soils, which are multi-layered with hydraulic conductivity decreasing with depth. For this study, the profile of Class 3 soils is simplified to a two-layer profile and the
assumption is made that the drain will be placed at the interface between two layers. Equivalent conductivity values are computed for the top and bottom soil layers.

Class 4 soils are those that have a layer of higher K below lower K layers. For Class 4 soils, the Ernst equation is appropriate. These soils will be modeled with a two-layer profile, with the layer interface at the depth where the hydraulic conductivity increases. The upper layer will be modeled as a homogeneous layer, with a depth-weighted hydraulic conductivity value.

4.3.1 Comparison of drain spacing equations

Although each of these soil classes has an equation that is considered more appropriate than the others, we will first examine the effect of using each equation on the spacing values of soils in each class. A drain depth of 90 cm, a steady-state water table depth of 30 cm, and a DDR of 0.95 cm/d is assumed for these comparisons.

The results for the Class 1 soils are given in Table 4.2, showing the spacings resulting from the Donnan equation, and the one- and two-layer Hooghoudt equations. Since the drain is placed at the impermeable layer, the Ernst equation cannot be used.

For most of the soils in this table, the drain depth is at the restrictive layer depth. In these cases, there is little difference in spacing between the Donnan equation and the one-layer Hooghoudt equation. Those differences that do occur, do so because the drains are assumed to be flowing half full, providing a value for the depth below the flow line. Since the Hooghoudt reduces this depth to an equivalent depth, there are slight reductions in spacing when the Hooghoudt equation is used in place of the Donnan equation.

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The two-layer Hooghoudt calculation is not used for those soils that have a restrictive layer above the nominal drain depth (90 cm). However, for the high permeability sequence, Avonburg, Ellsworth, Loudonville, Rarden, and Rossmoyne do not show a restrictive layer. In these cases the two-layer Hooghoudt equation is valid. When the soil profile is homogeneous, the two-layer Hooghoudt equation results in a drain spacing value that is identical to the one-layer Hooghoudt equation, as in the case of Ellsworth, Loudonville, and Rarden. When the soil underlying layers are of lower conductivity, the two-layer equation produces a narrower spacing because of the lower hydraulic conductivity of a portion of the soil profile.

Figure 4.2 is a graphical representation of the spacing results for Crosby, Mermill, Rarden, and Wasueon, soils which have a restrictive layer for both the high and low permeability sequences in the SIR. This figure shows that the Donnan and Hooghoudt calculations produce virtually identical results, even for soils with different K values. Therefore, either the Donnan or the single layer Hooghoudt equation can be used to estimate drain spacing when the drain will be installed at the depth of the restrictive layer.

The drain spacing results for Class 2 soils are shown in Table 4.3. These soils are assumed to have a homogeneous profile with respect to K, and a restrictive layer which is below drain depth. Since the K values are identical above and below the drain, both the one-layer and two-layer Hooghoudt equations produce identical spacing values. These values are usually quite a bit less than the spacings calculated using the Donnan equation, because of the substitution of the smaller equivalent depth for the actual depth of the restrictive layer below the drain.
Table 4.2. Layer depth, hydraulic conductivity, and calculated spacing values for soils in Classification 1.

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Profile Classification</th>
<th>Restrictive Layer Depth (cm)</th>
<th>Drain Depth (cm)</th>
<th>Equivalent hydraulic conductivity</th>
<th>Calculated spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single Layer Top Bottom</td>
<td>Donnan Hooghoudt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(cm/h)</td>
<td>(cm/h)</td>
</tr>
<tr>
<td>Avonburg</td>
<td>1</td>
<td>Low</td>
<td>53.3</td>
<td>53.3</td>
<td>1.524</td>
</tr>
<tr>
<td>Avonburg</td>
<td>3</td>
<td>High</td>
<td>94</td>
<td>90</td>
<td>2.821</td>
</tr>
<tr>
<td>Canfield</td>
<td>1</td>
<td>Low</td>
<td>66.0</td>
<td>66.0</td>
<td>1.524</td>
</tr>
<tr>
<td>Canfield</td>
<td>3</td>
<td>High</td>
<td>66.0</td>
<td>66.0</td>
<td>5.08</td>
</tr>
<tr>
<td>Crosby</td>
<td>1</td>
<td>Low</td>
<td>71.1</td>
<td>71.1</td>
<td>1.524</td>
</tr>
<tr>
<td>Crosby</td>
<td>1</td>
<td>High</td>
<td>71.1</td>
<td>71.1</td>
<td>5.08</td>
</tr>
<tr>
<td>Ellsworth</td>
<td>1</td>
<td>Low</td>
<td>94</td>
<td>90</td>
<td>0.152</td>
</tr>
<tr>
<td>Ellsworth</td>
<td>2</td>
<td>High</td>
<td>152.4</td>
<td>90</td>
<td>0.508</td>
</tr>
<tr>
<td>Frenchtown</td>
<td>1</td>
<td>Low</td>
<td>76.2</td>
<td>76.2</td>
<td>1.524</td>
</tr>
<tr>
<td>Frenchtown</td>
<td>1</td>
<td>High</td>
<td>76.2</td>
<td>76.2</td>
<td>5.08</td>
</tr>
<tr>
<td>Loudonville</td>
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<td>Low</td>
<td>96.5</td>
<td>90</td>
<td>1.524</td>
</tr>
<tr>
<td>Loudonville</td>
<td>2</td>
<td>High</td>
<td>121.9</td>
<td>90</td>
<td>5.08</td>
</tr>
<tr>
<td>Mermill</td>
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<td>Low</td>
<td>86.4</td>
<td>86.4</td>
<td>1.524</td>
</tr>
<tr>
<td>Mermill</td>
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<td>High</td>
<td>86.4</td>
<td>86.4</td>
<td>5.08</td>
</tr>
<tr>
<td>Millsdale</td>
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<td>Low</td>
<td>78.7</td>
<td>78.7</td>
<td>0.571</td>
</tr>
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<td>High</td>
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<td>81.3</td>
<td>1.733</td>
</tr>
<tr>
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<td>Low</td>
<td>76.2</td>
<td>76.2</td>
<td>1.524</td>
</tr>
<tr>
<td>Muskego</td>
<td>1</td>
<td>High</td>
<td>76.2</td>
<td>76.2</td>
<td>1.524</td>
</tr>
<tr>
<td>Omulga</td>
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<td>Low</td>
<td>68.6</td>
<td>68.6</td>
<td>1.524</td>
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<tr>
<td>Omulga</td>
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<td>High</td>
<td>68.6</td>
<td>68.6</td>
<td>5.08</td>
</tr>
<tr>
<td>Rarden</td>
<td>1</td>
<td>Low</td>
<td>86.4</td>
<td>86.4</td>
<td>0.152</td>
</tr>
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<td>Rarden</td>
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<td>High</td>
<td>111.8</td>
<td>90</td>
<td>0.508</td>
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<td>Ross moyne</td>
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<td>Low</td>
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<td>58.4</td>
<td>1.524</td>
</tr>
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<td>Ross moyne</td>
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<td>High</td>
<td>246.4</td>
<td>90</td>
<td>1.991</td>
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<tr>
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<td>58.4</td>
<td>0.508</td>
</tr>
<tr>
<td>Wadsworth</td>
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<td>High</td>
<td>58.4</td>
<td>58.4</td>
<td>5.08</td>
</tr>
<tr>
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<td>86.4</td>
<td>5.08</td>
</tr>
<tr>
<td>Wauscon</td>
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<td>High</td>
<td>86.4</td>
<td>86.4</td>
<td>15.24</td>
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Figure 4.2  Range of drain spacing values for four Class 1 soils using three steady-state drain spacing equations and the high and low permeability values found in the SSSD. Depth to drain is the restrictive layer depth, and the steady-state water table depth is 30 cm.
Table 4.3  Layer depth, hydraulic conductivity, and calculated spacing values for soils in Class 2.

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Profile Classification</th>
<th>Restrictive Layer Depth (cm)</th>
<th>Drain Depth (cm)</th>
<th>Equivalent Hydraulic Conductivity</th>
<th>Calculated Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single Layer Profile</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Top Profile (cm/h) Bottom Profile (cm/h)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barkcamp</td>
<td>2 Low</td>
<td>152.4</td>
<td>90.0</td>
<td>5.08</td>
<td>23.1 21.0 21.0</td>
</tr>
<tr>
<td>Barkcamp</td>
<td>2 High</td>
<td>152.4</td>
<td>90.0</td>
<td>50.8</td>
<td>73.1 70.4 70.4</td>
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<tr>
<td>Bennington</td>
<td>2 Low</td>
<td>203.2</td>
<td>90.0</td>
<td>0.152</td>
<td>5.0 2.8 2.8</td>
</tr>
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<td>Bennington</td>
<td>3 High</td>
<td>203.2</td>
<td>90.0</td>
<td>1.137</td>
<td>13.5 9.9 9.9</td>
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<td>Blount</td>
<td>2 Low</td>
<td>203.2</td>
<td>90.0</td>
<td>0.152</td>
<td>5.0 2.8 2.8</td>
</tr>
<tr>
<td>Blount</td>
<td>2 High</td>
<td>203.2</td>
<td>90.0</td>
<td>1.524</td>
<td>15.7 11.9 11.9</td>
</tr>
<tr>
<td>Carlisle</td>
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<td>167.6</td>
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<tr>
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Table 4.3 (continued) Layer depth, hydraulic conductivity, and calculated spacing values for soils in Class 2.

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<th>Soil Series</th>
<th>Profile Classification</th>
<th>Restrictive Layer Depth (cm)</th>
<th>Drain Depth (cm)</th>
<th>Equivalent hydraulic conductivity</th>
<th>Calculated spacing</th>
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<td>0.152</td>
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<td>0.001</td>
</tr>
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<td>203.2</td>
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<td>1.524</td>
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<td>0.152</td>
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<td>High</td>
<td>152.4</td>
<td>90.0</td>
<td>0.508</td>
</tr>
<tr>
<td>Upshur</td>
<td>2</td>
<td>Low</td>
<td>182.9</td>
<td>90.0</td>
<td>0.152</td>
</tr>
<tr>
<td>Upshur</td>
<td>2</td>
<td>High</td>
<td>182.9</td>
<td>90.0</td>
<td>0.508</td>
</tr>
</tbody>
</table>
Figure 4.3  Range of drain spacing values for five Class 2 soils using three steady-state drain spacing equations and the high and low permeability values found in the SSSD. Depth to drain is 90 cm, steady-state water table depth is 30 cm, and a restrictive layer is assumed at the bottom of the mapped profile.
Figure 4.3 illustrates the range of spacing values using the Donnan and both Hooghoudt equations for the Class 2 soils. While the Hooghoudt equation produces spacing values that are less than the values from the Donnan equation, the range of possible hydraulic conductivity values produces a wide range in possible spacing values for both equations that substantially overlap. Therefore, the accurate estimation of the hydraulic conductivity for a site is more important than the choice of spacing equations used. Once an accurate hydraulic conductivity value is determined, the Hooghoudt equation is preferred over the Donnan, because it takes into account the head loss into the drain.

Drain spacing results for the Class 3 soils are shown in Table 4.4. These soils have a soil profile with predominantly decreasing K values. Here the two-layer Hooghoudt produces a drain spacing that is usually narrower than the one-layer Hooghoudt, although often the values are not very different. The only exception in the table is for the high permeability sequence of the Luray soil series. In this case, the bottom layer conductivity actually increases, placing it in Class 4. The two-layer Hooghoudt calculation produces a wider spacing than does the one-layer Hooghoudt.

A graphical representation is provided in Fig. 4.4. The two Hooghoudt calculations provide virtually identical spacing values, which are quite a bit less than spacing values from the Donnan equation. Either of the Hooghoudt calculations would be preferred, but again, an accurate estimation of the hydraulic conductivity is more important than the selection of a particular drain spacing equation.
Table 4.4  Layer depth, hydraulic conductivity, and calculated spacing values for soils in Class 3.

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Profile Classification</th>
<th>Restrictive Layer Depth (cm)</th>
<th>Drain Depth (cm)</th>
<th>Equivalent hydraulic conductivity</th>
<th>Calculated spacing</th>
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<tbody>
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<td>Single Layer Profile (cm/h)</td>
<td>Top (cm/h)</td>
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<td>66.0</td>
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<td>1.524</td>
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<tr>
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<td>1  High</td>
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<td>66.0</td>
<td>5.08</td>
<td>5.08</td>
</tr>
<tr>
<td>Centerburg</td>
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<td>152.4</td>
<td>90.0</td>
<td>0.596</td>
<td>0.688</td>
</tr>
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<td>90.0</td>
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<tr>
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<td>90.0</td>
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Figure 4.4  Range of drain spacing values for five Class 3 soils using three steady-state drain spacing equations and the high and low permeability values found in the SSSD. Depth to drain is 90 cm, steady-state water table depth is 30 cm, and a restrictive layer is assumed at the bottom of the mapped profile.
Table 4.5 shows spacing values calculated for the Class 4 soils using the Donnan and one- and two-layer Hooghoudt equations, and Table 4.6 shows the spacing values obtained using the Ernst equation. These soils have a high conductivity layer below layers of lower conductivity. Generally, all layers of the soils in this list have high conductivity relative to soils in the first three classes, and these soils may seldom need artificial drainage. They are being shown here to illustrate the different response these soils have to drainage.

For the Class 4 soils, which are being modeled as a two layer system with $K_t < K_b$, the Hooghoudt equation is not appropriate (Raadsma, 1974) and the Ernst equation is preferred (Raadsma, 1974; Ritzema, 1994). However, results from the other equations are given in Table 4.5, and graphically illustrated in Fig. 4.5, to show how they compare with results obtained by the Ernst equation (Table 4.6).

Comparison of the results from the Ernst equation (Table 4.6) and the Hooghoudt equation in Table 4.5 show similar spacings from the two-layer Hooghoudt equation and the Ernst equation for Adrian, Eldean, Haney and Millgrove soils, while spacings for the Sleeth and Wheeling soils are substantially different for these two equations. This is illustrated in Fig. 4.5. The main difference among these soils is the placement of the drain in relation to the interface between layers; the drain is below the interface for the former soils, and above the interface for the latter. van Beers (1979) commented that it is possible to use the Hooghoudt equation when the drains are located below the interface, but the degree of accuracy is unknown without further calculations. When the drain is above the layer interface, the Ernst equation is used.
<table>
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<th>Profile Classification</th>
<th>Restrictive Layer Depth (cm)</th>
<th>Drain Depth (cm)</th>
<th>Equivalent Hydraulic Conductivity</th>
<th>Calculated Spacing</th>
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Table 4.6  Calculated drain spacing for soils in Class 4 using the Ernst equation.

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<th>Restrictive Layer Depth (cm)</th>
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<th>Interface Depth (cm)</th>
<th>Equivalent Hydraulic Conductivity (cm/hr)</th>
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<td>86.4</td>
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<td>90.0</td>
<td>121.9</td>
<td>5.08</td>
<td>36.9</td>
</tr>
<tr>
<td>Wheeling</td>
<td>Low</td>
<td>182.9</td>
<td>90.0</td>
<td>152.4</td>
<td>1.524</td>
<td>15.6</td>
</tr>
<tr>
<td>Wheeling</td>
<td>High</td>
<td>182.9</td>
<td>90.0</td>
<td>152.4</td>
<td>5.542</td>
<td>36.9</td>
</tr>
</tbody>
</table>
Table 4.7. Calculated drain spacing values for soils that fall into different classes depending on whether low or high permeability values are used to estimate the saturated hydraulic conductivity.

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Profile Classification</th>
<th>Restrictive Layer Depth (cm)</th>
<th>Drain Depth (cm)</th>
<th>Interface Depth (cm)</th>
<th>Equivalent Hydraulic Conductivity Top (cm/hr)</th>
<th>Equivalent Hydraulic Conductivity Bottom (cm/hr)</th>
<th>Ernst Equation Spacing (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitchville</td>
<td>2 Low</td>
<td>152.4</td>
<td>--</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Fitchville</td>
<td>4 High</td>
<td>152.4</td>
<td>90.0</td>
<td>101.6</td>
<td>1.524</td>
<td>5.08</td>
<td>15.9</td>
</tr>
<tr>
<td>Glenford</td>
<td>2 Low</td>
<td>152.4</td>
<td>--</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Glenford</td>
<td>3 High</td>
<td>152.4</td>
<td>90.0</td>
<td>106.7</td>
<td>3.667</td>
<td>5.08</td>
<td>19.5</td>
</tr>
<tr>
<td>Luray</td>
<td>3 Low</td>
<td>152.4</td>
<td>--</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Luray</td>
<td>4 High</td>
<td>152.4</td>
<td>90.0</td>
<td>81.3</td>
<td>1.91</td>
<td>5.08</td>
<td>19.6</td>
</tr>
<tr>
<td>Wooster</td>
<td>3 Low</td>
<td>147.3</td>
<td>--</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Wooster</td>
<td>3 High</td>
<td>215.9</td>
<td>90.0</td>
<td>147.3</td>
<td>2.693</td>
<td>5.08</td>
<td>19.7</td>
</tr>
</tbody>
</table>

*The hydraulic conductivity of these soils increases with depth, so the Ernst equation was not used.*
Figure 4.5 illustrates how the calculated drain spacing for three of the Class 4 soils changes by using the different equations at a 90 cm drain depth. The spacing provided by the two-layer Hooghoudt for Adrian is virtually identical to that provided by the Ernst equation. The drain depth is below the layer interface, but is also nearly at the same depth. This leads to hydraulic conductivity values that are nearly identical for the two equations, and are identical for the important bottom layer, where much of the flow will take place. For the Eldean series, we see that the interface depth is much shallower than the drain depth, especially for the low conductivity phase. This leads to somewhat different top and bottom conductivity values for the profile for each equation, and different drain spacings. The drain spacings from the Ernst equation are 8.8% and 7.5% greater than those obtained from the two-layer Hooghoudt, for the lower and higher conductivity ranges respectively. Thus, the two-layer Hooghoudt provides a more conservative design, and, with the wide range of possible hydraulic conductivity values for these Class 4 soils, would provide an adequate estimate of drain spacing for general use when the drain is below the interface between the low and high conductivity layers.

The Sleeth and Wheeling series have a deeper layer of high hydraulic conductivity than the previous soils. With a drain depth of 90 cm, the drain will be above the interface between the low and high conductivity layers. Figure 4.4 illustrates the difference in spacing calculated by each equation for the Sleeth series compared with Adrian and Eldean. Here we see a major difference in the spacing. Comparing the equivalent hydraulic conductivity of each layer in the two layer profile of the Hooghoudt equation (Table 4.5) with the profile used with the Ernst equation (Table 4.6), we find a considerable difference in the hydraulic conductivity of the bottom layer. These different
values combined with the different methods of calculation result in substantially different spacing values. In this case, the two layer Hooghoudt does not result in spacing values close to the Ernst. We conclude that it would not be appropriate to use the two-layer Hooghoudt to estimate drain spacing for Class 4 soils when the drain is above the interface between layers with low hydraulic conductivity in the top layer, and a layer with much higher hydraulic conductivity in the bottom layer.

Most of the Class 4 soils have bottom layers that are relatively high in hydraulic conductivity. However, some soil series have a bottom layer that is only slightly higher in hydraulic conductivity than the top layer. The Doles series in Table 4.5 and 4.6 is an example. In many of these, the drain would be installed above the layer interface, and the Ernst equation would be the appropriate equation to use. However, a comparison of the spacing results from the 2-layer Hooghoudt equation with those from the Ernst equation for these soils shows the spacings to be quite similar. For these particular soils, at least, the two-layer Hooghoudt equation appears to provide an adequate estimate of the drain spacing for the criteria used in this figure.
Figure 4.5  Range of drain spacing values for three class 4 soils using four steady-state drain spacing equations and the high and low permeability values found in the SSSD. Depth to drain is 90 cm, steady-state water table depth is 30 cm, and an impermeable layer is assumed at the bottom of the mapped profile.

4.3.2 Effects of changes in drain depth

Up to this point we have considered drain spacing estimates for a single drain depth of 90 cm, a steady-state water table depth of 30 cm, and a design drainage rate (DDR) of 0.95 cm/d. In this section, we will consider the effects of different drain depths on the estimated drain spacing for the four classes of soils, using the spacing equation most appropriate for these soils. The water table depth and DDR will remain the same.

For Class 1 soils, the Donnan or the one-layer Hooghoudt equation are used to provide drain spacing estimates. However, since these soils have a restrictive layer, and the drain is installed at the depth of the restrictive layer, the drain depth will not change.
We can vary the drain depth for the other classes. Figure 4.6 illustrates the drain spacing estimates for Class 2 and Class 3 soils for four drain depths. As we increase drain depth, the estimated spacing increases. This is because of the increased hydraulic head. From Eq. 2, we see that increasing the hydraulic head \( h \) leads to an increase in the spacing, if the other parameters remain the same. A similar pattern results from increasing the drain depth for Class 4 soils using the Ernst equation, as shown in Fig. 4.7. As long as there are no restricting soil layers, and adequate outlets are available, increasing drain depth will allow for increased drain spacing for the same design criteria.

4.3.3 Effects of changing the water table depth

Decreasing the steady-state water table depth criteria will have the same effect as increasing the depth, by providing an increased hydraulic head. Schwab et al. (1982) suggested that a 20 cm water table depth should be adequate for most field crops. The 30 cm depth used here may be conservative, but would be suitable for high value crops, and would provide better trafficability.
Figure 4.6 Range of drain spacing values for Class 2 and Class 3 soils using the two-layer Hooghoudt equation with four drain depths. Steady-state water table depth is 30 cm, and an impermeable layer is assumed at the bottom of the mapped profile.
Figure 4.7  Range of drain spacing values for Class 4 soils using the two-layer Ernst equation with four drain depths. Steady-state water table depth is 30 cm, and an impermeable layer is assumed at the bottom of the mapped profile.
4.3.4 Design Drainage Rate

The design drainage rate (DDR) as used here is equivalent to the drainage coefficient and the variable $q$ in Eq. 2, which is the flow rate of the drainage system. For subsurface drainage only, current recommendations for field crops in Ohio are for a DDR of $0.95 - 1.27$ cm/d ($3/8 - 1/2$ in/d). Higher DDR values may be used for higher value crops (USDA-SCS, 1976). For this study, DDR values of $0.95$ cm/d and $1.27$ cm/d were calculated for four depths, two values of depth to the restrictive layer, and all four drainage equations.

Schwab et al. (1982), in a study using irrigation to induce drainage conditions, calculated the drainage coefficient from measured drainable porosities for 11 sites in northwest Ohio. They found the drainage coefficients to be slightly less than $0.95$ cm/d for $0 - 10$ cm drawdown depths, and about $1.27$ cm/d for $0 - 20$ cm drawdown depths. However, they also stated that $9.5$ mm/d might be an adequate design value, since the return period of rainfall equivalent to their irrigation depth was about once every four years. In another study, using 16 years of tile flow data, Hoover and Schwab (1969) estimated that the probability of a daily drain flow rate of $9.5$ mm/d would be $0.45\%$ on a Nappanee soil with $10$ m drain spacing.

From Eq. 2, it can be seen that the relative effect of DDR ($q$) and hydraulic conductivity ($K$) are the same. However, van Beers (1979) points out that the values of these variables differ considerably in importance as a source of possible errors in computing a drain spacing. The DDR normally has little variation. The DDR values reported by Schwab et al. (1982) for 10 sites varied from $9.65$ to $15.2$ mm/d (0.38 to 0.60
in/d). However, the values for $K$ can vary considerably more and the estimate of this factor can differ by factor of 100 or more from the true value. For instance, Dorsey et al. (1990) found point saturated hydraulic conductivity estimates within a 0.75 ha Ravenna silt loam site that varied from 0.03 to 35 mm/h with an average of 3.4 mm/h, and values from a 0.5 ha Hoytville silt clay loam site that varied from 0.01 to 260 mm/h with an average of 2.2 mm/h. This large variability in $K$ values between samples requires a large number of measurements to obtain reliable values of $K$.

Because of the difficulty of obtaining reliable $K$ values from point data, Hoffman and Schwab (1964) and Skaggs (1976) developed methods for determining field effective $K$ values and drainable porosity, by measuring the drawdown and drain flow or just the drawdown of the water table under saturated conditions from a previously installed drain. The values so obtained can be substituted into an appropriate equation to obtain drain spacings.

Figure 4.8 shows how drain spacing estimates vary using two values of DDR and for five soils representing the four soil classes. Increasing the DDR from 9.5 to 12.7 cm/d results in a narrower drain spacing for each soil, meaning a more conservative design. It can again be seen that the possible variation in $K$ values for these soils results in more variation in drain spacing estimates than does this 33% increase in DDR. Based on previous studies referenced earlier, a DDR of 9.5 mm/h should be adequate for general design purposes.
Figure 4.8  Range in drain spacing values for Class 1 (Crosby), Class 2 (Blount), Class 3 (Hoytville) and Class 4 (Eldean and Sleeth) soils for two design drainage rates using the one-layer Hooghoudt (H1), two layer Hooghoudt (H2), and Ernst (E2) equations. Drain depth is 90 cm and a restrictive layer is assumed to be at the bottom of the mapped profile for all but the Crosby, which has a restrictive layer and drain depth at 71 cm.
4.3.5 Change in depth to the restrictive layer

The depth to the restrictive layer \( D \) is often unknown without a field investigation. Consequently, it is important to estimate the effect of this value on the results of the drainage equations used in this study.

From Eq. 2, we see that increasing the depth to the restrictive layer will increase the spacing, and a shallow estimate of this value will result in a more conservative design. In the Hooghoudt equation, an equivalent depth \( (d_e) \) is substituted for the actual depth to the restrictive layer \( (D) \) in order to account for the head loss because of radial flow near the drain. For values of \( D > 1/4 \) \( L \), the equivalent depth remains almost constant (Ritzema, 1994).

While the value for \( D \) is as important as the value for \( K_b \), the relative effect of errors in estimating these values on the resulting drain spacing is similar to that of DDR and \( K \). While \( D \) can vary much more than the DDR, it is still less variable than \( K \).

The effects of using two assumed \( D \) values are shown in Fig. 4.9. It can be seen that the effect is less at low \( K \) values than at higher values, but even at the higher value of \( K \) and \( D \), the potential spacing change because of an increase of 50 to 100% in the \( D \) value is generally less than about 10% in these soils. For the Wooster soil, the drain spacing \( (L) \) increases from 20 m to about 22.5 m when the depth to the restrictive layer increases from 2.16 to 3.05 m. Thus, proper estimation of \( K_b \) is relatively more important than the estimation of \( D \) in obtaining a reliable drain spacing estimate using these steady state equations.
Figure 4.9  Range in drain spacing for Class 2 (Blount and Toledo) and Class 3 (Hoytville and Wooster) soils using the two-layer Hooghoudt equation based on two assumed values for the restrictive layer. Design drainage rate is 0.95 cm/d and drain depth is 90 cm.
4.4 Summary and conclusions

A FORTRAN computer program was written to calculate drain spacing using three steady-state drain spacing formulae, and the permeability values found in the SIR for 53 Ohio soils. Spacing estimates were made for four drain depths, two design drainage rates, and two depths to a restrictive layer for both high and low permeability values. The results were discussed based on four soil classes derived from the saturated hydraulic conductivity profile for these soils.

The following conclusions were reached:

1. Either the Donnan or the single layer Hooghoudt equation can be used to estimate drain spacing when the drain will be installed at the depth of the restrictive layer;

2. The Hooghoudt equation would be preferred over the Donnan for soils with homogeneous profiles or profiles with K decreasing with depth;

3. The two-layer Hooghoudt provides a more conservative design, and with the wide range of possible hydraulic conductivity values for these Class 4 soils, would provide an adequate estimate of drain spacing for general use, when the drain is below the interface between the low and high conductivity layers;

4. For those soil series having a bottom layer that is only slightly higher in hydraulic conductivity than the top layer, the two-layer Hooghoudt equation appears to provide an adequate estimate of the drain spacing, compared with the Ernst equation, even when the drain is placed in the top layer;

5. It would not be appropriate to use the two-layer Hooghoudt to estimate drain spacing for Class 4 soils when the drain is above the interface between layers
with low hydraulic conductivity in the top layer, and a layer with much higher hydraulic conductivity in the bottom layer. The Ernst equation should be used for these soils;

6. Proper estimation of the saturated hydraulic conductivity, especially in the bottom layer, is relatively more important than the proper estimation of the depth to the restrictive layer or the design drainage rate, in obtaining a reliable drain spacing estimate using these steady state equations.

7. With no impeding layers, and an adequate outlet, deeper drain installation will allow wider drain spacing for subsurface drainage.

The key to effective drainage design is the accurate estimation of the saturated hydraulic conductivity of the site. van Beers (1979) noted, "The importance of a good drainage formula for planning the proper drain spacing is often overrated. The chain is only as strong as its weakest link. The weak link in the calculation of drain spacing is not the formula itself, but the data substituted in it, viz. the drainage criteria and hydrological soil data. Since the hydrological soil data in particular may vary extensively within a short distance, their accuracy is very often in doubt." The use of $K$ values from soil surveys allows only a gross estimation of hydraulic conductivity. Drain spacing values obtained using these $K$ values can only serve as a guide to a good system design.
4.5 References


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Schwab, G.O. 1969. Procedure for determining hydraulic capacity of tile drains in humid areas. Trans. ASAE


CHAPTER 5

INSTALLATION PRACTICES AND CHARACTERISTICS OF SUBSURFACE DRAINAGE CONTRACTORS IN OHIO

5.1 Introduction

Drainage contractors are one of the key audiences of the proposed Ohio Agricultural Water Management Guide and its predecessors the Ohio Drainage Guide (USDA, 1973) and the Ohio Irrigation Guide. In their discussion of drainage design practices at the Fifth National Drainage Symposium, Nolte et al. (1987) state that the majority of on-farm drainage systems are designed by contractors. They also indicate that the producer’s wishes are often the deciding factor in most design decisions, and that tradition has a great influence on system design. Skaggs (1987) also notes that most drainage systems are not designed using any objective method for tailoring the systems to particular soil properties and crop needs, in spite of decades of research in drainage design.

Nolte et al. (1987) discuss the role of drainage guides in drainage system design. The drainage guide serves as a general reference to drainage design, often containing a general description of the area for which they are written, the extent of drainage problems, a discussion of drainage methods, and often a list of soil associations with accompanying drainage guidelines. They feel the drainage guide should be especially
useful to drainage contractors and planners, but state that the guide is not intended to be the sole reference for system design.

However, little data exists in the literature regarding drainage contractors, their practices, and their need for a drainage or water management guide. In the only related study found by the author, Buriak et al. (1993) used a Delphi process to identify 89 technical and 41 business/professional competencies needed by a successful land improvement contractor. No other examples of studies relating to drainage contractors were found.

To support efforts to develop a useful Ohio Agricultural Water Management guide, a mail survey of Ohio drainage contractors was envisioned to provide information relating to the practices of drainage contractors. This study had three objectives:

1. Profile subsurface drainage contractors doing work in Ohio;
2. Assess subsurface drainage, controlled drainage, and subirrigation installation activity in Ohio;
3. Compare subsurface drain installation depth and spacing used by Ohio contractors with the results of the Hooghoudt equation.

The results of this survey are presented in this paper. We will first review the methods used to conduct the study, then discuss contractor characteristics, the tools used to design drainage systems, educational topics of interest, the amount of subsurface drain pipe installed, and finally, the drain depth and spacing values reported by contractors for the installation of drain pipe in several common soil series in Ohio.

5.2 Methods

To meet the objectives of this study, a survey instrument was developed for mailing to Ohio subsurface drainage contractors. Several iterations of the instrument were developed prior to sending a draft instrument to several key people for review.
Reviewers included Art Brate and Mike Monan of USDA-NRCS, Dale Arnold of Ohio Land Improvement Contractor's Association (OLICA), Kevin Elder of ODNR-DSWC, Fred Galehouse (drainage contractor) and Scott Ganz (drainage contractor). Comments by the reviewers were addressed in the final survey instrument. The survey instrument and examples of correspondence sent to the participants can be found in Appendix H.

The names and addresses used for the survey were obtained from three sources: 1) the Overholt Drainage Education and Research Program mailing list; 2) the Ohio Land Improvement Contractor's Association (OLICA) membership list; and 3) soil and water conservation districts (SWCDs) in many counties of Ohio. This produced a list of approximately 475 names and addresses. Although it was suspected that many of the names on the resulting list were not active subsurface drainage contractors, no systematic attempt was made to remove inactive contractors or uninterested parties from the list in order to provide the greatest opportunity for all active subsurface drainage contractors to participate in the survey; only those very obviously not active contractors, and duplicates were removed from the list, producing a final mailing list of 393 names.

A postcard announcing the upcoming survey was mailed to all names on the mailing list on March 4, 1998. The survey packet was mailed March 9. The survey packet contained the survey instrument, a self-addressed and stamped return envelope for the survey instrument, and a postcard to be returned separately from the survey instrument. Participants were to use the return postcard to confirm that the survey instrument had been completed and returned, or to inform us that they were not an active subsurface drainage contractor. Those respondents returning postcards were removed from subsequent mailings. By using a return postcard separate from the survey
instrument, identification was not required on the survey instrument, thus ensuring completely anonymous responses.

One week following the mailing of the survey instrument packet, a reminder postcard was mailed. Three weeks after the initial survey instrument mailing, a second survey packet was mailed to those who had not returned postcards. At seven weeks, a third and final survey packet was mailed to those on the list who had not previously responded.

5.3 **Subsurface drainage contractor profile**

The 1998 Subsurface Drainage Survey instrument was mailed to 393 potential subsurface drainage contractors. We received a total of 185 return postcards (47%) and 107 completed questionnaires (27%). However, only 73 postcards indicated that a survey had been returned and 112 postcards indicated that the respondent did not install subsurface drain pipe. Since only 73 postcards were received indicating a returned questionnaire, but there were 107 questionnaires returned, perhaps as many as 34 people completed a questionnaire without returning the postcard. If true, the total response rate could have been nearly 56% (219 of 393) of the total mailing.

Since the survey responses were meant to be completely anonymous, it is difficult to reconcile the disparity between the 107 returned surveys and the 73 postcards indicating a returned survey. Two possible scenarios to explain this are: 1) some respondents returned both a completed survey and a return postcard indicating they did not install subsurface drain pipe, or 2) respondents completed a survey but did not return the postcard. There were 14 questionnaires returned by people or firms that did not
install drain pipe during the survey period, which supports the first scenario. Presumably the second scenario explains the 20 additional returned questionnaires.

The initial motivation for doing the survey was to gather information in support of the Ohio Agricultural Water Management Guide. A major part of the guide focuses on using computer modeling to formulate drain depth and spacing recommendations for the more than 475 soils series mapped in Ohio. It was felt that a survey of subsurface drainage contractors could obtain the drain depths and spacing they actually use, and would provide insight on how well the modeling reflected installation practices. While the survey questionnaire focused on this issue, more general information was requested in an attempt to profile subsurface drainage contractors in terms of their equipment use, design practices, attitudes and educational needs.

It was expected that there would be a wide range in size of the firms responding. Some firms install drain pipe as their main business and have large crews, while others might be one person operations. A natural method of dividing the responses for analysis is between firms for which subsurface drain installation is their primary business and firms for which it is a sideline business (Question Q-7). Indeed, by examining the responses in this way, we will see in the next section that the mainline firms installed 89% of the total drain pipe installation reported during 1995-1997. We find that 59 respondents considered subsurface drain installation their primary business, while 48 respondents did not (Table 5.1). In this paper, we will call firms that consider subsurface drain pipe installation their primary business “mainline” firms, while those that do not consider subsurface drain pipe installation their main business will be called “sideline” firms.
The mainline and sideline firms show considerable differences in terms of length of time in business. From Table 5.1, we find that on average, the mainline firms have been in business over 11 years more than the sideline firms, with an average of over 32 years in business. Over 90% (54 of 59) of the mainline firms responding have been in business for 11 years or more, and nearly 29% (17 of 59) have been in business over 41 years. One mainline firm reported being in business for 98 years. In comparison, over 29% (10 of 34) of the sideline firms that reported subsurface drain installation in 1995-1997 have been in business less than 10 years, and only 1 sideline firm has been in business over 41 years. These mainline firms in general have much experience with subsurface drainage.
Table 5.1. Subsurface drainage installation equipment use and age of business reported by subsurface drainage contractors, 1995 - 1997.

<table>
<thead>
<tr>
<th></th>
<th>Not Primary Business (Sideline Firms)</th>
<th>Is Primary Business (Mainline Firms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Total responding</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Number that reported installing</td>
<td>34 70.8%</td>
<td></td>
</tr>
<tr>
<td>drain pipe 1995 - 1997</td>
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<td></td>
</tr>
</tbody>
</table>

Equipment use by firms that reported installing drain pipe 1995 - 1997

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percent</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel trencher</td>
<td>26</td>
<td>76.5%</td>
<td>44</td>
<td>74.6%</td>
</tr>
<tr>
<td>Chain trencher</td>
<td>4</td>
<td>11.8%</td>
<td>14</td>
<td>23.7%</td>
</tr>
<tr>
<td>Plow</td>
<td>9</td>
<td>26.5%</td>
<td>31</td>
<td>52.5%</td>
</tr>
<tr>
<td>Computer</td>
<td>22</td>
<td>64.7%</td>
<td>28</td>
<td>47.5%</td>
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</table>

Length of time in business (years)

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percent</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did not reply or 0</td>
<td>2</td>
<td>5.9%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>1-10</td>
<td>8</td>
<td>23.5%</td>
<td>5</td>
<td>8.5%</td>
</tr>
<tr>
<td>11-20</td>
<td>9</td>
<td>26.5%</td>
<td>10</td>
<td>16.9%</td>
</tr>
<tr>
<td>21-30</td>
<td>9</td>
<td>26.5%</td>
<td>17</td>
<td>28.8%</td>
</tr>
<tr>
<td>31-40</td>
<td>5</td>
<td>14.7%</td>
<td>10</td>
<td>16.9%</td>
</tr>
<tr>
<td>41+</td>
<td>1</td>
<td>2.9%</td>
<td>17</td>
<td>28.8%</td>
</tr>
</tbody>
</table>

Average years in business

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21.2</td>
<td>32.4</td>
</tr>
</tbody>
</table>

There are some differences in the equipment used by the mainline firms compared to the sideline firms (Table 5.1). The proportion of firms in each category using wheel machines to install drain pipe is about the same, but mainline firms are twice as likely to use chain trenchers (23.7% vs. 11.8%) and plows (52.5% vs. 26.5%) as the sideline firms. Chain trenchers and plows are more expensive to own and maintain, so they would require a high usage rate to be cost-effective, thus favoring usage by the mainline firms.

More sideline firms than mainline firms report using computers. While less than 50% (28 of 59) of the mainline firms report computer usage, nearly two-thirds (22 of 34)
of the sideline firms that installed drain pipe use a computer (Table 5.2). Bookkeeping is done on computer by virtually all firms of both categories, with only one sideline firm not doing so. Table 5.2 shows computer usage for several tasks. Although the percentage of mainline firms using a computer is less than for the sideline firms, those mainline firms that do use a computer apparently have integrated them into everyday use more than the sideline firms. Drainage design, Email, and plan drawing are done more frequently by mainline firms than by sideline firms. The rate of plan drawing is three times higher (43% vs. 14%) for mainline firms vs. sideline firms. About 36% (10 of 28) mainline firms that have a computer use the World Wide Web, and nearly 40% (11 of 28) use Email.

Table 5.2. Computer usage by active subsurface drainage contractors.

<table>
<thead>
<tr>
<th>How computer is used</th>
<th>Mainline firms that installed drain pipe, 1995-1997</th>
<th>Percent</th>
<th>Sideline firms that installed drain pipe, 1995-1997</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total firms in category</td>
<td>59</td>
<td></td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Firms using a computer</td>
<td>28</td>
<td>47.5%</td>
<td>22</td>
<td>64.7%</td>
</tr>
<tr>
<td>Bids and estimates</td>
<td>10</td>
<td>35.7%</td>
<td>7</td>
<td>31.8%</td>
</tr>
<tr>
<td>Bookkeeping</td>
<td>28</td>
<td>100.0%</td>
<td>21</td>
<td>95.5%</td>
</tr>
<tr>
<td>Business planning</td>
<td>8</td>
<td>28.6%</td>
<td>5</td>
<td>22.7%</td>
</tr>
<tr>
<td>Drainage design</td>
<td>8</td>
<td>28.6%</td>
<td>4</td>
<td>18.2%</td>
</tr>
<tr>
<td>Email</td>
<td>11</td>
<td>39.3%</td>
<td>6</td>
<td>27.3%</td>
</tr>
<tr>
<td>Financial management</td>
<td>11</td>
<td>39.3%</td>
<td>7</td>
<td>31.8%</td>
</tr>
<tr>
<td>Plan drawing</td>
<td>12</td>
<td>42.9%</td>
<td>3</td>
<td>13.6%</td>
</tr>
<tr>
<td>World wide web</td>
<td>10</td>
<td>35.7%</td>
<td>6</td>
<td>27.3%</td>
</tr>
<tr>
<td>Other uses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Billing</td>
<td>--</td>
<td></td>
<td>1</td>
<td>4.5%</td>
</tr>
<tr>
<td>GPS mapping</td>
<td>2</td>
<td>7.1%</td>
<td>1</td>
<td>4.5%</td>
</tr>
<tr>
<td>Surveying and data collection</td>
<td>1</td>
<td>3.6%</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
Table 5.3 shows computer usage sorted by size. There does not appear to be a clear trend, although the very largest firms seem to have a higher use rate, especially for the mainline firms. These data may reflect that computer ownership in many cases is based on factors other than a business need. Clearly computers are used more for accounting than for drainage design.

<table>
<thead>
<tr>
<th>Reported subsurface drain installation, 1995-1997 (thousand ft)</th>
<th>Mainline firms</th>
<th>Sideline firms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of firms</td>
<td>Percent</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>&lt;100</td>
<td>2</td>
<td>50.0%</td>
</tr>
<tr>
<td>100-250</td>
<td>1</td>
<td>20.0%</td>
</tr>
<tr>
<td>250-500</td>
<td>3</td>
<td>42.9%</td>
</tr>
<tr>
<td>500-1000</td>
<td>6</td>
<td>37.5%</td>
</tr>
<tr>
<td>1000-2000</td>
<td>8</td>
<td>50.0%</td>
</tr>
<tr>
<td>2000-3000</td>
<td>4</td>
<td>66.7%</td>
</tr>
<tr>
<td>3000+</td>
<td>4</td>
<td>80.0%</td>
</tr>
</tbody>
</table>

Another issue addressed in this survey was the contractors’ interest in potential educational topics. Respondents were asked to rate each of 16 topics using a 5-point Likert-type scale. A summary of the responses is found in Table 5.4, with the topics ranked from highest to lowest average rating. The various topics were ranked similarly by both categories of drainage firm. The effects of compaction on drainage and drain pipe quality (4.8 rating) were the highest rated topics by the mainline firms, with adequate outlets and installation standards rated nearly as high (4.6 rating).
Table 5.4. Ranking of educational topics according to average rating by respondents.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Mainline firms</th>
<th></th>
<th></th>
<th>Sideline firms</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of</td>
<td>Average</td>
<td>Standard</td>
<td>Number of</td>
<td>Average</td>
<td>Standard</td>
</tr>
<tr>
<td></td>
<td>Responses</td>
<td>Rating</td>
<td>Deviation</td>
<td>Responses</td>
<td>Rating</td>
<td>Deviation</td>
</tr>
<tr>
<td>Compaction effects</td>
<td>58</td>
<td>4.8</td>
<td>0.46</td>
<td>44</td>
<td>4.6</td>
<td>0.66</td>
</tr>
<tr>
<td>Drain pipe quality</td>
<td>58</td>
<td>4.8</td>
<td>0.51</td>
<td>42</td>
<td>4.5</td>
<td>0.67</td>
</tr>
<tr>
<td>Adequate outlets</td>
<td>57</td>
<td>4.6</td>
<td>0.72</td>
<td>44</td>
<td>4.6</td>
<td>0.65</td>
</tr>
<tr>
<td>Installation standards</td>
<td>56</td>
<td>4.6</td>
<td>0.76</td>
<td>43</td>
<td>4.4</td>
<td>0.76</td>
</tr>
<tr>
<td>Drainage economics</td>
<td>57</td>
<td>4.4</td>
<td>0.91</td>
<td>44</td>
<td>4.3</td>
<td>0.81</td>
</tr>
<tr>
<td>Rights of upstream owners</td>
<td>56</td>
<td>4.4</td>
<td>0.91</td>
<td>44</td>
<td>4.3</td>
<td>0.90</td>
</tr>
<tr>
<td>Farm mapping</td>
<td>57</td>
<td>4.1</td>
<td>0.93</td>
<td>42</td>
<td>3.8</td>
<td>0.88</td>
</tr>
<tr>
<td>Assessments for ditches</td>
<td>56</td>
<td>4.1</td>
<td>1.01</td>
<td>42</td>
<td>4.1</td>
<td>0.97</td>
</tr>
<tr>
<td>Controlled drainage</td>
<td>54</td>
<td>3.7</td>
<td>1.22</td>
<td>43</td>
<td>4.0</td>
<td>0.72</td>
</tr>
<tr>
<td>Pesticide discharges</td>
<td>55</td>
<td>3.6</td>
<td>1.15</td>
<td>43</td>
<td>3.7</td>
<td>0.85</td>
</tr>
<tr>
<td>Nitrate discharges</td>
<td>55</td>
<td>3.5</td>
<td>1.10</td>
<td>42</td>
<td>3.6</td>
<td>0.83</td>
</tr>
<tr>
<td>GPS</td>
<td>54</td>
<td>3.5</td>
<td>1.19</td>
<td>42</td>
<td>3.5</td>
<td>0.99</td>
</tr>
<tr>
<td>Site Specific Farming</td>
<td>51</td>
<td>3.3</td>
<td>1.03</td>
<td>38</td>
<td>3.4</td>
<td>0.72</td>
</tr>
<tr>
<td>Swampbuster regulations</td>
<td>52</td>
<td>3.3</td>
<td>1.29</td>
<td>43</td>
<td>3.6</td>
<td>1.03</td>
</tr>
<tr>
<td>Iron ochre</td>
<td>56</td>
<td>3.2</td>
<td>1.31</td>
<td>40</td>
<td>3.4</td>
<td>1.15</td>
</tr>
<tr>
<td>Subirrigation</td>
<td>55</td>
<td>2.9</td>
<td>1.29</td>
<td>42</td>
<td>3.6</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Total responses 58 45

*Responses were based on a 5-point Likert scale: 1 - not important; 2 - somewhat unimportant; 3 - neutral; 4 - somewhat important; and 5 - very important.

Since this survey was related to the Ohio Agricultural Water Management Guide, which is meant to be a resource to drainage contractors, one section of the questionnaire
asked about the resources contractors used in determining size, depth, spacing and other design considerations prior to installing a drainage system. A list of seven resources was provided, and respondents were asked to rate their usage of each of these resources on a 5-point Likert-type scale. Table 5.5 summarizes the responses.

Table 5.5. Frequency that various design aids are used by mainline firms.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average response</td>
<td>2.1</td>
<td>1.9</td>
<td>1.0</td>
<td>1.2</td>
<td>2.3</td>
<td>4.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Never</td>
<td>30.6%</td>
<td>53.3%</td>
<td>97.6%</td>
<td>83.7%</td>
<td>14.3%</td>
<td>0.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>¼ or less</td>
<td>75.5%</td>
<td>77.8%</td>
<td>97.6%</td>
<td>95.3%</td>
<td>75.5%</td>
<td>0.0%</td>
<td>7.8%</td>
</tr>
<tr>
<td>about half</td>
<td>16.3%</td>
<td>11.1%</td>
<td>2.4%</td>
<td>2.3%</td>
<td>10.2%</td>
<td>3.6%</td>
<td>11.8%</td>
</tr>
<tr>
<td>¾ or more</td>
<td>8.2%</td>
<td>11.1%</td>
<td>0.0%</td>
<td>2.3%</td>
<td>14.3%</td>
<td>96.4%</td>
<td>80.4%</td>
</tr>
<tr>
<td>Always</td>
<td>4.1%</td>
<td>6.7%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>4.1%</td>
<td>76.8%</td>
<td>60.3%</td>
</tr>
</tbody>
</table>

*Responses were based on a 5-point Likert scale: 1 = never, 2 = about 25% of the time, 3 = about 50% of the time; 4 = about 75% of the time; and 5 = always

There was very little difference when the responses were stratified by mainline vs. sideline firms, so only the mainline firm summary is reported, as these firms are responsible for most drain pipe installation. Mainline firms were slightly less likely to use the soil survey, a hydraulic conductivity test, or a private consultant to help with the design of a system compared with sideline firms (data not shown). Although hydraulic conductivity is one of the main criteria in the design of a drainage system, a hydraulic conductivity test is rarely conducted. This is probably because of the large number of samples needed to properly estimate the hydraulic conductivity (Schwab et al., 1982), because of inherent spatial variability in the soil, and variability introduced by farm management decisions.
Only a self-prepared elevation map of the site, and the contractor’s experience were reported to be consistently used more than 25% of the time by a substantial percentage of the respondents. These two resources were used about 75% or more of the time by over 80% of the mainline contractors. Even a soil survey is not frequently used - 75% of the respondents report using the soil survey 25% of the time or less. Apparently drainage system design is based almost exclusively on contractor experience and topography of the site, in spite of recognized variability in drainage system response among sites (Schwab et al., 1982).

Contractors often price jobs by the amount of pipe installed, thus the incentive is to maximize pipe installation, leaving little incentive to place much effort into the design of a system. Contractors only make money when the machine is working. For these reasons, we wanted to explore how receptive contractors would be to working with private consultants to provide better design information for themselves and to their clients.

The design phase was split into two components: 1) obtaining a topographic survey (questions Q-10 and Q-11), and 2) completing the actual design (questions Q-12 and Q-13). No details were provided regarding the design process. For instance, it was not made clear that a hydraulic conductivity test might be part of the design process. This deficiency should be addressed in future surveys.

The responses to questions Q-10 and Q-12 are summarized in Table 5.6 from data in Table 1.5 in Appendix I. A 5-point Likert-type scale was used to rate the respondents interest in using a consultant to obtain a topographic survey and a drainage system design. Overall, sideline firms were slightly more interested in using consultants to
provide these services than were mainline firms. The overall interest was low for both
groups. Only 7 of 58 mainline firms (12%) were interested or very interested in using a
consultant for topographic surveys, while 8 of 34 sideline firms (23.5%) were interested
or very interested. A slightly higher percentage of each group was interested or very
interested in using a consultant for drainage system design: 9 of 58 (15.5%) of the
mainline firms and 9 of 34 (27.2%) of the sideline firms.

Table 5.6. Interest of drainage contractors in using private consulting services.

<table>
<thead>
<tr>
<th>Interest expressed in hiring a topographic survey</th>
<th>Mainline firms</th>
<th>Sideline firms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number responding</td>
<td>Percent of total</td>
<td>Number responding</td>
</tr>
<tr>
<td>Not interested</td>
<td>34</td>
<td>58.6%</td>
<td>15</td>
</tr>
<tr>
<td>Slightly interested</td>
<td>12</td>
<td>20.7%</td>
<td>7</td>
</tr>
<tr>
<td>Neutral</td>
<td>5</td>
<td>8.6%</td>
<td>4</td>
</tr>
<tr>
<td>Interested</td>
<td>6</td>
<td>10.3%</td>
<td>6</td>
</tr>
<tr>
<td>Very interested</td>
<td>1</td>
<td>1.7%</td>
<td>2</td>
</tr>
<tr>
<td>Number responding</td>
<td>58</td>
<td></td>
<td>34</td>
</tr>
<tr>
<td>Average response</td>
<td>1.5</td>
<td></td>
<td>2.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interest expressed in using a design consultant</th>
<th>Mainline firms</th>
<th>Sideline firms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number responding</td>
<td>Percent of total</td>
</tr>
<tr>
<td>Not interested</td>
<td>36</td>
<td>62.1%</td>
</tr>
<tr>
<td>Slightly interested</td>
<td>9</td>
<td>15.5%</td>
</tr>
<tr>
<td>Neutral</td>
<td>4</td>
<td>6.9%</td>
</tr>
<tr>
<td>Interested</td>
<td>8</td>
<td>13.8%</td>
</tr>
<tr>
<td>Very interested</td>
<td>1</td>
<td>1.7%</td>
</tr>
<tr>
<td>Number responding</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Average response</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.17</td>
<td></td>
</tr>
</tbody>
</table>

The 15 mainline and sideline firms interested or very interested in hiring a
topographic survey installed 13.6 million feet of drain pipe over the three years of the
survey, about 15% of the total reported, and enough to systematically drain about 13,000
acres. The 18 firms interested or very interested in having a consultant complete the system design installed 12.9 million feet of drain pipe, about 14% of the total drain pipe installation reported. Only 12 firms responded to both questions.

We next asked the respondents about the value of these services to the contractor or his client. The summary in Table 5.7 shows that the potential value of these services can be pretty high. Among those firms that provided an estimate of value for these services, the average amount firms estimated they or their clients would be willing to pay for a topographic services ranged from $4.30 to $5.60 per acre, with a high value of $20.00 per acre. For system design, estimates ranged from $3.60 to $6.70 per acre. One firm estimated that clients would be willing to pay as much as $25.00 per acre for a drainage system design.

A higher number of mainline firms provided value information than did the sideline firms. The mainline firms responding to this question seemed to place more value on design assistance than did the sideline firms, and on average were willing to pay nearly twice as much ($6.70 vs. $3.60) per acre for design assistance.
Table 5.7. The amount respondents estimated that they or their clients would be willing to pay for survey and design services provided by a consultant.

<table>
<thead>
<tr>
<th></th>
<th>Mainline Firms</th>
<th></th>
<th>Sideline Firms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount ($/ac)</td>
<td>Percent of Total</td>
<td>Number Responding</td>
<td>Percent of Total</td>
</tr>
<tr>
<td>Amount firm would be willing to pay for a topographic survey</td>
<td>14</td>
<td>24.1%</td>
<td>7</td>
<td>20.6%</td>
</tr>
<tr>
<td>Minimum</td>
<td>$1.00</td>
<td></td>
<td>$1.00</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>$10.00</td>
<td></td>
<td>$20.00</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>$4.30</td>
<td></td>
<td>$4.70</td>
<td></td>
</tr>
<tr>
<td>Amount client would be willing to pay for survey</td>
<td>9</td>
<td>15.5%</td>
<td>5</td>
<td>14.7%</td>
</tr>
<tr>
<td>Minimum</td>
<td>$0.00</td>
<td></td>
<td>$1.00</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>$15.00</td>
<td></td>
<td>$10.00</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>$5.60</td>
<td></td>
<td>$4.60</td>
<td></td>
</tr>
<tr>
<td>Amount firm would be willing to pay for design</td>
<td>12</td>
<td>20.7%</td>
<td>5</td>
<td>15.2%</td>
</tr>
<tr>
<td>Minimum</td>
<td>$1.00</td>
<td></td>
<td>$2.00</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>$25.00</td>
<td></td>
<td>$5.00</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>$6.70</td>
<td></td>
<td>$3.60</td>
<td></td>
</tr>
<tr>
<td>Amount client would be willing to pay for design</td>
<td>10</td>
<td>17.2%</td>
<td>5</td>
<td>15.2%</td>
</tr>
<tr>
<td>Minimum</td>
<td>$2.50</td>
<td></td>
<td>$2.00</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>$12.00</td>
<td></td>
<td>$10.00</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>$6.60</td>
<td></td>
<td>$5.00</td>
<td></td>
</tr>
</tbody>
</table>

While this survey does provide some insights into subsurface drainage contractors activities and attitudes, some of the topics could have been explored further. An open-ended question about each firms’ design process would be appropriate. This question could investigate how contractors design projects and their needs for additional tools or information.
Additional topics that would be useful would be: cost of installation, size range of jobs, use of drain spacing equations, use of computer software to design a drainage system. The latter question is similar to question Q-27, part 3, but perhaps would have been appropriate here as well.

5.4 Subsurface drainage installation activity in Ohio

The amount of drain pipe installation reported is summarized in Table 5.8. Data for this table was taken from Appendix I, tables I.1 and I.10. Firms whose main business is drain pipe installation installed about 89% of the total reported in this survey. Overall, a firm installing drain pipe as their main business installed an average of 4.6 times as much drain pipe as did a firm installing drain pipe as a sideline.

The trend indicated increasing amounts of drain pipe installation in each year of the survey, especially for mainline firms. While some of this may be because of the fact that more firms reported in 1997 compared with 1995, it may also be because of improved weather-related installation conditions, or increased demand. The same mainline firm reported the maximum amount of drain pipe installation in each year of any firm in the survey. This firm increased its productivity by about 500,000 ft per year during the three years of the survey. There was no information provided in the survey to learn why this firm's productivity increased by this amount. Nor was there any attempt made to estimate demand in this survey. Questions relating to changing productivity and demand may be appropriate in a future survey.
Table 5.8. Drain pipe installation reported by Ohio drainage contractors.

<table>
<thead>
<tr>
<th>Type of firm</th>
<th>Amount of Drain Pipe Installed (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1995</td>
</tr>
<tr>
<td>Sideline firms</td>
<td></td>
</tr>
<tr>
<td>Number of firms reporting</td>
<td>28</td>
</tr>
<tr>
<td>Average</td>
<td>109,643</td>
</tr>
<tr>
<td>Minimum</td>
<td>5,000</td>
</tr>
<tr>
<td>Maximum</td>
<td>500,000</td>
</tr>
<tr>
<td>Total drain pipe installed</td>
<td>3,070,000</td>
</tr>
</tbody>
</table>

Mainline firms

| Number of firms reporting | 53 | 56 | 56 | 56 |
| Average       | 449,132 | 462,321 | 545,411 | 1,432,804 |
| Minimum       | 30,000 | 10,000 | 50,000 | 90,000 |
| Maximum       | 2,447,000 | 2,990,000 | 3,572,000 | 9,009,000 |
| Total drain pipe installed | 23,804,000 | 25,896,000 | 30,543,000 | 80,237,000 |

Total drain pipe installed | 26,874,000 | 28,946,400 | 34,098,300 | 89,918,700 |

In addition to estimating drain pipe installation for each of the three years 1995-1997, respondents were asked to estimate the percentage (within 5%) of drain pipe that was installed in each county. By summarizing this data, we can estimate the total amount of drain pipe installed in each of Ohio’s counties by the respondents to this survey.

These estimates are displayed on a map of Ohio counties in Fig. 5.1. By looking for county totals that differ markedly from that of neighboring counties, we can estimate the quality of these values. For example, Licking County has a much higher value of drain pipe installation than any of the surrounding counties, raising the possibility that the
adjoining counties may be under-reported. Similarly, several counties in west-central Ohio have quantities that seem low compared with counties to the west and north (e.g., Allen, Champaign, Logan, Shelby, and Miami). The most glaring discrepancy is in Allen County, whose total is less than 25% of the counties to the east, north and west.

Table 5.9. Estimate, by county, of subsurface drain installation in Ohio during 1995-1997.

<table>
<thead>
<tr>
<th>County</th>
<th>Estimated length installed drains (thousands)</th>
<th>County</th>
<th>Estimated length installed drains (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of contractors</td>
<td>(ft)</td>
<td>(m)</td>
</tr>
<tr>
<td>Allen</td>
<td>5</td>
<td>815</td>
<td>248</td>
</tr>
<tr>
<td>Ashland</td>
<td>2</td>
<td>1,004</td>
<td>306</td>
</tr>
<tr>
<td>Ashtabula</td>
<td>8</td>
<td>3,116</td>
<td>950</td>
</tr>
<tr>
<td>Auglaize</td>
<td>5</td>
<td>1,538</td>
<td>469</td>
</tr>
<tr>
<td>Brown</td>
<td>3</td>
<td>362</td>
<td>110</td>
</tr>
<tr>
<td>Carroll</td>
<td>1</td>
<td>150</td>
<td>46</td>
</tr>
<tr>
<td>Champaign</td>
<td>1</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>Clermont</td>
<td>1</td>
<td>37</td>
<td>11</td>
</tr>
<tr>
<td>Clinton</td>
<td>2</td>
<td>568</td>
<td>173</td>
</tr>
<tr>
<td>Columbiana</td>
<td>3</td>
<td>754</td>
<td>230</td>
</tr>
<tr>
<td>Crawford</td>
<td>5</td>
<td>2,347</td>
<td>715</td>
</tr>
<tr>
<td>Cuyahoga</td>
<td>7</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Darke</td>
<td>6</td>
<td>5,382</td>
<td>1,640</td>
</tr>
<tr>
<td>Defiance</td>
<td>4</td>
<td>1,426</td>
<td>435</td>
</tr>
<tr>
<td>Delaware</td>
<td>1</td>
<td>495</td>
<td>151</td>
</tr>
<tr>
<td>Erie</td>
<td>2</td>
<td>1,280</td>
<td>390</td>
</tr>
<tr>
<td>Fairfield</td>
<td>5</td>
<td>845</td>
<td>258</td>
</tr>
<tr>
<td>Fayette</td>
<td>2</td>
<td>246</td>
<td>75</td>
</tr>
<tr>
<td>Franklin</td>
<td>3</td>
<td>103</td>
<td>31</td>
</tr>
<tr>
<td>Fulton</td>
<td>5</td>
<td>2,395</td>
<td>730</td>
</tr>
<tr>
<td>Geauga</td>
<td>2</td>
<td>104</td>
<td>32</td>
</tr>
<tr>
<td>Greene</td>
<td>1</td>
<td>638</td>
<td>194</td>
</tr>
<tr>
<td>Hancock</td>
<td>11</td>
<td>3,444</td>
<td>1,050</td>
</tr>
<tr>
<td>Hardin</td>
<td>7</td>
<td>5,182</td>
<td>1,579</td>
</tr>
<tr>
<td>Henry</td>
<td>6</td>
<td>4,402</td>
<td>1,342</td>
</tr>
<tr>
<td>Highland</td>
<td>3</td>
<td>744</td>
<td>227</td>
</tr>
<tr>
<td>Holmes</td>
<td>1</td>
<td>38</td>
<td>12</td>
</tr>
<tr>
<td>Huron</td>
<td>4</td>
<td>2,173</td>
<td>662</td>
</tr>
<tr>
<td>Knox</td>
<td>1</td>
<td>248</td>
<td>76</td>
</tr>
<tr>
<td>Lake</td>
<td>3</td>
<td>491</td>
<td>150</td>
</tr>
<tr>
<td>Licking</td>
<td>4</td>
<td>3,383</td>
<td>1,031</td>
</tr>
<tr>
<td>Logan</td>
<td>3</td>
<td>494</td>
<td>151</td>
</tr>
<tr>
<td>Lorain</td>
<td>7</td>
<td>22</td>
<td>7</td>
</tr>
</tbody>
</table>
Figure 5.1  Agricultural subsurface drain pipe installation by county, 1995-1997, in thousands of feet, reported by respondents to the 1998 Subsurface Drainage Survey. Counties with "--" had no reported installations.
5.5 Water table management practices

In Section II of the survey, respondents were asked to indicate if they had installed either new or retrofitted controlled drainage systems during the years 1995-1997. A summary of the results for controlled drainage systems is shown in Table 5.10, compiled from data found in Table I.6 and Table I.7. Only 8 contractors reported the installation of 13 new CD systems, and 5 reported the retrofitting of 8 systems. Ten of the new CD systems affected 290 acres of land, and 7 of the retrofitted systems affected 343 acres. Only three new CD systems controlling 25 acres were known to have some type of waste products applied to the land affected. Five contractors reported on the management of systems they had installed, and indicated that 70% (7 of 10) of the new CD systems were being managed successfully. The four contractors reporting on the management of retrofitted CD systems reported more successfully managed systems than they had installed, making these answers suspect.

Table 5.10. Controlled drainage system installation in Ohio, 1995-1997.

<table>
<thead>
<tr>
<th></th>
<th>New CD Systems</th>
<th></th>
<th>Retrofitted CD Systems</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of contractors reporting</td>
<td>Total Number of Systems</td>
<td>Number of contractors reporting</td>
<td>Total Number of Systems</td>
</tr>
<tr>
<td>Number of new installations</td>
<td>8</td>
<td>13</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Area affected (acres)</td>
<td>6</td>
<td>290</td>
<td>4</td>
<td>343</td>
</tr>
<tr>
<td>Number of control structures</td>
<td>7</td>
<td>23</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Number of systems judged to be managed successfully</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systems having waste products applied</th>
<th>New CD Systems</th>
<th>Retrofitted CD Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid pit manure (no.)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Holding pond manure (no.)</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Lagoon liquid (no.)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Municipal sludge (no.)</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
A summary of responses to questions about subirrigation (SI) systems is provided in Table 5.11, compiled from data in Table I.8 and Table I.9. Again, not all contractors who reported the installation of these systems provided the additional data requested. Five contractors reported the installation of 18 SI systems, but one contractor accounted for 11 of these. Total area affected by these 18 systems was 460 acres, an average of 25.5 ac/system. Seven contractors reported retrofitting 8 systems for subirrigation, affecting 438 acres, an average of 55 ac/system. The number of control structures is obviously underreported, with fewer control structures than systems. The contractors may not have understood this question.

An adequate water supply is critical for an SI system. A source capable of producing 5 gpm per acre is required to meet maximum ET demands. The most common water source for SI systems was a pond. Fourteen of the 18 new SI systems (78%) and 5 of the retrofitted SI systems (63%) used a new pond for the water supply, while existing ponds were a source of water for two each of the new and retrofitted SI systems. Streams were a source of water for two new and three retrofitted SI systems. Existing wells were a source of water for one new and three retrofitted SI systems. No new wells were constructed to provide water to SI systems. One of the new SI systems and three of the retrofitted SI systems had multiple sources of water. Two of the new SI systems (11%) and two of the retrofitted SI systems (25%) included new wetlands as a component of the system.

Four contractors reported that 86% (6 of 7) of the new SI systems installed were being managed successfully. However, the contractor that constructed 11 systems reported he did not know if they were being managed successfully.
### Table 5.11. Number of subirrigation systems installed and components used, 1995-1997.

<table>
<thead>
<tr>
<th></th>
<th>New SI Systems Number of contractors reporting</th>
<th>Total amount</th>
<th>Retrofitted SI Systems Number of contractors reporting</th>
<th>Total amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI installed</td>
<td>5</td>
<td>18</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>SI acres</td>
<td>5</td>
<td>460</td>
<td>7</td>
<td>438</td>
</tr>
<tr>
<td>SI control structures</td>
<td>5</td>
<td>15</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>SI managed success</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

Components included in installations

<table>
<thead>
<tr>
<th></th>
<th>Existing pond</th>
<th>New pond</th>
<th>Stream</th>
<th>Existing well</th>
<th>New well</th>
<th>Existing wetland</th>
<th>New wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of contractors reporting</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total amount</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Controlled drainage systems and subirrigation systems accounted for a very small fraction of subsurface drain pipe installed by the respondents from 1995 through 1997. Although these systems have the potential to reduce the adverse environmental effects of subsurface drainage (Skaggs et al., 1994), they do not seem to be frequently installed in Ohio. One respondent mentioned that “*We had a lot of interest in sub-irrigation in the 1980s. I haven’t even heard it mentioned in the last five years.*” The management requirements, increased design effort needed for a successful system, site constraints including topography and water supply needs, and increased costs likely contribute to low interest in these systems. Brown et al. (1998) are investigating the integration of subirrigation with constructed wetlands and water supply reservoirs in Northwest Ohio,
and these studies may lead to increased interest in subirrigation in Ohio. More detailed studies will be necessary to document the extent of subirrigation and controlled drainage systems in Ohio.

5.6 Drain depth and spacing by soil series

One of the main goals of the survey was to determine the depth and spacing values drainage contractors use to install drain pipe in various soil series. To assess the depth and spacing values used by contractors when installing drain pipe, respondents were asked to provide estimates of typical, minimum, and maximum depth in inches and spacing in feet used for the installation of lateral drains by soil series. A list of 28 soil series was provided, with the option for the respondents to add other soil names. This list consisted of the 28 soils of greatest area in Ohio having a high water table sometime during the year, derived from the State Soil Survey Database.

Responses were obtained for 60 soil series. Two respondents indicated they did not know the soil series, while nine others provided textural or descriptive responses such as black, clay, sand, muck, or gravel, to the question. A number of contractors apparently do not consider the soil series in the design of a drainage system. Seven respondents indicated that they used the same depth and spacing values for all soils.

Ninety contractors reported depth values for multiple soils. Fifty-seven of 90 (63%) provided identical values for typical, minimum and maximum installed depth for each of the soils they listed. In some cases the soils listed have very similar characteristics (e.g., Bennington and Blount (USDA-SCS, 1994)), but in other cases the soils listed have characteristics different enough to warrant different installation depths.
(e.g., Blount and Haskins (USDA-SCS, 1994)). However, drain depth is often limited by outlet conditions and not soil characteristics, and the values provided may reflect this constraint more than the variation in characteristics among the soils. No attempt was made in this survey to find out if the soil characteristics, the outlet conditions, or other factors controlled the installation depth used.

There were 269 soil series/contractor entries provided for typical depth, 270 for minimum installation depth, and 264 for maximum installation depth. The distribution of depths reported for all soils is shown in Fig. 5.2. A typical installation depth of 31-36 in was reported by 58% (156 of 269) of the respondents, while another 26% (70 of 269) reported a typical installation depth between 25 in and 30 in. Minimum installation depth responses fell mainly into two ranges: 19-24 in (47%) and 25-30 in (44%). Maximum installation depth varied more, with the largest number of responses in the 43-48 in range (32%), followed by 37-42 in (27%) and 31-36 in (21%).
Figure 5.2. Frequency that drains were installed at various depth ranges for all soils; (a) minimum; installation depth; (b) typical installation depth; (c) maximum installation depth.
Figure 5.3. Frequency that various spacing values were used for all soils reported by contractors; (a) is the minimum installed spacing; (b) is the typical installed spacing; (c) is the maximum installed spacing reported.
For the named soil series, there were 270 soil series/contractor entries provided for typical spacing, 236 for minimum spacing, and 228 for maximum spacing. As for the installation depth responses, many of the contractors do not appear to change spacing for different soils. Thirty-three of 90 contractors (37%) indicated the same typical installation spacing for the soil series they reported, while 28 of 90 (31%) indicated the same typical, minimum and maximum installation spacing.

The frequency that various spacing values used for minimum, typical and maximum drain spacings were reported by the contractors is shown in Fig. 5.3. The greatest number of responses indicated a typical spacing of 40 ft (35%), with the second greatest number of contractors using a spacing of 50 ft (20%). Figure 5.3a shows the responses for minimum installation spacing. Here there is less variability, likely because of the increasing cost of installing closely spaced drains. Contractors reported 25 ft (24%) and 30 ft (25%) nearly equally, with 19% indicating a minimum spacing of 40 ft.

The greatest number of responses for the maximum spacing were for a spacing of 50 ft (40%), with the 40 ft spacing selected by 19% of the respondents (Fig. 5.3c). Values used for maximum spacing varied more than minimum or typical spacing, ranging from 25 ft to 100 ft.

5.7 Evaluation of individual soils for depth and spacing

A major objective of this study was to compare the depth and spacing used by contractors with depth and spacing values computed using the Hooghoudt equation using the permeability values found in the Soil Interpretation Records contained in the State Soil Survey Database. Lucas (1982) compared the field performance of subsurface
drainage systems in 14 Midwest soils with the Hooghoudt equation and reported that reasonable values of drain spacing were obtainable using permeability values contained in the NRCS Soil Interpretation Records.

Of the 60 soil series with depth and spacing data, there were 8 soil series with data provided by 10 or more respondents, that were also in the group of benchmark soils for which drain spacing evaluations had been completed using the Hooghoudt equation (reported in preceding chapter). For each of these soils, both depth and spacing responses were examined. Some respondents did not provide individual values for each of the items (typical, minimum, and maximum depth and spacing) requested. For example, there were 27 respondents that provided some information for the Hoytville series. However, only 20 provided complete information for depth and only 19 provided complete information on spacing. Three respondents wrote in ranges for the typical depth, while four did not provide information for at least one item (typical, minimum, or maximum depth). Only those responses that provided complete data for either drain depth or drain spacing were selected for further analysis.

Figure 5.4 summarized the drain depth data reported for these 8 soils. On average, subsurface drains are installed between 30 in and 36 in deep on these soils, although the typical installation depth reported ranged from 24 in to 45 in. These values correspond quite well with the average installation depth for all soils reported in Fig. 5.2b. However, respondents were not asked to specify whether depth was constrained by soil attributes or by outlet conditions, so it is not certain that the reported depths were constrained only by soil conditions.
A soil attribute that would influence drain depth is the depth to a restrictive layer. The results were examined to determine if the contractors were influenced by the depth to restrictive layer reported by SIR data. For example, data for the Crosby soil series shows a layer beginning at about 28 in deep that could be a restrictive layer. However, respondents indicate that drains in the Crosby are typically installed at 36 in, 8 in deeper than the typical restrictive layer reported in the SIR. While this could indicate a lack of consideration for the restrictive layer, it could also reflect the natural variance of the depth to this layer. Only a site-by-site determination could resolve this issue. On the other hand, the Mernill soil series has a restrictive layer at about 34 in deep, nearly the same depth as the typical drain installation.
Figure 5.4 Average, range, and number of reports of typical installation depth for 8 soil series. The range in reported values for each soil series is shown by the brackets.

The other soils do not have a soil layer that acts as a restrictive layer, based on permeability data in the SIR. However, some soils have very low permeability. For example, data in the Paulding SIR show this soil to have extremely low permeability. Using the SIR values in the Hooghoudt equation results in a calculated drain spacing of less than 10 ft, even using the high permeability value. A drainage system with such a narrow spacing would be very expensive to install.

Figures 5.5a-h compare the typical, minimum and maximum spacing reported for these 8 soils with the spacing calculated using the Hooghoudt equation based on a steady-
state water table depth of 30 cm and a drain depth of 90 cm. For all soils, the typical installation spacing reported is usually greater than that calculated by the Hooghoudt equation. Only for Brookston (1 instance) and Mermill (2 instances) is a typical installation spacing reported in the range calculated by Hooghoudt. Except for the Crosby and the Paulding soils, a minimum spacing is reported in the Hooghoudt range for all soils. Information on the effectiveness of the installed spacings for various soils is lacking. It has been suggested that fractures in the glacial till, or other causes of increased flow may allow wider spacings to perform satisfactorily in the field (Discussion in Master’s Examination, May 12, 1999). It may also be that producers are making a tradeoff between performance and cost of installation. It would take a detailed study to resolve some of these issues.

The range of typical spacing is quite wide for Brookston (30 - 66 ft) and Crosby (40 - 70 ft) compared with the other soils, which all have a range 15 ft wide. Unfortunately, this study did not request additional information that would help to analyze the variability in responses.

Schwab et al. (1982) reported on a field evaluation of drainage systems on several soils in Ohio, including two sites with Paulding soils. Their objective was to determine pipe drain spacing recommendations for these soils. On the first Paulding site, the water table depth at mid-spacing was shallower than 30 cm after 24 hours, so an effective drain spacing could not be calculated. However, on the second site the water table was below 30 cm deep after 24 hours, and a drain spacing of 19 ft (5.7 m) was calculated. Schwab et al. (1982) indicated that the producer’s soil management was quite different at these
two sites, and questioned whether soil type should be used as the only basis for drain spacing calculations.

In addition to the Paulding soil series, Schwab et al. (1982) calculated drain spacings for Hoytville (11.8 m, 39 ft) and Nappanee (7.7 m, 25 ft) which are higher than spacings calculated from the Hooghoudt equation using the high permeability values for these soils. However, the Schwab et al. (1992) calculations are based on an unsteady-state equation, and thus the results obtained may not be strictly comparable to the steady-state Hooghoudt equation.

While this study provides information on how drainage contractor practices compare with the Hooghoudt equation calculations, it provides no information regarding the effectiveness of the systems installed. It should not be assumed that all systems are equally effective. Each site is likely to have different characteristics that would allow different drain spacings, even within the same soil series, as shown by Schwab et al. (1982) in the above example.

It would be very helpful to have additional information for the analysis of these data. An open-ended question about the contractors' selection of drain spacing and depth might provide useful information. Contractors could be asked whether drain depth was constrained mostly by outlet conditions or by soil characteristics. They could also be asked if the installation spacing was affected by the depth of installation used. To be most useful, these questions should be related to specific soils. Soil management
Figure 5.5 (continued) Frequency and distribution of specific minimum, typical, and maximum installed spacing values reported for (e) Mermill, (f) Nappanee, (g) Paulding, and (h) Pewamo soil series. These are shown in relation to the spacing range, shown as the shaded area, obtained by using SIR minimum and maximum permeability values with the 2-layer Hooghoudt equation.
practices appear to affect a field’s drainage characteristics, and might influence the spacing selected by contractors.

5.8 Summary and conclusions

A mail survey of drainage contractors was conducted in early 1998. Of 393 survey packets mailed, 107 completed questionnaires were returned. For the survey period, 1995 through 1997, 59 mainline and 34 sideline contractors installed nearly 90 million feet of drain pipe, with the mainline contractors responsible for 89% of the total. The installation of drain pipe increased in each year of the survey. Very few controlled drainage or subirrigation systems were installed during the survey period.

Mainline contractors were more likely to use drain plows than sideline contractors. Less than 50% (28 of 59) of the mainline firms report computer usage, but nearly two-thirds (22 of 34) of the sideline firms that installed drain pipe use a computer. Computers are used for bookkeeping by nearly all the firms that use a computer. Of the mainline firms using a computer, about 43% use a computer for plan drawing, and 29% use it for system design.

Drainage contractors were queried about several possible educational topics relevant to the drainage industry. The effects of compaction on drainage, drain pipe quality, adequate outlets and installation standards were the highest rated topics by both mainline and sideline firms.

Drainage contractors make little use of soil surveys or the Ohio Drainage Guide when designing a system, relying primarily on experience and a self-generated topographic map. Almost none use a hydraulic conductivity test. Only 12% of mainline
firms and 23.5% of sideline firms were interested or very interested in using a consultant for topographic surveys. A slightly higher percentage of each group was interested or very interested in using a consultant for drainage system design.

Drain pipe is installed at depths ranging from 18 in to 72 in, but is typically installed from 30 in to 76 in deep for many soil series. Drain spacing values reported ranged from 18 ft to 100 ft. Many drainage contractors reported the same typical, minimum and maximum depth and spacing values for multiple soil series, suggesting that drains are often installed without much regard for differences in soil types.

In general, drains are typically installed at spacings greater than that calculated using the Hooghoudt equation with permeability data from the SIR records. Only for those soils for which the Hooghoudt calculation results in a spacing approaching 40 ft is there much overlap with contractor practices. This may be because of the increased cost incurred when installing drain pipe at narrower spacing. Many contractors may consider recommendations based on the Hooghoudt equation to be overly conservative or impractical.

5.9 Recommendations for future work

While this survey does provide some insights into subsurface drainage contractors activities and attitudes, some of the topics could have been explored further. An open-ended question about each firm’s design process would be appropriate. This question could investigate how contractors design projects and their needs for additional tools or information. Contractors could be asked whether drain depth was constrained mostly by outlet conditions or by soil characteristics. They could also be asked if the installation
spacing was affected by the depth of installation used. To be most useful, these questions should be related to specific soils and soil management practices.

Additional data that would be useful include: cost of installation, size range of jobs, use of drain spacing equations, and the use of computer software to design a drainage system.

The trend indicated increasing amounts of drain pipe installation in each year of the survey, especially for mainline firms. Questions relating to changing productivity and demand may be appropriate in the next survey.

Last, a study on the effectiveness of drainage systems installed at various depths and spacings would be useful. We know there is a wide range of typical installation spacings used by contractors, but we do not know how the effectiveness of these systems might vary.

5.10 References


CHAPTER 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Studies were conducted to investigate group drainage activity and assessment methods used in Ohio, drain spacing calculations using steady-state equations, and characteristics and practices of subsurface drainage contractors. The results of these studies were presented in this thesis, and are summarized in this chapter. Recommendations resulting from this study are also presented.

6.1 Group drainage activity

A mail survey of county engineer offices and SWCDs in 50 counties was conducted in 1997 to measure the extent of new group drainage improvement activity and obtain information about the size of ditch maintenance programs to compare with previous survey data. The participation rate was high, although some information was not provided by several agencies because of high workloads preventing the research necessary for local agency personnel to summarize the data. Thus the information obtained for total benefited area and the breakdown of projects by legal authority is not complete.

Demand for group drainage improvement remains high in many counties in Ohio. The number of requests for assistance with group drainage improvements during 1994-1996 remained fairly steady, averaging about 150 requests annually for the counties
reporting. Nearly half (48%) of the requests were for improvements organized under the mutual agreement (MA) process. These requests were almost always approved by the administrative authority. County petition requests are the second most numerous, with 136 total requests made during 1994 – 1996, about 30% of the total requests. Only 75% of the MA requests were approved, with 26% being rejected or withdrawn. SB-160 requests make up 22% of the total. The smaller number of SB requests is a reflection of the smaller number of counties using this process.

The number of active SB requests at the end of the year increased dramatically from 55 in 1994 to 86 in 1996, an increase of 56%. At the end of 1996, there was a backlog equivalent to over three years worth of SB requests. By contrast, the MA backlog was approximately 1 year (79 requests active vs. 72 new requests annually), and the CP backlog was less than 2 years (79 requests active vs. an average of 45 new requests annually). The backlog may reflect the size and complexity of the projects constructed under each legal authority.

Agencies in 37 counties reported the construction of 342 improvements costing over $9.5 million for the three year period. Subsurface mains were most numerous with 153 reported, followed by 134 open ditch improvements. About 192.4 miles (309.6 km) of open ditches were constructed over the three year period, benefiting 144,127 ac (58,276 ha) of land. Twenty-eight improvements totaling 61.4 miles (98.8 km) of subsurface mains were installed benefiting 26,535 ac (10,739 ha).

Of the 50 counties in the survey, 34 ditch maintenance programs are administered by the county engineer’s office and 13 by soil and water conservation districts. Three counties reported no ditch maintenance program. Total maintenance fund expenditures
reported for the 47 county programs in 1996 amounted to $2,754,064.81. These counties reported $56,372.22 in other expenditures, for total maintenance expenditures of $2,810,437.03. Six counties reported no expenditures during 1996. Thirty-two counties with complete information reported 2,384,285 acres (964,907 ha) benefiting from improvements on their ditch maintenance programs. Using an average value for area benefited, an estimated 3.1 million acres (1.25 million ha) is benefited by ditch maintenance programs statewide.

Thirty-eight agencies provided detailed information about open ditch improvements constructed during the period 1988-1992. The most important reason given for constructing these open ditches was to provide an adequate outlet for subsurface drains, the second most important reason was to improve crop production, and the third most important was to place the ditch on the county maintenance program.

Nearly 90% of the costs of group drainage projects was borne by the landowners. The agency costs amounted to 8% of the total reported costs, while state and federal funds used for these projects amounted to 2.6% and 1.7% respectively. By combining all erosion control related expenses, rock chutes, surface inlets, seeding and outlet pipes, we find that these expenses average 39% of the total for MA improvements, 46% for SB improvements, and only 19% for CP improvements. The earthwork costs were remarkably consistent across the three legal authorities, amounting to about 30% of total expenses. Survey and design costs are about 9% of the total costs for CP improvements and about 7.5% for MA improvements. These costs were not well reported for SB improvements. Using these averages, we estimate that for new open ditch improvements that survey, design and layout costs for the average open ditch improvement will be about
10% of the cost, earthwork will amount to about 30%, brush 10 – 15%, and erosion control practices about 40% of the total costs.

6.2 Group drainage assessment methods

The 1997 Group Drainage Survey also provided information about assessment methods used by the local agencies to distribute costs. Seventeen methods or formulae were found to be in use by the agencies to distribute the costs of group drainage projects among the benefiting parcels of land. In this thesis, these methods and formulae were presented using common symbology, and were evaluated. The following conclusions were reached.

Agencies in general do not determine benefits resulting from the construction of group drainage improvement projects when making assessment calculations. Training on benefit cost analysis is needed for agency personnel involved with assessing landowners for group drainage projects. A procedure is needed that will allow agencies to calculate benefits for individual parcels and for land uses other than agriculture. The Sectionalized Method (Early, 1990) appears to do a reasonable job estimating some of the benefits, but improvements can be made.

Benefits to land uses other than agricultural crop land must be considered. Knowledge on how other land uses benefit from drainage is lacking at the county level. As the population increases, other land uses will become more predominant in areas benefited by group drainage improvements. There is a need to compile the benefits of drainage to these other land uses, such as roads, residences, commercial land, etc. The use of stormwater management and the installation of wetlands by landowners will affect
the hydrology of a watershed and may reduce the benefits of improved drainage. These relationships need to be established.

With the large number of group drainage projects being completed, there is opportunity and need for ex ante and ex post studies of the benefits and costs of these projects. Such studies would be very useful in developing improved assessment methods.

Although there are many deficiencies in the methods used by the county agencies to assess land for drainage improvements, most of the counties have developed systems that work well and are accepted by the public and the public officials involved in their application.

6.3 Estimating drain spacing using steady-state drainage equations

A FORTRAN computer program was written to calculate drain spacing using three steady-state drain spacing formulae, and the permeability values found in the SIR for 53 Ohio soils. Spacing estimates were made for four drain depths, two design drainage rates, and two depths to a restrictive layer for both high and low permeability values. The results were discussed based on four soil classes derived from the saturated hydraulic conductivity profile for these soils.

The following conclusions were reached:

1. Either the Doman or the single layer Hooghoudt equation can be used to estimate drain spacing when the drain will be installed at the depth of the restrictive layer;

2. The Hooghoudt equation would be preferred over the Doman for soils with homogeneous profiles or profiles with saturated hydraulic conductivity decreasing with depth;
3. The two-layer Hooghoudt provides a more conservative design, and with the wide range of possible hydraulic conductivity values for these Class 4 soils, those with increasing saturated hydraulic conductivity with depth, would provide an adequate estimate of drain spacing for general use, when the drain is below the interface between the low and high conductivity layers;

4. For those soil series having a bottom layer that is only slightly higher in hydraulic conductivity than the top layer, the two-layer Hooghoudt appears to provide an adequate estimate of the drain spacing even when the drain is placed in the top layer;

5. It would not be appropriate to use the two-layer Hooghoudt to estimate drain spacing for Class 4 soils when the drain is above the interface between layers with low hydraulic conductivity in the top layer, and much higher hydraulic conductivity in the bottom layer. The Ernst equation should be used for these soils;

6. Proper estimation of the saturated hydraulic conductivity, especially in the bottom layer, is relatively more important than the proper estimation of the depth to the restrictive layer or the design drainage rate, in obtaining a reliable drain spacing estimate using these steady state equations;

7. With no impeding layers, and an adequate outlet, deeper drain installation will allow wider drain spacing for subsurface drainage.

6.4 Subsurface drainage contractor characteristics and practices

A mail survey of drainage contractors was conducted in early 1998. Of 393 survey packets mailed, 107 completed questionnaires were returned. For the survey period, 1995 through 1997, 59 mainline and 34 sideline contractors installed nearly 90

275
million feet of drain pipe, with the mainline contractors responsible for 89% of the total. The installation of drain pipe increased in each year of the survey. Very few controlled drainage or subirrigation systems were installed during the survey period.

Mainline contractors were more likely to use drain plows than sideline contractors. Less than 50% (28 of 59) of the mainline firms report computer usage, but nearly two-thirds (22 of 34) of the sideline firms that installed drain pipe use a computer. Computers are used for bookkeeping by nearly all the firms that use a computer. Of the mainline firms using a computer, about 43% use a computer for plan drawing, and 29% use it for system design.

Drainage contractors were queried about several possible educational topics relevant to the drainage industry. The effects of compaction on drainage, drain pipe quality, adequate outlets and installation standards were the highest rated topics by both mainline and sideline firms.

Drainage contractors make little use of soil surveys or the Ohio Drainage Guide when designing a system, relying primarily on experience and a self-generated topographic map. Almost none use a hydraulic conductivity test. Only 12% of mainline firms and 23.5% sideline firms were interested or very interested in using a consultant for topographic surveys. A slightly higher percentage of each group was interested or very interested in using a consultant for drainage system design.

Drain pipe is installed at depths ranging from 18 in to 72 in, but is typically installed from 30 to 36 in deep. Drain spacing used ranges from 18 ft to 100 ft. A large number of contractors reported using the same typical, minimum and maximum spacing
for multiple soils, suggesting that drains are installed without much regard for differences in soil types. Further investigation must be done to confirm this, however.

In general, drains are typically installed at spacings greater than that calculated using the Hooghoudt equation and permeability data from the SIR records. Only for those soils for which the Hooghoudt calculation results in a spacing approaching 40 ft (12 m) is there much overlap with contractor practices. This may be because of the increased cost of installing drain pipe at narrower spacing.

Overall, a trend of increasing amounts of drain pipe installation in each year of the survey was found. This was especially true for mainline firms. Questions relating to changing productivity and demand may be appropriate in the next survey.

6.5 Recommendations

This was the first time new group drainage construction activity in Ohio has been quantified in this detail. The main procedural problem was the lack of complete participation by the counties. This was evidently because of a high workload and the lack of a readily available, current summary of improvements on the maintenance program.

In order to extend the information collected in this study, county agencies should be surveyed at the end of the 1999 calendar year to gather 1997, 1998, and 1999 data. Special attempts should be made to gather data from counties that did not provide complete information for the 1997 survey. The 1999 survey could be done concurrently with the distribution of a draft report of the 1997 survey to be sent to agencies for review and comment. After seeing the results of the 1997 Group Drainage Survey, the agencies may be inclined to provide more complete information about activities and assessment
methods in order to make a final report more accurate. On-site interviews with many of
the agencies with high workloads should be planned to ensure complete data collection.
Only parts I and II of the current survey need to be conducted on a regular basis. Some
enhancement of the questions would lead to more useful information.

It may be desirable to consider an annual survey of group drainage activities in
Ohio. An annual survey might improve responses by eliminating the need for agency
personnel to look through previous years records to complete surveys covering multiple
years. However, a project may be needed to initially summarize the relevant data relating
to projects currently on ditch maintenance programs and computerize these records for
agencies that have not done this, creating a historical database of group project activity
in each county. Basic information concerning project identification, year constructed,
length, benefited acres, annual costs and work done, legal authority used to originally
create the project, changes in the assessment base and components of the system would
be very useful. Such a project could help ensure that data reported by counties was of
equal quality, and would simplify later reporting.

To improve the agency response rate to these surveys, a worksheet could be
developed for agencies to use to summarize data for individual project requests as they
are submitted and are processed through withdrawal, rejection or construction. This
worksheet could be based on the survey instrument used in this study, but with some
enhancements to improve the quality of the information. For instance, agencies were not
asked for the reasons that requests were rejected or withdrawn, or even to differentiate
between the two outcomes. The agencies should be asked to specify which action was
taken and why. More categories of projects need to be considered, since several counties
are placing storm water control structures on the county maintenance programs. Some clarification of project types would be in order, or we could differentiate several components in one project. For example, many grassed waterways also have a subsurface drain components, which may have led to double counting of length and benefited acres. Better explanations of the project categories would help minimize double counting. Appendix D contains examples of two draft spreadsheets that could be used to provide summary information about group drainage project activity.

If agency personnel are diligent in keeping these worksheets up-to-date, the information could be submitted and summarized on a statewide basis annually or less often, with little extra effort on the part of agency personnel. This would also eliminate the need for agency personnel to summarize the information, which could be done at the state level. The worksheet could be implemented as a computer spreadsheet or database at the local level, in which case it would provide the agencies with current information whenever needed. As resources become available, summary information could be entered on this worksheet for improvements already on the maintenance program. It may be worth considering a statewide project to obtain this information for all counties in Ohio. Several agencies do not have their group drainage records summarized or in a computer database. A multi-agency project could be developed to create a database of information regarding historic group drainage activities and background data of projects on the county maintenance program in each county.

Boards of county commissioners and the public will be increasingly critical of cost analysis methods used to justify assessments for group drainage projects. In order to evaluate the economic viability of group drainage projects, it will be necessary to include
the environmental impacts in the cost-benefit analysis (Hey et al., 1983), as well as the
return to agricultural land, and the benefits on other land uses. There are other aspects
that must be considered as well, such as the benefits to state, county and township roads
and in some cases, benefits to railroads.

Many counties have procedures that work well for them. However, the author
believes that it would be wise for all counties to join in an effort to improve the process
of distributing assessments for group drainage improvements. Based on the studies
reported in this thesis, the author proposes that the following activities be considered to
improve our understanding of group drainage assessments and subsurface drainage
design.

With the large number of projects being completed, there is ample opportunity for
ex ante and ex post studies of the benefits of drainage to cropland. These studies could
evaluate various soil types, cropping systems, etc., and would be very useful in
evaluating current and proposed assessment methods.

Computer modeling can be used to provide insight into the relationship among
drainage benefits and soil types, distance from a project, and other soil and landscape
parameters. One approach is to model crop yields and hydrology using DRAINMOD
(Skaggs, 1980) and FLDNSTRM (Konyha and Skaggs, 1992), a channel hydrology
model based on DRAINMOD. However, to utilize these models effectively, more
extensive soil databases must be created to improve the reliability of DRAINMOD in
modeling crop response to drainage in Ohio. The greatest need is for reliable values of
hydraulic conductivity and air volume at the time fields are trafficable.

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One basis for relating benefits to group drainage projects is the increased value of the parcels of land benefiting by such projects. Hedonic price studies are one way to estimate the increased value of land because of drainage improvements. A hedonic price study would lead to some insights as to whether buyers have been willing to pay for the presence of a maintained outlet, for example. A hedonic study which included drainage as a factor was conducted in North Carolina, with positive results (Palmquist and Danielson, 1989). A properly designed study in Ohio would be very valuable. Will a properly designed study be able to show that buyers are willing to pay more for property with a drainage outlet on a county maintenance program? Such knowledge could be very helpful in evaluating existing or proposed assessment methods.

Some of the narrative provided by county agencies with their assessment methods revealed imperfect knowledge of cost-recovery calculations. This knowledge is critical in the proper estimation of costs and benefits. A fact sheet on this subject is needed and would be useful for training agency personnel responsible for administering group drainage projects.

Finally, a state-wide task force consisting of personnel from the various agencies involved, extension personnel, including economists, and the public should be formed to create and evaluate a process to be used statewide in evaluating the benefits accruing to various property as the result of a drainage improvement. This procedure must then be written in clear, concise language, which is clearly lacking for all current assessment procedures used in Ohio. This task force would be charged with reaching consensus on procedures to use when evaluating benefits. Where consensus on a procedure can not be
reached, the task force could identify research needs. A successful effort would be very helpful to county engineers and SWCDs in Ohio.

While the 1998 Subsurface Drainage Survey does provide some insights into subsurface drainage contractors activities and attitudes, some of the topics could have been explored further. An open-ended question about each firms’ design process would be appropriate. This question could investigate how contractors design projects and their needs for additional tools or information. Contractors could be asked whether drain depth was constrained mostly by outlet conditions or by soil characteristics. They could also be asked if the installation spacing was affected by the depth of installation used. To be most useful, these questions should be related to specific soils and soil management practices. Additional data that would be useful include: cost of installation, size range of jobs, use of drain spacing equations and computer software to design a drainage system.

A study on the effectiveness of drainage systems installed at various depths and spacings would be useful. We know there is a wide range of typical installation spacings used by contractors, but we do not know how the effectiveness of these systems might vary. In order to improve the subsurface drainage design process, future research must concentrate on practical ways to estimate the saturated hydraulic conductivity.

6.6 References


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7.1 Legal citations – case law


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APPENDIX A

1997 GROUP DRAINAGE SURVEY AND SUPPORTING DOCUMENTS
Exhibit A.1. Survey instrument for group drainage survey.

1997 Group Drainage Improvement Survey

Thank you for participating in the 1997 Group Drainage Improvement Survey sponsored by the Department of Food, Agricultural, and Biological Engineering and the Overholt Drainage Education and Research Program at The Ohio State University. This survey is part of a larger study of the benefits of group drainage improvement projects in Ohio. The information you provide by completing the survey will help us successfully complete this study.

This questionnaire has been reviewed at various stages of its development by a few of your colleagues. We appreciate the helpful comments and encouragement of Doug Durkin, Deputy Engineer, of the Paulding County Engineer’s office; Cary Brickner and Don Ruffing, Group Projects Coordinator and Ditch Maintenance Supervisor, respectively, with the Huron SWCD; Doug Deardorff, District Conservationist in Hardin County; and Fred Gurke, Urban Technician with the Fairfield SWCD. Kevin Elder, Cost Share Coordinator with the Division of Soil and Water Conservation - ODNR and Art Brats, State Conservation Engineer, with the Natural Resources Conservation Service - USDA both expressed the support of their agencies for this survey.

The survey contains four sections. Each section is briefly described below.

Section I. Drainage Project Type and Annual Activity. Questions in this section relate to the amount of group drainage project activity during the period 1994 - 96, categorized by project type and the legal authority used to make assessments. Your answers to these questions will allow us to develop an up-to-date summary of how much group drainage work is being done over this three year period. We then will be able to develop an up-to-date estimate of the expenditures being made to improve drainage in Ohio. We are requesting three years of information since the level of group drainage improvement activity may vary from year to year.

Section II. County Ditch Maintenance Program Update. Questions in this section relate to your county’s ditch maintenance program. A study of ditch maintenance costs was completed in 1994 by Don Vigh with the Allen SWCD. However, we want to obtain information current through 1996 in order to more accurately summarize maintenance programs and costs relative to the data obtained in Section I.

Section III. Selected Ditch Project Details. Questions in this section will ask for details of a representative ditch project in your county. Since previous ditch maintenance studies show that nearly 90% of group drainage improvement projects are ditches, we have chosen to focus on ditches in this section. We are asking you for information on a project from the 1988 - 1992 time period so that we can conduct an analysis of both construction and maintenance costs for these projects. We hope to also use the information that you provide in this section as a base for another study to evaluate how the presence of drainage improvement affects the price purchasers pay for land.

Section IV. Assessment or Cost Allocation Methods. A summary of the different assessment or cost allocation methods used in Ohio will be of interest to many people. It has been said that there are as many different methods of calculating assessments as there are counties doing group drainage improvement work. Is this true? The information you provide will help us answer this question, but more importantly allow us to summarize the major similarities and differences among the different methods in use around the state. In an additional study, we will compare the assessments produced by a few of the most widely used methods for several case study projects.

For the purposes of this survey, the terms relating to the legal authority used for group drainage improvement projects are defined as follows:

“County Petition” projects refer to projects based on Chapter 6131 (6131.01 - 6131.64) of the Ohio Revised Code (ORC);

“Senate Bill 160” projects refer to improvement projects based on Chapter 1515 ORC. These are also known as Conservation Works of Improvement.

“Mutual Agreement” projects refer to those based on Section 6131.63 ORC.

Continued
### SECTION I. Drainage Project Type and Annual Activity

In this section please quantify the group drainage improvement work done with your agency’s assistance from January 1, 1994 through December 31, 1996 based on the legal authority used. The questions on this page relate to the assistance your agency provided to county petition projects.

Q-1 DID YOUR AGENCY ASSIST WITH ANY COUNTY PETITION PROJECTS FROM JANUARY 1, 1994 THROUGH DECEMBER 31, 1996? (Please circle one number.)

1 Yes (If yes, please go to question Q-2.)
2 No (If no, please go to page 3.)

Q-2 PLEASE PROVIDE THE FOLLOWING INFORMATION FOR EACH CALENDAR YEAR IN THE APPROPRIATE BLANK TO THE RIGHT OF EACH QUESTION. (Include joint county projects if and only if your county is the lead county. Active petitions include those filed but still in the approval process. Please include action taken on petitions carried over from previous years.)

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Q-3 PLEASE LIST THE NUMBER OF COUNTY PETITION PROJECTS, BY CATEGORY, FOR WHICH INITIAL CONSTRUCTION WAS COMPLETED DURING THE CALENDAR YEAR INDICATED.

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Q-4 PLEASE LIST THE TOTAL LENGTH, IN FEET, OF THE COMPLETED PETITION PROJECTS LISTED IN QUESTION Q-3.

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Q-5 PLEASE LIST THE TOTAL ACRES BENEFITTED BY THE COMPLETED PETITION PROJECTS LISTED IN QUESTION Q-3.

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**Q-6** PLEASE LIST THE TOTAL COSTS IN DOLLARS FOR THE COMPLETED PETITION PROJECTS LISTED IN QUESTION Q-3. (Please indicate estimated figures by circling them. Enter NC if an item was not considered; 0 (zero) if zero; DK if you don’t know.)

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**SECTION I. (Continued)**

Section 6131.63 of the Ohio Revised Code provides for groups of landowners to mutually agree to construct and pay for a drainage improvement project. The questions on this page relate to these mutual agreement projects and the assistance provided by the county engineer’s office. Please do not count or provide information on projects for which the local soil and water conservation district (SWCD) provided the majority of assistance.

**Q-7** DID YOUR AGENCY PROVIDE THE PRIMARY ASSISTANCE FOR ANY MUTUAL AGREEMENT PROJECTS FROM JANUARY 1, 1994 THROUGH DECEMBER 31, 1996? (Please circle one number.)

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**Q-8** PLEASE PROVIDE THE FOLLOWING INFORMATION FOR EACH CALENDAR YEAR IN THE APPROPRIATE SLANT ON THE RIGHT OF EACH QUESTION. (Include joint county mutual agreement projects if and only if your county is the lead county. Active mutual agreement requests include those filed and still in the approval process. Please include action taken on requests carried over from previous years.)

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**Q-9** PLEASE LIST THE NUMBER OF MUTUAL AGREEMENT PROJECTS FOR WHICH INITIAL CONSTRUCTION WAS COMPLETED DURING THE CALENDAR YEAR INDICATED.

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**Q-10** PLEASE LIST THE TOTAL LENGTH, IN FEET, OF THE COMPLETED PROJECTS IDENTIFIED IN QUESTION Q-8.

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**Q-11** PLEASE LIST THE TOTAL ACRES BENEFITTED BY THE COMPLETED PROJECTS IDENTIFIED IN QUESTION Q-8.

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**Exhibit A.1. (continued)**

Q-12 PLEASE LIST THE TOTAL COSTS IN DOLLARS FOR THE COMPLETED MUTUAL AGREEMENT PROJECTS LISTED IN QUESTION Q-8. (Please indicate estimated figures by circling them. Enter NG if an item was not considered; 0 (zero) if zero; DK if you don't know.)

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**Section II. County Ditch Maintenance Program Update**

We would like to know the status of your county's ditch maintenance program as of December 31, 1996 so we have information that coincides with the construction activities described in Section I.

Q-13 DOES YOUR AGENCY ADMINISTER THE DITCH MAINTENANCE PROGRAM IN YOUR COUNTY? (Please circle one number.)

Yes (If yes, please go to question Q-14.)

No (If no, please go to page 5.)

Q-14 IN WHAT YEAR WAS YOUR COUNTY DITCH MAINTENANCE PROGRAM BEGUN? (Please enter the year.)

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In questions Q-15 to Q-18, please tell us about the composition of projects on your county's ditch maintenance program as of December 31, 1996, and the 1996 expenditures, in dollars, by entering the figures in the appropriate blanks. Please make reasonable estimates where appropriate and indicate estimated figures by circling them. Enter DK if you think there were expenses in a category but you feel you cannot reasonably estimate them. Enter 0 (zero) where appropriate. Enter NA if a category is not applicable. The last column, other maintenance expenditures, would include expenditures not charged to the maintenance fund such as cost-share funds, grants, in-kind contributions, administrative time not charged, assessment reductions, etc.

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<tr>
<td>Q-15 OPEN DITCHES</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>a) County petition projects</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>b) SB-160 projects</td>
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<td>c) Mutual agreement projects</td>
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<tr>
<td>d) Other (Please specify)</td>
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<tr>
<td>Q-16 SUBSURFACE MAINS</td>
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<tr>
<td>a) County petition projects</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>b) SB-160 projects</td>
<td></td>
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<td></td>
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<tr>
<td>c) Mutual agreement projects</td>
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<td></td>
<td></td>
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<tr>
<td>d) Other (Please specify)</td>
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<tr>
<td>Q-17 GRASSED WATERWAYS</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>a) County petition projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>b) SB-160 projects</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>c) Mutual agreement projects</td>
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<td></td>
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<tr>
<td>d) Other (Please specify)</td>
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<tr>
<td>Q-18 OTHER (Please specify)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>a) County petition projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>b) SB-160 projects</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>c) Mutual agreement projects</td>
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</tr>
<tr>
<td>d) Other (Please specify)</td>
<td></td>
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</tbody>
</table>

Continued
Exhibit A.1 (continued)

Section III. Selected Ditch Project Details

We want to get financial details and other information about one group ditch improvement project for which construction was completed during the period 1988 through 1992. We have selected these years so that there will be a history of maintenance expenditures as well as original construction expenditures. We are only asking about ditch projects since they make up nearly 90% of the group drainage projects on county maintenance programs. This information will be used in a detailed analysis of the costs and benefits of the selected ditch projects.

Q-19 For HOW MANY DITCH improvement PROJECTS was construction COMPLETED WITH YOUR AGENCY'S ASSISTANCE IN THE PERIOD 1988 through 1992? (Please circle one number.)

1 None (Please go to question Q-39 on page 9.)
2 _____ Ditch projects were completed (Please continue with the following paragraph.)

In questions 20 through 38, please provide information for an actual ditch project of your choice, which your agency helped with and for which construction was completed sometime during the period 1988-1992. The selected project should be representative of projects in your county.

Q-20 PLEASE LIST THE NAME OR OTHER IDENTIFIER OF THE DITCH PROJECT YOU HAVE SELECTED FOR THIS SECTION.

Q-21 UNDER WHICH LEGAL AUTHORITY WAS THIS PROJECT ORGANIZED? (Please circle one number.)

1 County petition
2 SB-160
3 Mutual agreement
4 Other (Please specify)

Q-22 PLEASE EXPLAIN WHY THIS LEGAL AUTHORITY WAS SELECTED.

Q-23 PLEASE PROVIDE THE MONTH AND YEAR WHEN THE INITIAL CONSTRUCTION OF THIS PROJECT WAS COMPLETED.

Q-24 HOW MANY ACRES ARE BENEFITTED BY THIS PROJECT?

Q-25 WHAT IS THE TOTAL PROJECT LENGTH IN FEET?

Q-26 WHAT IS THE CAPACITY (CFS) OF THE PROJECT AT THE OUTLET?

Q-27 PLEASE LIST THE NAME OF THE ASSESSMENT OR COST ALLOCATION METHOD THAT WAS USED FOR THIS DITCH PROJECT. (When you return the survey please enclose an explanation of this method.)

Note: If you have a project report that covers some or all of the information requested, please attach it to the survey when you return it.

Q-28 PLEASE DESCRIBE THE FACTORS YOUR AGENCY USED TO ESTIMATE BENEFITS FOR THIS DITCH PROJECT.

Continued
Q-29 PLEASE INDICATE THE LEVEL OF IMPORTANCE OF EACH OF THE FOLLOWING REASONS, a) THROUGH k), FOR COMPLETING THE DITCH PROJECT IDENTIFIED IN QUESTION Q-20. (Please circle one answer for each reason.)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Not Important</th>
<th>Somewhat Important</th>
<th>Important</th>
<th>Very Important</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve crop production</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce flooding damage to agricultural land</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce flooding damage to residential land</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce flooding damage to agricultural buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce flooding damage to residential buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce flooding damage to roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provide adequate outlet for subsurface drains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provide adequate outlet for accelerated runoff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce a threat to public health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place ditch on county maintenance program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Please identify)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Other (Please identify)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Q-30 DID YOUR AGENCY ESTIMATE THE BENEFITS OR IMPACTS RELATED TO THE CONSTRUCTION OF THIS DITCH PROJECT? (Please circle one number.)

1 Yes (If yes, please go to question Q-31.)
2 No (If no, please go to page 7.)

Q-31 FOR ITEMS a) THROUGH k), PLEASE PROVIDE THE ANNUAL VALUE OF BENEFITS, IN DOLLARS, YOUR AGENCY ESTIMATED FOR THE DITCH PROJECT IDENTIFIED IN QUESTION Q-20. (Please enter NC if an item was not considered. Enter 0 (zero) if no benefit was estimated. Enter DK if you don’t know.)

<table>
<thead>
<tr>
<th>Item (a through k)</th>
<th>The Benefits Attributed to Real Property</th>
<th>The Benefits Attributed to the Welfare of the General Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Improve crop production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Reduce flooding of agricultural land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Reduce flooding damage to residential land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Reduce flooding damage to agricultural buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) Reduced flooding of residential buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Reduced flooding of roads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g) Provide adequate outlet for subsurface drains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h) Provide adequate outlet for accelerated runoff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Reduce a threat to public health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j) Place ditch on county maintenance program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k) Other (Please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued
Section III. (Continued)

Q-32 For each item, a) through f), listed below, Please list the expenditures, in dollars, for all work related to the design, approval and construction of the ditch project identified in question Q-20. (Please provide reasonable estimates where appropriate and indicate estimated figures by circling them. Enter DK if you don't know a value and feel you cannot provide a reasonable estimate. Please enter NC if the item was not considered. Enter 0 (zero) if there was no expenditure.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Expenditures paid by Landowners</th>
<th>Expenditures paid by Your Agency not included in First Column</th>
<th>Expenditures paid with State Funds not included in First Two Column</th>
<th>Expenditures paid with Federal Funds not included in First Three Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Survey &amp; design, engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Permitting (404, 401, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Construction layout and inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>Purchase of land rights, easements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e)</td>
<td>Earthwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f)</td>
<td>Brush clearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g)</td>
<td>Erosion control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h)</td>
<td>Surface inlets to ditch (e.g., rock chutes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Subsurface drain outlet pipes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j)</td>
<td>Access pipes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k)</td>
<td>Crossings</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>l)</td>
<td>Seeding, fertilizer, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m)</td>
<td>Loan fees and interest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n)</td>
<td>Legal fees</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>o)</td>
<td>Other (Specify)</td>
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<tr>
<td>p)</td>
<td>Other (Specify)</td>
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<td></td>
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<tr>
<td>q)</td>
<td>Total project expenditures</td>
<td></td>
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</tr>
</tbody>
</table>

Q-33 FOR EACH ITEM, a) THROUGH f), LISTED BELOW, PLEASE PROVIDE THE ANNUAL VALUE OF ANY OTHER POSITIVE OR NEGATIVE IMPACTS, IN DOLLARS, YOUR AGENCY ESTIMATED FOR THE DITCH PROJECT IDENTIFIED IN QUESTION Q-20. (Please provide reasonable estimates where appropriate and indicate estimated figures by circling them. Enter DK if you don't know a value and feel you cannot provide a reasonable estimate. Please enter NC if the item was not considered. Enter 0 (zero) if there was no impact.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>The Impacts</th>
<th>The Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Attributed to</td>
<td>Attributed to the General</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Real Property</td>
<td>Welfare of the Public</td>
</tr>
<tr>
<td>a)</td>
<td>Positive impact on an environmentally significant area(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Negative impact on an environmentally significant area(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Positive impacts downstream</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>Negative impacts downstream</td>
<td></td>
<td></td>
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<tr>
<td>e)</td>
<td>Other (Please specify)</td>
<td></td>
<td></td>
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<tr>
<td>f)</td>
<td>Other (Please specify)</td>
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</table>

Q-34 PLEASE DESCRIBE ANY UNIQUE OR UNUSUAL ASPECTS OF THIS PROJECT THAT AFFECTED THE CONSTRUCTION COSTS.

Continued
Exhibit A.1. (continued)

Section III. (Continued)

The questions on this page relate to the maintenance expenditures for the project identified in question Q-20. If your agency does not administer your county's ditch maintenance program, please obtain the relevant information from the appropriate agency or have someone from that agency complete this page. If someone else completes this page, please write their name on the return envelope along with their agency's name.

Q-35 FROM THE DATE OF ORIGINAL CONSTRUCTION THROUGH 1996, HOW MANY YEARS HAS THE PROJECT IDENTIFIED IN QUESTION Q-20 BEEN ON THE COUNTY MAINTENANCE PROGRAM? (Please enter the number of years.)

Q-36 FOR ALL YEARS LISTED BELOW WHICH ARE APPLICABLE, THROUGH 1996, PLEASE LIST THE ANNUAL MAINTENANCE EXPENDITURES FOR THE PROJECT IDENTIFIED IN QUESTION Q-20. (Please include direct costs, administrative costs, work done by landowners that has not been reimbursed, cost-share funding, grant finding, assessment reductions, etc. Please provide reasonable estimates where appropriate and indicate estimated figures by circling them. Enter DK if you don't know a value and don't feel you can provide a reasonable estimate. Please enter NC if the item was not considered. Enter 0 (zero) if there was no expenditure.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Expenditures paid by Maintenance Fund</th>
<th>Expenditures paid by Landowners not Charged to Maintenance Fund</th>
<th>Expenditures paid by Your Agency not included in first 2 columns</th>
<th>Expenditures paid with State Funds not included in first 3 columns</th>
<th>Expenditures paid with Federal Funds not included in first 4 columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 1988</td>
<td></td>
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<tr>
<td>b) 1989</td>
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<tr>
<td>c) 1990</td>
<td></td>
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<tr>
<td>d) 1991</td>
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<tr>
<td>e) 1992</td>
<td></td>
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<tr>
<td>f) 1993</td>
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<td>g) 1994</td>
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<tr>
<td>h) 1995</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>i) 1996</td>
<td></td>
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</tbody>
</table>

Some major expenditures for work done as part of a maintenance program could be amortized over a period of years. Doing so would affect the calculation of the annual maintenance cost of the project. The next question asks you to identify such expenditures.

Q-37 FOR THE PROJECT IDENTIFIED IN QUESTION Q-20, PLEASE LIST ANY EXPENDITURE OVER $1,000 FOR WORK HAS AN EXPECTED LIFE OF MORE THAN FIVE YEARS AND WHICH WAS INCLUDED IN THE MAINTENANCE EXPENDITURES SHOWN IN QUESTION Q-35. (For example, a ditch bottom clean-out may have been done in 1994 with an expected life of 10 years. A rock chute may have an expected life of 10 or more years.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Year Installed</th>
<th>Expected life (years)</th>
<th>Total Amount Expended for this Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Q-38 PLEASE DESCRIBE ANY UNIQUE OR UNUSUAL ASPECTS OF THIS PROJECT THAT HAVE AFFECTED THE MAINTENANCE COSTS.

Continued
Exhibit A.1. (continued)

Section IV: Assessment or Cost Allocation Methods

To understand how the costs and benefits of group drainage improvement projects are calculated and allocated to the benefiting land, it is important to review the methods used to do these calculations. The questions in this section deal with these assessment or cost allocation methods.

Q-39 DOES YOUR AGENCY PROVIDE ASSISTANCE TO LANDOWNERS FOR GROUP DRAINAGE IMPROVEMENT PROJECTS? (Please circle one number.)

1 Yes (If yes, please continue with question Q-40.)
2 No (If no, please go to Section V on the bottom of page 10.)

Q-40 DOES YOUR AGENCY HAVE AN ASSESSMENT OR COST ALLOCATION METHOD FOR COUNTY PETITION PROJECTS? (Please circle one number.)

1 Yes (If yes, please continue with question Q-41.)
2 No (If no, please go to question Q-47.)

Q-41 PLEASE LIST THE NAME OF THE METHOD THAT YOUR AGENCY CURRENTLY USES TO CALCULATE ASSESSMENTS OR ALLOCATE COSTS FOR COUNTY PETITION PROJECTS. (When you return the survey please enclose an explanation of this method.)

Q-42 WHEN WAS THIS METHOD FIRST USED BY YOUR AGENCY TO CALCULATE ASSESSMENTS OR ALLOCATE COSTS FOR COUNTY PETITION PROJECTS? (Please write the year.)

19

Q-43 SINCE IT WAS FIRST USED, HOW MANY PROJECTS HAVE BEEN CONSTRUCTED USING THIS METHOD? (Please write the number of projects. Enter DK if you do not know and cannot make a reasonable estimate. Circle the number if it is an estimate.)

Projects have been completed using this method

Q-44 HAVE ASSESSMENTS OR COST ALLOCATIONS USING THIS METHOD EVER BEEN CHALLENGED IN ANY OHIO COURT? (Please circle each number that applies.)

1 No (If no, please go to question Q-47.)
2 Yes, in Common Pleas Court
3 Yes, in the Court of Appeals
4 Yes, in the Ohio Supreme Court

Q-45 IN GENERAL, WHAT WAS THE OUTCOME?

Q-46 PLEASE LIST THE COURT CASE NUMBER(S) OR NAME(S) OF THE CASE(S) REFERRED TO IN QUESTION Q-44.

Q-47 DOES YOUR AGENCY HAVE AN ASSESSMENT OR COST ALLOCATION METHOD FOR MUTUAL AGREEMENT PROJECTS? (Please circle one number.)

1 Yes (If yes, please continue with question Q-48.)
2 No (If no, please go to page 10.)

Q-48 PLEASE LIST THE NAME OF THE METHOD THAT YOUR AGENCY CURRENTLY USES TO CALCULATE ASSESSMENTS OR ALLOCATE COSTS FOR MUTUAL AGREEMENT PROJECTS? (When you return the survey please enclose an explanation of this method.)

Continued
Q-48 WHEN WAS THIS METHOD FIRST USED BY YOUR AGENCY TO CALCULATE ASSESSMENTS OR ALLOCATE COSTS FOR MUTUAL AGREEMENT PROJECTS? (Please write the year.)

19

Q-50 SINCE IT WAS FIRST USED, HOW MANY PROJECTS HAVE BEEN CONSTRUCTED USING THIS METHOD? (Please write the number of projects. Enter DK if you do not know and cannot make a reasonable estimate. Circle the number if it is an estimate.)

Projects have been completed using this method

Section IV. (Continued)
Q-51 PLEASE DESCRIBE ANY CHANGES YOU HAVE MADE IN YOUR METHODS OF CALCULATING ASSESSMENTS OR ALLOCATING COSTS FOR GROUP DRAINAGE IMPROVEMENT PROJECTS SINCE 1985.

Q-52 PLEASE DESCRIBE ANY CHANGES IN LAW, PROCEDURES, ETC. THAT COULD BE MADE TO IMPROVE THE GROUP DRAINAGE IMPROVEMENT PROCESS.

Q-53 PLEASE DESCRIBE ANY UNIQUE, UNUSUAL OR DIFFERENT ASPECTS OF YOUR GROUP DRAINAGE IMPROVEMENT PROGRAM THAT YOU ARE AWARE OF WITH RESPECT TO OTHER COUNTIES IN OHIO.

Q-53 HOW WILLING WOULD YOUR AGENCY BE TO CHANGE ITS CURRENT ASSESSMENT OR COST ALLOCATION METHODS? (Please circle one number.)

1 Unwilling
2 Somewhat unwilling
3 Neutral
4 Willing
5 Very willing

Although each drainage project is unique, we would like to be able to place ditch projects statewide into a few categories (drainage regimes) to facilitate further research into the value of drainage ditches to Ohio's land. The ditches in each group might have similar characteristics such as soils, land use, climate, need, etc.

Q-54 BASED ON YOUR EXPERIENCE AND KNOWLEDGE, PLEASE DESCRIBE HOW YOU WOULD DIFFERENTIATE ONE CLASS OF GROUP DRAINAGE IMPROVEMENT PROJECTS FROM ANOTHER IN ORDER TO COMPARE BENEFITS AND COSTS?

Section V. Conclusion

Reminder: Please attach a copy of the assessment or cost allocation procedures for each of the methods identified in questions Q-27, Q-41, and Q-48. Also, please write your name on the return envelope so we may call you if we have questions about your responses.

Thank you very much for taking the time to respond to this survey. The information you have provided will be essential in developing an up-to-date review of group drainage improvement construction activity and the various assessment and cost allocation methods in use in Ohio. This information will also provide an excellent base of knowledge for further research on estimating the value of drain improvement projects to Ohio's land. We will provide you with a summary of the results of this survey within 6 months following completion of the study.

Please phone Bruce Atherton at 614-292-1405 with your questions and comments regarding this survey. If you prefer, you can fax Bruce at 614-292-9448 or send email to atherton10@osu.edu.

If you have additional comments about this subject, please write them on a separate paper and enclose them, along with this survey and additional documents asked for, in the enclosed self-addressed stamped envelope and mail to Bruce Atherton, 590 Woody Hayes Drive, Columbus, OH 43210-1057.
November 18, 1997

Dear <prefix> <last name>:

Group drainage improvement projects, such as county petitions and Senate Bill 160 projects, continue to receive scrutiny from the public. While a summary of ditch maintenance costs was done recently, there is no up-to-date information available in Ohio regarding the level of new and existing group drainage improvement activities, the benefits of those projects to adjacent agricultural land, and the methods used to assess landowners for the costs of these projects.

We have initiated a study to evaluate the benefits of group drainage improvement projects in Ohio and we need your help. To collect the information needed for this study, we are sending the enclosed questionnaire to the county engineers and soil and water conservation districts doing drainage work in Ohio. In order for this study to accurately reflect drainage activity throughout the state, it is important that every questionnaire be completed and returned. Please read through the entire questionnaire and respond to all questions that are appropriate to the level of your agency’s group drainage improvement activities, even if there is currently no activity. Where appropriate, please coordinate your responses with other agencies in your county that have responsibilities for group drainage improvement and maintenance. If you are not the best person to complete the questionnaire, please forward it to the appropriate person in your agency. We ask that the person completing the questionnaire write his or her name on the return envelope so that we know who to contact if we have any questions about your responses.

In order to ensure anonymity of responses, an identification number has been assigned to each questionnaire for mailing and tracking purposes. Most information will be summarized at the area or state level. Results may be reported at area, state or regional levels.

Please return the completed survey by December 15, 1997. If we receive the completed survey by December 15, we will mail you a coupon worth $25 towards the registration fee for any workshop sponsored by Dr. Brown, including the Overholt Drainage School. A summary will be mailed to you within 6 months of the completion of the study. We have enclosed a self-addressed, stamped envelope for your convenience in returning the questionnaire.

Either Bruce or Larry will be most happy to answer any questions you may have about this study. You can reach Bruce by phone at 614-292-1406, by fax at 614-292-9448 or by email at atherton.10@osu.edu. Thank you for your assistance with this study.

Very Truly Yours,

Bruce Atherton
Graduate Research Associate

Larry C. Brown, Associate Professor
Extension Agricultural Engineer
APPENDIX B

RESPONSES FROM THE 1997 GROUP DRAINAGE IMPROVEMENT SURVEY
Table B.1. Survey responses for questions 1, 7, 13, 14 and 19.

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* Table entries are the actual responses provided by the agencies.
1 Column headings are abbreviations of actual questions.
2 CP indicates County Petition project.
3 SB indicates Senate Bill 160 project.
* MA indicates Mutual Agreement project.
** DM indicates Ditch Maintenance.
*** "--" indicates no response.
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*Table entries are the actual responses provided by the agencies.

1 Questions 2A-E relate to CP projects for county engineer respondents, and to SB projects for SWCD respondents. Question 8A-E relates to MA projects for both agencies.

2 CP indicates County Petition project; SB indicates Senate Bill 160 project; MA indicates Mutual Agreement project.

4 Column headings are abbreviations of actual questions.
Table B.3. Survey responses for questions 3A, 4A, 5A, 9A, 10A and 11A.*

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*Table entries are the actual responses provided by the agencies.

1Questions 3, 4, and 5 relate to CP projects for county engineer respondents, and to SB projects for SWCD respondents. Question 9, 10, and 11 relates to MA projects for both agencies.

2CP indicates County Petition project; SB indicates Senate Bill 160 project; MA indicates Mutual Agreement project.

3Column headings are abbreviations of actual questions.
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* Table entries are the actual responses provided by the agencies.
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* CP indicates County Petition project; SB indicates Senate Bill 160 project; MA indicates Mutual Agreement project.
* Column headings are abbreviations of actual questions.
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*Table entries are the actual responses provided by the agencies.
†Questions 3, 4, and 5 relate to CP projects for county engineer respondents, and to SB projects for SWCD respondents. Question 9, 10, and 11 relates to MA projects for both agencies.
‡CP indicates County Petition project; SB indicates Senate Bill 160 project; MA indicates Mutual Agreement project.
§Column headings are abbreviations of actual questions.
Table B.6. Survey responses for questions 6A-6B and 12A-12B.

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Table entries are the actual responses provided by the agencies.

Questions 6A and 6B relate to CP projects for county engineer respondents, and to SB projects for SWCD respondents. Questions 12A and 12B relate to MA projects for both agencies.

CP indicates County Petition project; SB indicates Senate Bill 160 project; MA indicates M A project.

Column headings are abbreviations of actual questions.

"-" indicates no response.

"NC" indicates the item was not considered.

"DK" indicates a don't know response.
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<td>Legal Authority⁵</td>
<td>Most agricultural watersheds use SB-160 petitions to save cost of engineering expenses.</td>
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<td>Mutual agreement between developer and county.</td>
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<td>E23</td>
<td>Schul Estates, Sec. 7A</td>
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<td>Method customarily used at the time.</td>
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<td>E29</td>
<td>Prairie Ditch 84-1</td>
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<td>Property owners felt it would be the quickest and most binding on objecting property owners.</td>
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<td>B &amp; O Ditch #31</td>
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<td>SB160 and Mutual Agreement projects are not promoted locally.</td>
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<td>Ditch No. 2064 South Branch Bad Creek</td>
<td>CP</td>
<td>Some landowners protested cleaning.</td>
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<td>Silver Creek</td>
<td>CP</td>
<td>Landowner came in office and requested to begin petition procedure.</td>
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<td>Silver Creek Ditch No. 1021</td>
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<td>Landowner file petition.</td>
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<td>Collins Ditch Pet 911</td>
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<td>SCs worked with group.</td>
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<td>#127 Children's Home Ditch</td>
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<td>Most expeditions.</td>
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<td>Landowners could not agree to do the project together.</td>
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<td>Kyle Prairie Dr. No. 90-99</td>
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<td>This legal authority offers the least cost to property owners. It is also the preferred method by memo of understanding between the board of city commissioners, city engineer, and SWCD.</td>
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<td>Too many contentious owners for private agreements.</td>
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<tr>
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<td>Landowners choice.</td>
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<td>No other authority could be found to assist with what would otherwise have been a township problem.</td>
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<td>Preferred method of landowners in Sandusky county.</td>
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<td>Petitioned by landowner.</td>
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<td>Only method available at the time. There was no other legal agreement the property owner could use at that time &amp; the project involves [sic] work along a RR.</td>
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<td>Too large to get voluntary cooperation.</td>
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<td>Large number of landowners along with large number of acres drains.</td>
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<td>It started as Mutual agreement but went to 160 in order to collect from Sate Hwy and one landowner.</td>
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<td>County - Petitioner was told SB-160 method would be cheaper (Co. Eng.). Mutual - requires all landowners to be in agreement (Prosecutor's view).</td>
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<td>Landowners request.</td>
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<td>Landowners decided to do some of the work themselves and hired rest of work done according to SWCD plans then petitioned for maintenance.</td>
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<td>Quickest and most economical. Promotes cooperation between neighbors; easy to understand; less expensive; fewer legalities/lawsuits; protects district image as cooperative, not regulatory agency. The landowners all agreed that the improvement was necessary and they all paid their assessment up front.</td>
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<td>One objecting landowner. Memo of understanding between the county engineer and the co. commission and the SWCD.</td>
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<td>Could not get 100% agreement and landowners did not want to petition through the county commissioners. County Petition was backed up. Farmers could use SB160 to get done sooner. At that time, the majority of landowners were in agreement, on or two key landowners helped to push project through. Landowners were amicable, no dissention as to cost allocation. Saved time and expense compared to SB-160 process.</td>
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<td>Not all landowners agreed to project and SB160 is cheaper than the county petition. Because 90% of all group project are mutual agreements here in Wyandot County.</td>
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Table entries are the actual responses provided by the agencies.  
† Project names are local names used by the respondent.  
‡ CP indicates County Petition project; SB indicates Senate Bill 160 project; MA indicates MA project.  
§ Column headings are abbreviations of actual questions.  
* "--" indicates no response.

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* Table entries are the actual responses provided by the agencies.

† Column headings are abbreviations of actual questions.

‡ "--" indicates no response.

§ "DK" indicates a don't know response.
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<th>Agency ID</th>
<th>Assessment Method</th>
<th>Q-27 Benefit Factors¹</th>
<th>Q-28 Benefit Factors¹</th>
<th>Q-30 Estimate Benefits?¹</th>
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<td>E22</td>
<td>Auglaize County Adopted Method</td>
<td>(1) Watershed acres drained; (2) Remoteeness coeff.; (3) Runoff coeff.; (4) Use of ditch; (5) Direct assessments.</td>
<td>No</td>
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<td>E23</td>
<td>Butler County Method</td>
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<td>See Q-27</td>
<td>No</td>
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<td>E29</td>
<td>Drainage Benefit</td>
<td>See attached assessment procedure</td>
<td>Yes</td>
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<td>E31</td>
<td>Variation of the Preble County Method (See attached sheets)</td>
<td>See attached assessment procedure</td>
<td>Yes</td>
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<td>E35</td>
<td>Varied Assessment Method</td>
<td>Area drained length of project used the distance from the project and any special benefits.</td>
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<td>E38</td>
<td>100% acres Ring Method Target</td>
<td>See Engineer’s report.</td>
<td>No</td>
<td>--¹</td>
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<td>E39</td>
<td>--</td>
<td>Length of project proximity to project, amount of project landowner will use and we determine the area that will receive the most benefit or relief from the project.</td>
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<td>E47</td>
<td>Uniform</td>
<td>Ac Benefited, reach, land use was all the same for this project.</td>
<td>No</td>
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<tr>
<td>E49</td>
<td>Uniform</td>
<td>Equal Benefit at and above headwall - reestablished subsurface outlets</td>
<td>Yes</td>
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<td>E50</td>
<td>Zone method, run-off factor</td>
<td>Reduce flooding of subdivision, increase agricultural drainage</td>
<td>Yes</td>
<td></td>
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<tr>
<td>E51</td>
<td>County ditch petition laws</td>
<td>--¹</td>
<td>No</td>
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</tr>
<tr>
<td>E53</td>
<td>Montgomery county drainage assessment procedure</td>
<td>Six factors: benefited acres, reach factor, volume runoff factor, location/elevation factor, potential increase in productivity factor, flood protection/property enhancement factor</td>
<td>No</td>
<td></td>
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<tr>
<td>E56</td>
<td>Paulding County Assessment Procedure</td>
<td>Acreage drained, land use, location on ditch, proximity to ditch, public safety, improvement of road shoulder, improvement of lot (enclosure of ditch)</td>
<td>Yes</td>
<td></td>
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<tr>
<td>E59</td>
<td>Acres benefited by percent used plus land use factor</td>
<td>Benefited acres, percent of ditch used, land use.</td>
<td>No</td>
<td></td>
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<tr>
<td>E60</td>
<td>Prorated by property size to benefiting property owners.</td>
<td>By determining the amount of local flooding impacting private property.</td>
<td>Yes</td>
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<td>E61</td>
<td>Sandusky Co. Assessment Procedure</td>
<td>Number of acres benefited, percent of project used, drainage classifications, overland distance to channel</td>
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<td>E63</td>
<td>Uniform Assessment</td>
<td>Acres benefited/realm/land use/elevation/soils/need/correction</td>
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<td>E65</td>
<td>Van Wert County Method</td>
<td>We use number of acres draining, location on ditch and distance from improvement.</td>
<td>No</td>
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<td>E67</td>
<td>Appraisal of Benefits</td>
<td>Cost to Benefit</td>
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<tr>
<td>S20</td>
<td>Varied-used by County Engineer</td>
<td>Location, land use</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>S22</td>
<td>County Engineer broke down assessments</td>
<td>Improved agricultural drainage, control and reduce soil erosion, improve water quality, reduce flooding of cropland, improve the economic base</td>
<td>Yes</td>
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</tr>
<tr>
<td>S29</td>
<td>Variable rate, see attached papers</td>
<td>See attached papers</td>
<td>Yes</td>
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<tr>
<td>S31</td>
<td>Preble?</td>
<td>Land use, soils hydrologic group, topographic elevation above outlet, acreage.</td>
<td>Yes</td>
<td></td>
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<tr>
<td>S33</td>
<td>Acres divided into cost</td>
<td>Landowners all agreed to an equal per acre assessment</td>
<td>No</td>
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<tr>
<td>S37</td>
<td>Estimated Maintenance cost/Total acres benefited</td>
<td>Group Determined their own benefits</td>
<td>No</td>
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<tr>
<td>S38</td>
<td>Equal Acre</td>
<td>Surface and subsurface drainage - equal acre for benefits.</td>
<td>No</td>
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Continued
Table B. 9. (continued)

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<td>S42</td>
<td>Acre-equal, convert to units: 1 sq acre = 1 unit; 1 house acre = 4 units; 1 rd acre = 2 units.</td>
<td>Acres and land use.</td>
<td>No</td>
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<tr>
<td>S53</td>
<td>Benefits per. 6131.01</td>
<td>None used</td>
<td>No</td>
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<tr>
<td>S55</td>
<td>Varied Assessment (100% acre method)</td>
<td>OSU Fact Sheets - Drainage effects on corn and soybean yields, figured increase over 20 yrs + interest on money invested. If cost did not exceed benefit, then OK.</td>
<td>Yes</td>
</tr>
<tr>
<td>S56</td>
<td>Variable based on % of ditch used.</td>
<td>Adopted Montgomery County Ditch Procedure (Kenny Adams) Benefited acres, Reach factor volume of runoff, location/elevation, potential increase in productivity, flood protection/property enhancement.</td>
<td>Yes</td>
</tr>
<tr>
<td>S57</td>
<td>Adopted Montgomery County Ditch Procedure (Kenny Adams)</td>
<td>Variable rate</td>
<td>Acres, reach (location), runoff, relative elevation, potential increase in productivity, flood protection/property enhancement.</td>
</tr>
<tr>
<td>S58</td>
<td>Variable rate</td>
<td>Cooperative Group</td>
<td>Maintenance base are the same as construction cost.</td>
</tr>
<tr>
<td>S62</td>
<td>Cooperative Group</td>
<td>--</td>
<td>Enclosed in appraisal Benefits Roll</td>
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<td>Variable rate</td>
<td>Acre Equal Method - Total cost / Total acres = cost per acre</td>
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* Table entries are the actual responses provided by the agencies.
† Column headings are abbreviations of actual questions.
‡ "—" indicates no response.
Table B.10. Survey responses for question 29A-29K.

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Improving road shoulder

Obstruction by R.R.

Landowner's age

Continued
Table B. 10. (continued)

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* Table entries are the actual responses provided by the agencies.
† Column headings are abbreviations of actual questions.
‡ "--" indicates no response.
Table B.11a. Survey data for question 31A-31D. *

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<th>Agency ID</th>
<th>Ben Rp Improve Crop</th>
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<th>Ben Rp Red Fld Ag Land</th>
<th>Ben Gw Red Fld Ag Land</th>
<th>Ben Rp Red Fld Residential Land</th>
<th>Ben Gw Red Fld Residential Land</th>
<th>Ben Rp Red Fld Ag Bldg.</th>
<th>Ben Gw Red Fld Ag Bldg.</th>
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* Table entries are the actual responses provided by the agencies.

† Column headings are abbreviations of actual questions.

‡ “DK” indicates a don’t know response.

§ “..” indicates a non response.

8 “NC” indicates item was not considered.
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* Table entries are the actual responses provided by the agencies.

* Column headings are abbreviations of actual questions.

* "DK" indicates a don't know response.

* "--" indicates a non response.

* "NC'' indicates item was not considered.
### Table B.11c. Survey responses for question 311-31K.

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</table>

*Table entries are the actual responses provided by the agencies.

1 Column headings are abbreviations of actual questions.

DK "DK" indicates a don't know response.

NC "NC" indicates item was not considered.

-- "--" indicates a non response.
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¹ Table entries are the actual responses provided by the agencies.
² Column entries are abbreviations of actual questions.
³ "-" indicates a non response.
⁴ "DK" indicates a don’t know response.
⁵ "NC" indicates item was not considered.
⁶ A box indicates an estimated value.
Table B.12b. Survey responses for question 32A-32P. *

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*Table entries are the actual responses provided by the agencies.

1 Column headings are abbreviations of actual questions.

2 "--" indicates no response.

3 "DK" indicates a don't know response.

4 "NC" indicates item was not considered.
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*Table entries are the actual responses provided by the agencies.
† Column headings are abbreviations of actual questions.
*: "--" indicates a non response.
§ "NC" indicates item was not considered.
* "DK" indicates a don't know response.
** A box indicates an estimated value
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*Table entries are the actual responses provided by the agencies.

+ Column headings are abbreviations of actual questions.
+ "-" indicates no response.
+ "$NC" indicates item was not considered.
+ "DK" indicates a don't know response.
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*Table entries are the actual responses provided by the agencies.
[^1] Column headings are abbreviations of actual questions.
[^3] "DK" indicates a don't know response.
Table B.12f. Survey responses for question 32A:32P.

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*Table entries are the actual responses provided by the agencies.

\* Column headings are abbreviations of actual questions.
\* "--" indicates no response.
\* "DK" indicates a don't know response.
\* A box indicates an estimated value.
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</table>

$^1$ Table entries are the actual responses provided by the agencies.

$^2$ Column headings are abbreviations of actual questions.

$^3$ "--" indicates no response.

$^4$ "DK" indicates a don't know response.

---

352
Table B.12h. Survey responses for question 32A-32P. *

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*Table entries are the actual responses provided by the agencies.

†Column headings are abbreviations of actual questions.

‡"-" indicates no response.

§"NC" indicates item was not considered.

¶"DK" indicates a don't know response.

**A box indicates an estimated value.
### Table R.12i. Survey responses for question 32A-32p.

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†Table entries are the actual responses provided by the agencies.

‡Column headings are abbreviations of actual questions.

§"-" indicates no response.

$"DK" indicates a don't know response.

"A box indicates an estimated value.
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*Table entries are the actual responses provided by the agencies.

* Column headings are abbreviations of actual questions.

* "--" indicates no response.

* "DK" indicates a don't know response.
Table B.12k. Survey responses for question 32A-32P.  

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Table entries are the actual responses provided by the agencies.

† Column headings are abbreviations of actual questions.

‡ "--" indicates no response.

§ "DK" indicates a don't know response.

* "NC" indicates item was not considered.
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*Table entries are the actual responses provided by the agencies.
† Column headings are abbreviations of actual questions.
‡ "--" indicates no response.
§ "DK" indicates a don't know response.
& A box indicates an estimated value.
Table B.12m. Survey responses for question 32A-32P. *

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*Table entries are the actual responses provided by the agencies.  
\(^t\) Column headings are abbreviations of actual questions.  
\(^s\) "-" indicates no response.  
\(^s\) "DK" indicates a don't know response.  
* "NC" indicates item was not considered.
Table B.12n. Survey responses for question 32A-32P. *

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Table entries are the actual responses provided by the agencies.
† Column entries are abbreviations of actual questions.
‡ "-" indicates no response.
§ "DK" indicates a don't know response.
$ "NC" indicates item was not considered.
Table B.12. Survey responses for question 32A-32P.*

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</table>

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‡ "- -" indicates no response.

§ "NC" indicates item was not considered.

* "DK" indicates a don't know response.
<table>
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<th>Project ID</th>
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*Table entries are the actual responses provided by the agencies.
† Column headings are abbreviations of actual questions.
‡ "-" indicates no response.
§ "NC" indicates item was not considered.
#
"DK" indicates a don't know response.
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*Table entries are the actual responses provided by the agencies.

† Column headings are abbreviations of actual questions.

$DK$ indicates a don't know response.

$NC$ indicates item was not considered.

$##$ indicates no response.
Table B.13b. Survey responses for question 33A-33F.

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* Table entries are the actual responses provided by the agencies.
† Column headings are abbreviations of actual questions.
‡ "DK" indicates a don't know response.
§ "- - -" indicates no response.
&& "NC" indicates item was not considered.
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<td>$663.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
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<td></td>
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<tr>
<td>S62D1</td>
<td>1995</td>
<td>$2,559.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
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<tr>
<td>S62D1</td>
<td>1996</td>
<td>$572.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>S68D1</td>
<td>1990</td>
<td>$388.00</td>
<td>$35.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td></td>
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<td>S68D1</td>
<td>1991</td>
<td>$429.06</td>
<td>$35.00</td>
<td>$0.00</td>
<td>$0.00</td>
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<td></td>
<td></td>
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<tr>
<td>S68D1</td>
<td>1992</td>
<td>$484.00</td>
<td>$35.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S68D1</td>
<td>1993</td>
<td>$0.00</td>
<td>$35.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>S68D1</td>
<td>1994</td>
<td>$1,016.00</td>
<td>$35.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>S68D1</td>
<td>1995</td>
<td>$658.00</td>
<td>$35.00</td>
<td>$0.00</td>
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<td>$0.00</td>
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<tr>
<td>S68D1</td>
<td>1996</td>
<td>$513.00</td>
<td>$35.00</td>
<td>$0.00</td>
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<td>$0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table entries are the actual responses provided by the agencies.

^1 Column entries are abbreviations of actual questions.

MF^2 indicates "no response.

^4 "DK" indicates a "don't know" response.

^5 "NC" indicates item was not considered.

** A box indicates an estimated value.
### Table B.15. Survey responses for question 37.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Capacity of item</th>
<th>Life Expectancy</th>
<th>Total Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>E49D1</td>
<td>Debris removal</td>
<td>8</td>
<td>$700.00</td>
</tr>
<tr>
<td>S20D1</td>
<td>Tile Outlet Pipes</td>
<td>20</td>
<td>$1,549.50</td>
</tr>
<tr>
<td>S20D1</td>
<td>Sprayed</td>
<td>5</td>
<td>$1,137.24</td>
</tr>
<tr>
<td>S20D1</td>
<td>Tile Repair</td>
<td>10</td>
<td>$1,048.55</td>
</tr>
<tr>
<td>S29D1</td>
<td>Dip-out</td>
<td>10</td>
<td>$1,440.56</td>
</tr>
<tr>
<td>S62D1</td>
<td>-</td>
<td>8</td>
<td>$1,800.00</td>
</tr>
</tbody>
</table>

*Table entries are the actual responses provided by the agencies.

†Column headings are abbreviations of actual questions.

‡"-" indicates item was not considered.

### Table B.16. Survey responses for question 38.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Q-38</th>
</tr>
</thead>
<tbody>
<tr>
<td>E22D1</td>
<td>Heavy rains have caused additional work on erosion structures.</td>
</tr>
<tr>
<td>E22D1</td>
<td>Heavy rains have caused additional work on erosion structures.</td>
</tr>
<tr>
<td>E22D1</td>
<td>Heavy rains have caused additional work on erosion structures.</td>
</tr>
<tr>
<td>E22D1</td>
<td>Heavy rains have caused additional work on erosion structures.</td>
</tr>
<tr>
<td>E47D1</td>
<td>The grass strip construction in 1990 was flowed over in 1991.</td>
</tr>
<tr>
<td>E49D1</td>
<td>due to ODOT replacing culvert, damage by construction</td>
</tr>
<tr>
<td>E59D1</td>
<td>Most of Money used for brush/cattail spray</td>
</tr>
<tr>
<td>E60D1</td>
<td>Required separation of a storm drain from a rural septic drain.</td>
</tr>
<tr>
<td>E67D1</td>
<td>Maintenance returned to township.</td>
</tr>
<tr>
<td>E67D1</td>
<td>We think the farmers are helping us to maintainance [sic] brush since</td>
</tr>
<tr>
<td>E67D1</td>
<td>we done [sic] very little of it &amp; the ditch is pretty free of it too</td>
</tr>
<tr>
<td>S29D1</td>
<td>In 1996 we had to dip-out upper end because of house lot septic outlets</td>
</tr>
<tr>
<td>S42D1</td>
<td>Landowners are doing all maintenance on this project.</td>
</tr>
<tr>
<td>S42D1</td>
<td>Only costs charged to group are ones for annual inspection</td>
</tr>
<tr>
<td>S42D1</td>
<td>and meeting with the advisory committee.</td>
</tr>
<tr>
<td>S42D1</td>
<td>Landowners do maintenance, estimated landowner cost</td>
</tr>
<tr>
<td>S42D1</td>
<td>Landowners do maintenance, estimated landowner cost</td>
</tr>
<tr>
<td>S42D1</td>
<td>Landowners do maintenance, estimated landowner cost</td>
</tr>
<tr>
<td>S42D1</td>
<td>Landowners do maintenance, estimated landowner cost</td>
</tr>
<tr>
<td>S55D1</td>
<td>One sided construction limits access for mowing and spraying along</td>
</tr>
<tr>
<td></td>
<td>wooded areas.</td>
</tr>
</tbody>
</table>

*Table entries are the actual responses provided by the agencies.

†Column headings are abbreviations of actual questions.
Table B.17. Survey responses for questions 39, 40, 41, 42, 43, 44, 45 and 46.

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Q-39 Assist Groups?</th>
<th>Q-40 Have CP Method?</th>
<th>Q-41 Name of method:</th>
<th>Q-42 Year Started</th>
<th>Q-43 CP No. 96</th>
<th>Q-44 CP Completes</th>
<th>Q-44 CP Appeals</th>
<th>Q-44 CP Supreme</th>
<th>Q-45 CP Outcome</th>
<th>Q-46 CP Casename</th>
</tr>
</thead>
<tbody>
<tr>
<td>E20</td>
<td>Yes</td>
<td>Yes</td>
<td>No official name.</td>
<td>1970</td>
<td>90</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E21</td>
<td>No</td>
<td>No</td>
<td>--</td>
<td>1974</td>
<td>137</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E22</td>
<td>Yes</td>
<td>Yes</td>
<td>Augusta County Adopted Method</td>
<td>1960</td>
<td>14</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E23</td>
<td>--</td>
<td>No</td>
<td>--</td>
<td>1986</td>
<td>3</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E24</td>
<td>Yes</td>
<td>Yes</td>
<td>Based on acreage benefited assessment procedure under the Ohio Drainage Law</td>
<td>1984</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E25</td>
<td>No</td>
<td>Yes</td>
<td>Assessment of the County Ditch Determination of County Ditch assessments Same as SWCD</td>
<td>1996</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E26</td>
<td>Yes</td>
<td>Yes</td>
<td>Montgomery County Method</td>
<td>1998</td>
<td>0</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Procedure approved</td>
<td>T.C. Case No. 94-263, H. Nolan Meyer, Plaintiff</td>
</tr>
<tr>
<td>E27</td>
<td>Yes</td>
<td>Yes</td>
<td>Varied, reach or uniform depending on the project Target</td>
<td>1976</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E29</td>
<td>Yes</td>
<td>Yes</td>
<td>Same as SWCD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>---</td>
</tr>
<tr>
<td>E30</td>
<td>Yes</td>
<td>Yes</td>
<td>Kyle Moran ODNR</td>
<td>1996</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E33</td>
<td>Yes</td>
<td>Yes</td>
<td>Montgomery County Method</td>
<td>1998</td>
<td>0</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Procedure approved</td>
<td>T.C. Case No. 94-263, H. Nolan Meyer, Plaintiff</td>
</tr>
<tr>
<td>E35</td>
<td>Yes</td>
<td>Yes</td>
<td>Varied, reach or uniform depending on the project Target</td>
<td>1976</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E39</td>
<td>Yes</td>
<td>Yes</td>
<td>Flat Rate</td>
<td>1965</td>
<td>276</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>method was ruled to be a valid method</td>
<td>N/A without extensive attic research</td>
</tr>
<tr>
<td>E40</td>
<td>No</td>
<td>Yes</td>
<td>Flat Rate</td>
<td>1970</td>
<td>10</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
<tr>
<td>E41</td>
<td>No</td>
<td>No</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>---</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Q-39 Assist Groups?</th>
<th>Q-40 Have CP Method?</th>
<th>Q-41 Name of method</th>
<th>Q-42 Year Started</th>
<th>Q-43 CP No. 96</th>
<th>Q-44 CP Complexes</th>
<th>Q-44 CP Appeals</th>
<th>Q-44 CP Supreme</th>
<th>Q-45 CP Outcome</th>
<th>Q-46 CP Casename</th>
</tr>
</thead>
<tbody>
<tr>
<td>E47</td>
<td>Yes</td>
<td>Yes</td>
<td>No name, consider area, use, and reach in the past we used equal charge/acre in watershed</td>
<td>DK</td>
<td>DK</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>E48</td>
<td>No</td>
<td>No</td>
<td>Soil types subsurface outlet benefits, proximity to improvement</td>
<td>1975</td>
<td>7</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>E49</td>
<td>Yes</td>
<td>Yes</td>
<td>Zone method, transportation method, Runoff factor</td>
<td>1969</td>
<td>118</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>E50</td>
<td>No</td>
<td>Yes</td>
<td>Zone method, transportation method, Runoff factor</td>
<td>DK</td>
<td>1</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Judge on his own reduced assessments of the plaintiffs</td>
</tr>
<tr>
<td>E51</td>
<td>No</td>
<td>Yes</td>
<td>Montgomery County Ditch Petition</td>
<td>1990</td>
<td>4</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>E52</td>
<td>Yes</td>
<td>Yes</td>
<td>Montgomery County drainage Assessment Procedure</td>
<td>1983</td>
<td>10</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>The Second district court of appeals upheld the decision of the Miami county court of common pleas regarding the legality of the assessment schedule of the Motler joint group project.</td>
</tr>
<tr>
<td>E56</td>
<td>Yes</td>
<td>Yes</td>
<td>Paulding county assessment procedure</td>
<td>1985</td>
<td>55</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>C1-91-047 William Heller Single Co. Ditch No. 240</td>
</tr>
<tr>
<td>E58</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>1971</td>
<td>--</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Upheld</td>
<td>--</td>
</tr>
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</table>

Continued
<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Assisted Groups?</th>
<th>Have CP Method?</th>
<th>CP Outcome</th>
<th>CP Casename</th>
</tr>
</thead>
<tbody>
<tr>
<td>E59</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>E60</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>E61</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Sandusky County Procedure was upheld.</td>
</tr>
<tr>
<td>E62</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>E63</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>E65</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>Not known, sometime in 1930's.</td>
</tr>
<tr>
<td>E67</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>Case # 81 CIV 422</td>
</tr>
<tr>
<td>E69</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

*Table entries are the actual responses provided by the agencies.
' Column headings are abbreviations of actual questions.
".." indicates no response.
"DK" indicates don't know response.
'A box indicates an estimated value.
Table B.18. Survey responses for questions 39, 40, 41, 42, 43, 44, 45 and 46.

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Q-39</th>
<th>Q-40</th>
<th>Q-41</th>
<th>Q-42</th>
<th>Q-43</th>
<th>Q-44</th>
<th>Q-45</th>
<th>Q-46</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assist Groups</td>
<td>Assistant</td>
<td>SB</td>
<td>Year Started</td>
<td>SB</td>
<td>SB</td>
<td>SB</td>
<td>SB</td>
</tr>
<tr>
<td>S20</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Co. Engineers method, using location and land use</td>
<td>1973</td>
<td>--</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S21</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S24</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
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</tr>
<tr>
<td>S25</td>
<td>Yes</td>
<td>No</td>
<td>County Engineer</td>
<td>--</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S26</td>
<td>No</td>
<td>Yes</td>
<td>Watershed Acreage</td>
<td>1972</td>
<td>69</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S27</td>
<td>No</td>
<td>Yes</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S29</td>
<td>Yes</td>
<td>Yes</td>
<td>Variable rate</td>
<td>1966</td>
<td>101</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>S30</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<td>--</td>
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<tr>
<td>S31</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
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<td>--</td>
<td>--</td>
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</tr>
<tr>
<td>S32</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S33</td>
<td>Yes</td>
<td>Yes</td>
<td>Montgomery County's</td>
<td>1998</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S35</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S37</td>
<td>Yes</td>
<td>Yes</td>
<td>Benefit Cost Procedure and Montgomery County Assessment</td>
<td>1995</td>
<td>1</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S38</td>
<td>No</td>
<td>Yes</td>
<td>Uniform Assessments - Equal Acre</td>
<td>1986</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S39</td>
<td>Yes</td>
<td>Yes</td>
<td>Varied. Each acre in the watershed charged diff %</td>
<td>1982</td>
<td>3</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S40</td>
<td>Yes</td>
<td>Yes</td>
<td>Benefited acres method</td>
<td>1976</td>
<td>15</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S41</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S42</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S43</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S46</td>
<td>Yes</td>
<td>Yes</td>
<td>Preble county SWCD method</td>
<td>1989</td>
<td>3</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
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</table>

Continued
<table>
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<tr>
<th>Agency ID</th>
<th>Q-39</th>
<th>Q-40</th>
<th>Q-41</th>
<th>Q-42</th>
<th>Q-43</th>
<th>Q-44</th>
<th>Q-44</th>
<th>Q-44</th>
<th>Q-45</th>
<th>Q-46</th>
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</thead>
<tbody>
<tr>
<td>S48</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S51</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S52</td>
<td>Yes</td>
<td>Yes</td>
<td>Montgomery county assessment procedure</td>
<td>1985</td>
<td>6</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Upheld</td>
<td>2nd court of appeals, court case 95-CA-63</td>
</tr>
<tr>
<td>S53</td>
<td>Yes</td>
<td>Yes</td>
<td>Montgomery Co. Drainage Assessment Procedure</td>
<td>1983</td>
<td>10</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Case No. 95-CA-63</td>
<td></td>
</tr>
<tr>
<td>S55</td>
<td>Yes</td>
<td>Yes</td>
<td>Varied Assessment (100% Acre method) Based on location on ditch -&gt; % of benefits [same as county engineer] Montgomery County method?</td>
<td>1989</td>
<td>3</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>S56</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S57</td>
<td>Yes</td>
<td>Yes</td>
<td>Montgomery County method?</td>
<td>1992</td>
<td>3</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>S58</td>
<td>Yes</td>
<td>Yes</td>
<td>Variable Rate Percentage Method</td>
<td>1990</td>
<td>4</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>S59</td>
<td>Yes</td>
<td>Yes</td>
<td>Method/Reverse Percentage (see back of this page)</td>
<td>1957</td>
<td>53</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>S62</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S66</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S67</td>
<td>Yes</td>
<td>Yes</td>
<td>Variable rate</td>
<td>1992</td>
<td>4</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>S68</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S69</td>
<td>Yes</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

* Table entries are the actual responses provided by the agencies.  
  † Column headings are abbreviations of actual questions.  
  ‡ "--" indicates no response.  
  § A box indicates an estimated value.
Table B.19. Survey responses for questions 47, 48, 49 and 50.

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Q-47</th>
<th>Q-48</th>
<th>Q-49</th>
<th>Q-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>E22</td>
<td>Yes</td>
<td>Auglaize County Adopted Method (use same method as petitions and SB-160)</td>
<td>Same method as</td>
<td>1980</td>
</tr>
<tr>
<td>E23</td>
<td>Yes</td>
<td>Q-27</td>
<td>1988</td>
<td>190</td>
</tr>
<tr>
<td>E27</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>E30</td>
<td>Yes</td>
<td>Kyle Moran/ODNR</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>E31</td>
<td>Yes</td>
<td>Strictly limited to Subdivisions (Storm system cost/Total lots = Maint. Base)</td>
<td>1990</td>
<td>13</td>
</tr>
<tr>
<td>E49</td>
<td>Yes</td>
<td>Same</td>
<td>1970</td>
<td>7</td>
</tr>
<tr>
<td>E53</td>
<td>No</td>
<td>--</td>
<td>--</td>
<td>DK</td>
</tr>
<tr>
<td>E60</td>
<td>Yes</td>
<td>Prorated by land area.</td>
<td>1900</td>
<td>DK</td>
</tr>
<tr>
<td>E63</td>
<td>Yes</td>
<td>Uniform Assessment Procedure</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>E69</td>
<td>Yes</td>
<td>Lot Acreage</td>
<td>1992</td>
<td>4</td>
</tr>
<tr>
<td>S20</td>
<td>Yes</td>
<td>(Same)</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>S25</td>
<td>Yes</td>
<td>Total Acreage method and Montgomery County Watershed Acreage</td>
<td>1989</td>
<td>0</td>
</tr>
<tr>
<td>S26</td>
<td>Yes</td>
<td>Variable rate or whatever the group would like sometime flat rate per acre</td>
<td>1964*</td>
<td>35</td>
</tr>
<tr>
<td>S29</td>
<td>No</td>
<td>Cost allocation is left up to the group</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S32</td>
<td>Yes</td>
<td>Developed our own formula based on soils, location, acres, % use, etc. developed on Lotus</td>
<td>1987</td>
<td>0</td>
</tr>
<tr>
<td>S33</td>
<td>Yes</td>
<td>Landowner Agreement cost per acre per reach</td>
<td>1993</td>
<td>3</td>
</tr>
<tr>
<td>S35</td>
<td>Yes</td>
<td>Landowner only pays the acres drained into project</td>
<td>1994</td>
<td>2</td>
</tr>
<tr>
<td>S37</td>
<td>Yes</td>
<td>We will use either total cost/total acre or Miami or Montgomery procedure. Which ever group wants.</td>
<td>1945</td>
<td>200*</td>
</tr>
<tr>
<td>S40</td>
<td>Yes</td>
<td>Benefited acres method.</td>
<td>1976</td>
<td>175*</td>
</tr>
<tr>
<td>S41</td>
<td>Yes</td>
<td>Break down cost by watershed area for each landowner</td>
<td>1978</td>
<td>3</td>
</tr>
<tr>
<td>S42</td>
<td>Yes</td>
<td>Acre-equal or choice of landowners</td>
<td>1970</td>
<td>60</td>
</tr>
<tr>
<td>S46</td>
<td>Yes</td>
<td>Same as SB-160</td>
<td>1990</td>
<td>5</td>
</tr>
<tr>
<td>S51</td>
<td>No</td>
<td>We let the group decide how to split cost. 95% of the time they use flat rate per acre.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S52</td>
<td>Yes</td>
<td>Montgomery county drainage assessment procedure</td>
<td>1994</td>
<td>4</td>
</tr>
<tr>
<td>S53</td>
<td>Yes</td>
<td>same as above</td>
<td>1983</td>
<td>2</td>
</tr>
<tr>
<td>S55</td>
<td>Yes</td>
<td>Varied Assessment (100% acre method)</td>
<td>1965</td>
<td>32</td>
</tr>
<tr>
<td>S56</td>
<td>Yes</td>
<td>Same as above (same as county engineer's method).</td>
<td>1997</td>
<td>1</td>
</tr>
<tr>
<td>S57</td>
<td>Yes</td>
<td>See enclosed - group makes final decision.</td>
<td>1984</td>
<td>2</td>
</tr>
<tr>
<td>S58</td>
<td>Yes</td>
<td>Variable rate</td>
<td>1990</td>
<td>2*</td>
</tr>
<tr>
<td>S59</td>
<td>Yes</td>
<td>Percentage Method/Reverse percentage (see back of this page)</td>
<td>1957</td>
<td>DK</td>
</tr>
<tr>
<td>S62</td>
<td>Yes</td>
<td>--</td>
<td>1966</td>
<td>112</td>
</tr>
<tr>
<td>S67</td>
<td>Yes</td>
<td>Variable rate.</td>
<td>1994</td>
<td>1</td>
</tr>
<tr>
<td>S68</td>
<td>Yes</td>
<td>Acre equal method (see page 5 of 10)</td>
<td>1959</td>
<td>55</td>
</tr>
<tr>
<td>S69</td>
<td>Yes</td>
<td>Log jam removal: 75% county, 25 % landowner</td>
<td>1992</td>
<td>1</td>
</tr>
</tbody>
</table>

Table entries are the actual responses provided by the agencies.

*Column headings are abbreviations of actual questions.

**--** indicates no response.

"DK" indicates a don't know response.
Table B.20. Survey responses for question 51. *

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Q-51 Changes Made to Methods*</th>
</tr>
</thead>
<tbody>
<tr>
<td>E22</td>
<td>All projects assessed all vary according to the characteristics of the project, but all use the same basis used (see question Q-28)</td>
</tr>
<tr>
<td>E29</td>
<td>On a small urban type project was done successfully on a per unit basis on approximately equal sized lots.</td>
</tr>
<tr>
<td>E30</td>
<td>We do not consider runoff.</td>
</tr>
<tr>
<td>E45</td>
<td>Generally we assess at flat rate per acre, varies with each individual ditch.</td>
</tr>
<tr>
<td>E50</td>
<td>Each project is unique and although, in general, methods of assessment are tailored to each project.</td>
</tr>
<tr>
<td>E53</td>
<td>None so far however we are currently reviewing the method and comparing it with other counties. This survey and subsequent report is very timely and important to Montgomery County.</td>
</tr>
<tr>
<td>E56</td>
<td>Classification of land according to use (more categories) Direct assessment for tile and pipe repair or replacement (1998 projects)</td>
</tr>
<tr>
<td>E60</td>
<td>We are leaning toward the Rational Determination method of determining assessments, having used the prorate by area method in the past.</td>
</tr>
<tr>
<td>E63</td>
<td>Established a 2 ac. minimum building sit for use factor, Whether Agricultural or Residential.</td>
</tr>
<tr>
<td>E65</td>
<td>We charge 50% of cost of brushing to the parcel of land it was on.</td>
</tr>
<tr>
<td>E69</td>
<td>We don't require a mutual agreement from a developer for a subdivision if the estimated cost of improvements outside the right of way will be less than $5,000 and the average lot assessment will be less than $5 per year.</td>
</tr>
<tr>
<td>S21</td>
<td>This district has worked on two group ditches and 2 SB 160's in the early to mid 80's. Both SB 160 assessment calc. were performed by Co. Engineer. Neither project was constructed.</td>
</tr>
<tr>
<td>S31</td>
<td>Added factors: distance from outlet, need for improvement based on soil types, % correction of problem. Using combination of benefit units and acreage to divide costs.</td>
</tr>
<tr>
<td>S33</td>
<td>Use an agent for the group to represent landowners more. Make that agent more active in the project.</td>
</tr>
<tr>
<td>S37</td>
<td>Have added Miami County-Montgomery county procedures</td>
</tr>
<tr>
<td>S38</td>
<td>Assessment method determined on case by case basis. Long narrow watersheds usually pay based on % of stream used. Small projects usually go equal acre basis. Group votes on which method is used.</td>
</tr>
<tr>
<td>S39</td>
<td>Most mutual projects are done with equal assessment. Since '85 we tried 1 SB project w/equal assessment and switched it to varied. All SB 160 projects are varied now.</td>
</tr>
<tr>
<td>S40</td>
<td>The method has not been changed although we have purchased a computer program that runs the calculations for us.</td>
</tr>
<tr>
<td>S41</td>
<td>Don't do enough projects to make a good assessment.</td>
</tr>
<tr>
<td>S52</td>
<td>None. The method now used was adopted in 1985.</td>
</tr>
<tr>
<td>S57</td>
<td>Drainage assessment used previously was cost per acres benefited. Several methods can be used now, present current assessment schedule, then let the group decide with SWCD input.</td>
</tr>
<tr>
<td>S58</td>
<td>Have set minimum assessments for small residential lots.</td>
</tr>
</tbody>
</table>

*Table entries are the actual responses provided by the agencies. Column headings are abbreviations of actual questions.
<table>
<thead>
<tr>
<th>ID</th>
<th>Method Improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>E20</td>
<td>Eliminate the 401 Certification (OEPA) and 404 Permit (Army Corps of Engineers)</td>
</tr>
<tr>
<td>E22</td>
<td>It would be nice if all 88 counties could agree to a standard assessment procedure.</td>
</tr>
<tr>
<td>E39</td>
<td>Eliminate the need for a 401 EPA and 404 Army Corps of Engineers permits for drainage projects</td>
</tr>
<tr>
<td>E49</td>
<td>Address Easement Rights for maintenance - in particular when ag land is sold for lots i.e. temporary</td>
</tr>
<tr>
<td>E51</td>
<td>Easement for spoil spreading is not adequate</td>
</tr>
<tr>
<td>E53</td>
<td>Make all counties use the same method</td>
</tr>
<tr>
<td>E55</td>
<td>Improve language in ORC 1515 regarding temporary and permanent easements; improve ORC 6131</td>
</tr>
<tr>
<td>E59</td>
<td>Make review and permit procedure by other govt agencies easier. Less paper work/more timely response.</td>
</tr>
<tr>
<td>E60</td>
<td>Simplify the process and give the Board of county Commissioners more authority in all ditch matters.</td>
</tr>
<tr>
<td>E63</td>
<td>Cost/Benefit ratio, develop a more defined method to justify benefit over cost for these projects.</td>
</tr>
<tr>
<td>E65</td>
<td>Have interest from ditch maintenance fund put back into ditch maintenance fund, not general fund. Also streamline permit process through Army Corps of Engineers and Ohio EPA.</td>
</tr>
<tr>
<td>E69</td>
<td>(1) Publication of a guidebook of &quot;accepted&quot; assessment methods; (2) allow commissioners to levy &amp; collect assessments based on estimated project costs, and allow them to place any leftover contingency amounts into maintenance account (ORC 6131.43); (3) indicate if outside funding (e.g., Issue 2) monies can be subtracted from &quot;cost&quot; for cost/benefit calc.</td>
</tr>
<tr>
<td>S21</td>
<td>Can't answer. Haven't seen a petition ditch go from petition to construction maintenance. All have died in the process</td>
</tr>
<tr>
<td>S25</td>
<td>Since Montgomery County method has been through the courts. This method should be adopted state wide to eliminate confusion.</td>
</tr>
<tr>
<td>S30</td>
<td>State approved guidelines for cost allocation that could be provided to mutual groups would be very beneficial.</td>
</tr>
<tr>
<td>S31</td>
<td>Change 6131 to accept 1515 projects onto county maintenance.</td>
</tr>
<tr>
<td>S32</td>
<td>prevail wage laws for 6131</td>
</tr>
<tr>
<td>S35</td>
<td>Our board said we would assist with project if group installed &quot;min&quot; 10' filter strip both sides of open ditch.</td>
</tr>
<tr>
<td>S37</td>
<td>Adapting the 160 process to urban and storm water controls. Need to improve method for determining benefits of drainage improvement values for residential acreage's.</td>
</tr>
<tr>
<td>S40</td>
<td>Assessment process is too complicated, but I don't have a better answer.</td>
</tr>
<tr>
<td>S41</td>
<td>Don't do enough projects to do a good assessment.</td>
</tr>
<tr>
<td>S42</td>
<td>ORC 1515 should be maintained according to ORC 6137. Cost share $ for erosion control to replace lost ACP monies.</td>
</tr>
<tr>
<td>S46</td>
<td>There should be a consistent method of assessment across the state. This would make it easier to justify assessment methods to landowners in more than one county</td>
</tr>
<tr>
<td>S52</td>
<td>A method to collect assessments from benefiting landowners within an established drainage area of a previous county petitioned drainage project that was completed before 1958. The funds collected would be used for future maintenance or replacement.</td>
</tr>
<tr>
<td>S53</td>
<td>Provide by law Temp. Const. easements and permanent maintenance language for SWCD with out using the 6131 Language.</td>
</tr>
<tr>
<td>S55</td>
<td>The laws could be made easier to understand. Different counties interpret the wording different.</td>
</tr>
<tr>
<td>S56</td>
<td>Find fair way to charge for brush removal.</td>
</tr>
<tr>
<td>S57</td>
<td>Allow government agencies such as Seabees - Mobil Naval Construction battalion, bid or work free gratis on group drainage projects.</td>
</tr>
<tr>
<td>S59</td>
<td>Remove DPA and C.O.E. from all projects with less than 10,000-acre watershed, especially if no public funds are used.</td>
</tr>
<tr>
<td>S68</td>
<td>Working well.</td>
</tr>
</tbody>
</table>

*Table entries are the actual responses provided by the agencies.  
†Column headings are abbreviations of actual questions.*
Table B.22. Survey responses for question 53.

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Q-53</th>
<th>Q-53*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prog Diff</td>
<td>Will Change</td>
</tr>
<tr>
<td>E20</td>
<td>Allen County - watershed based on surface drainage; Putnam County - Watershed based on Sub-surface drainage.</td>
<td>4</td>
</tr>
<tr>
<td>E22</td>
<td>Auglaize county performs 100% of all maintenance work on 162 projects. No contracts are let for maintenance.</td>
<td>3</td>
</tr>
<tr>
<td>E24</td>
<td>Not Known</td>
<td>4</td>
</tr>
<tr>
<td>E27</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>E29</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>E31</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>E33</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>E35</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>E39</td>
<td>None known</td>
<td>2</td>
</tr>
<tr>
<td>E45</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>E47</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>E48</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>E49</td>
<td>We mow all open ditches - since 1972</td>
<td>1</td>
</tr>
<tr>
<td>E50</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>E51</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>E53</td>
<td>Through a memo of understanding between board of city comm., city engineer and MSWCD the district will maintain ORC 1515 Improvements. We also use prisoner details to reduce expenses.</td>
<td>4</td>
</tr>
<tr>
<td>E56</td>
<td>The spirit of rugged individualism causes many problems with group projects in Paulding County. Neighbors cannot agree so they are forced into the petition or SB-160 route.</td>
<td>3</td>
</tr>
<tr>
<td>E58</td>
<td>Repair ditches; old county petition projects fixed by authority of commissioners on request of landowners. These ditches are not on the maintenance program.</td>
<td>1</td>
</tr>
<tr>
<td>E59</td>
<td>None</td>
<td>3</td>
</tr>
<tr>
<td>E60</td>
<td>--</td>
<td>5</td>
</tr>
<tr>
<td>E61</td>
<td>Seems that most counties determine their final watershed from topographic maps. We send our initial mailings based on topographic maps, but determine final watershed from personal interviews w/ all owners. This is very time consuming, but priceless when it comes to having an informed watershed at hearings!</td>
<td>1</td>
</tr>
<tr>
<td>E63</td>
<td>None</td>
<td>4</td>
</tr>
<tr>
<td>E65</td>
<td>None.</td>
<td>1</td>
</tr>
<tr>
<td>E69</td>
<td>None that I'm aware of.</td>
<td>5</td>
</tr>
<tr>
<td>S20</td>
<td>EPA has effectively stopped work on any projects that need deepening</td>
<td>3</td>
</tr>
<tr>
<td>S25</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>S26</td>
<td>--</td>
<td>2</td>
</tr>
<tr>
<td>S27</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>S29</td>
<td>--</td>
<td>2</td>
</tr>
<tr>
<td>S30</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>S31</td>
<td>We're all different.</td>
<td>4</td>
</tr>
<tr>
<td>S32</td>
<td>It is a horrible and confusing mess because it relies on too many people/departments to make it work. We only have 1 on maintenance and every year it is a disaster.</td>
<td>3</td>
</tr>
<tr>
<td>S33</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>S35</td>
<td>--</td>
<td>1</td>
</tr>
<tr>
<td>S37</td>
<td>None</td>
<td>3</td>
</tr>
<tr>
<td>S38</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>S39</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>S40</td>
<td>None that I am aware of.</td>
<td>3</td>
</tr>
<tr>
<td>S41</td>
<td>Not aware of any.</td>
<td>4</td>
</tr>
<tr>
<td>S42</td>
<td>Excessive grades in unstable soils.</td>
<td>2</td>
</tr>
<tr>
<td>S43</td>
<td>Last group project in county was in 1980.</td>
<td>4</td>
</tr>
<tr>
<td>S46</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>S51</td>
<td>--</td>
<td>3</td>
</tr>
</tbody>
</table>

Continued
Table B. 22. (continued)

<table>
<thead>
<tr>
<th>Agency ID</th>
<th>Q-53</th>
<th>Prog Diff*</th>
<th>Q-53*</th>
<th>Will Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>S52</td>
<td>The Miami SWCD works very close with the Miami Co. Engineer. The first step in all drainage improvement projects is the use of the mutual agreement. If that procedure fails than the petition method is used.</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>S53</td>
<td>We have a solid team; Co. Commissioner, Co. Eng., Prosecutor, Health department, twp. trustees and sheriffs' office. Are system is slowly breaking down.</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S55</td>
<td>--</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S56</td>
<td>--</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>S57</td>
<td>None.</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S58</td>
<td>Bland</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S59</td>
<td>We are damned good at what we do! Since 1990 our office has been involved with a total of 53 group projects, ranging in size from 1 mile to 29 miles. Our 160 program is growing &amp; succeeding.</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>S62</td>
<td>--</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>S66</td>
<td>--</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S67</td>
<td>--</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S68</td>
<td>We contract out all work except record keeps and inspection. We are considering having a contractor do inspection in the future.</td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*Table entries are the actual responses provided by the agencies.
†Column headings are abbreviations of actual questions.
‡"- -" indicates no response.
APPENDIX C

EXAMPLE ASSESSMENT METHODS AS REPORTED BY RESPONDENTS
Assessment Calculations

\[ PBF = AC \times RC \times LF \]

\[ PA = \left( \frac{(PBF)}{\sum PBF} \right) \times CI \]

\( AC \) = Acres
\( RC \) = Runoff Coefficient
\( LF \) = Location Factor

Two Components
Location of parcel relative to the project
Location along the project

\( PBF \) = Parcel Benefit Factor
\( PA \) = Parcel Assessment
\( CI \) = Cost of Improvement
\( \sum \) = summation symbol
\( / \) = division symbol
\( x \) = multiplication symbol

**Runoff Coefficients**

<table>
<thead>
<tr>
<th>Type</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road R/W</td>
<td>0.60</td>
</tr>
<tr>
<td>Railroad</td>
<td>0.45</td>
</tr>
<tr>
<td>Agricultural</td>
<td>0.15</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
</tr>
<tr>
<td>( x \geq 2 \text{ Ac.} )</td>
<td>0.25</td>
</tr>
<tr>
<td>( 2 &gt; x \geq 1 )</td>
<td>0.30</td>
</tr>
<tr>
<td>( x &lt; 1 )</td>
<td>0.35</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.65</td>
</tr>
<tr>
<td>Commercial (Mall)</td>
<td>0.85 – 1.00</td>
</tr>
<tr>
<td>Grass (Parks, etc.)</td>
<td>0.20</td>
</tr>
<tr>
<td>Woods</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Exhibit C.2. Assessment Method provided by Auglaize County Engineer.

ASSESSMENT CALCULATION

The considerations that were used to determine individual assessments are as follows:

ACRES DRAINED: only the physical acreage of land within the actual watershed boundary is considered in making assessments.

RUNOFF COEFFICIENT: each tract of land contributing runoff water to the proposed improvement is assessed according to the amount of water that is actually being generated from that tract of land. Runoff is determined by land use, ground cover, soil type, and ground contour/elevation.

USE OF IMPROVEMENT: your ground is assessed only on that portion of the ditch project that you runoff water physically travels through. You have no responsibility to help share in the cost of construction being done upstream from where your stormwater runoff enters the ditch.

REMOTENESS FROM IMPROVEMENT: the more distant a tract of land within the watershed is from the ditch improvement, the lower that land is assessed.

DIRECT ASSESSMENTS: a special direct assessment sometimes may be levied on a property above and beyond his calculated assessment. Items such as brush removal, junk pile removal, certain outlet pipe, or any items which only benefit an individual landowner or a particular group of landowners.

SAMPLE ASSESSMENT CALCULATION:

<table>
<thead>
<tr>
<th>Property owner</th>
<th>Acres drained</th>
<th>% runoff</th>
<th>% use</th>
<th>% Remote</th>
<th>% Total</th>
<th>Benefit Acres</th>
<th>Total Assmt</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Doe</td>
<td>10</td>
<td>40</td>
<td>100</td>
<td>50</td>
<td>20</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>40 Acre Farm owned</td>
<td>5</td>
<td>30</td>
<td>80</td>
<td>75</td>
<td>18</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>30 Acre Drained</td>
<td>10</td>
<td>40</td>
<td>100</td>
<td>75</td>
<td>30</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0</td>
<td>60</td>
<td>100</td>
<td>24</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.10</td>
<td>$473.33</td>
</tr>
</tbody>
</table>

Total cost of Project = $10,000.00
Total of all Benefit Acres in Watershed = 150
Cost per Benefit Acre = $10,000/150 = $66.67
John Doe’s Assessment = $66.67 x 7.10 = $473.33

Continued
Exhibit C.2. (continued)

<table>
<thead>
<tr>
<th>Property Owner</th>
<th>Parcel Number</th>
<th>Acres Owned</th>
<th>Acres Drained</th>
<th>Remote Index</th>
<th>Runoff Index</th>
<th>Usage Index</th>
<th>Total Index</th>
<th>Benefit Acres</th>
<th>Direct Assessment</th>
<th>Total Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Page Total
ASSessment PROCEDURE

Determine drainage area for improvement and plot on contour map.

Transfer property lines from tax maps to drainage area on contour map and fill in property owner names for each parcel.

Prepare list of all property owners in drainage area in alphabetical order. Use this list to complete Schedule “B” (schedule of land owners) and assessment calculation sheets.

Prepare Schedule “B” (Exhibit #3)

Check property owner’s names against grand list using property descriptions and acreages listed.
Determine mailing addresses from treasurer’s office index cards.

Using preliminary estimate of construction costs, prepare sample assessments on Assessment Calculation Sheet (Exhibit #4)

Alphabetically place all property owner names on calculation sheet by parcel, with lot numbers and section numbers.
Determine watershed reach factor.
For each parcel, determine the length of the improvement each owner’s water uses.
Calculate the entire cost of the improvement for the length determined in (1) above.
Divide cost determined in (2) above by entire construction cost of the improvement and multiply by 10, round off to nearest whole number; this is the Reach Factor.
Using the following criteria, determine the land use intensity factor for each parcel:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 8</td>
<td>Roads, paved areas, commercial and industrial area. Residential lots 1 acre or less.</td>
</tr>
<tr>
<td>7</td>
<td>Residential lots, 1-2 acres.</td>
</tr>
<tr>
<td>6</td>
<td>Residential lots, 2-5 acres.</td>
</tr>
<tr>
<td>6 - 4</td>
<td>Potential urban, suburban development areas. (inside municipalities)</td>
</tr>
<tr>
<td>4 - 2</td>
<td>Agricultural areas, obvious development potential, 1 acre as residential.</td>
</tr>
<tr>
<td>2 - 1</td>
<td>Agricultural areas, remote development potential, 1 acre as residential.</td>
</tr>
<tr>
<td>1 - .25</td>
<td>Mixed cover rural areas, agricultural limited to pasture.</td>
</tr>
<tr>
<td>.25 - 1</td>
<td>Wooded rural areas, no agricultural utility value.</td>
</tr>
</tbody>
</table>

Continued
Exhibit C.3. (continued)

Determine Surface Drainage Factor using average natural slope for each parcel and the values listed below:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Depressional areas</td>
</tr>
<tr>
<td>8</td>
<td>Flat - 0% slope</td>
</tr>
<tr>
<td>6</td>
<td>0 - 2% slope</td>
</tr>
<tr>
<td>4</td>
<td>2 - 6% slope</td>
</tr>
<tr>
<td>2</td>
<td>6 - 12% slope</td>
</tr>
<tr>
<td>1</td>
<td>12% and greater slopes</td>
</tr>
</tbody>
</table>

E. Determine Soil Group Factor.

Locate each parcel on soil survey maps and list soil types.

Assign value to soils based on their hydrological soil group as listed in Table #3.

Factors corresponding to the values listed in Table #7 are as follows:

- 5 = Residential
  - A = 4
  - B = 3
  - C = 2
  - D = 1

Determine factor for degree of need for problem correction. Assign factors as follows:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 8</td>
<td>Areas inundated, severe threat to structure and health.</td>
</tr>
<tr>
<td>8 - 6</td>
<td>Areas saturated, substantial threat to structure and health.</td>
</tr>
<tr>
<td>6 - 4</td>
<td>Areas of slow drainage, potential threat to drainage structure.</td>
</tr>
<tr>
<td>4 - 2</td>
<td>Areas of medium drainage, remote threat to drainage structure.</td>
</tr>
<tr>
<td>2 - 1</td>
<td>Areas of rapid drainage, no threat to drainage structure.</td>
</tr>
<tr>
<td>1 - 1</td>
<td>Areas of watershed legally obligated for improvement, no new drainage benefits</td>
</tr>
</tbody>
</table>

Determine factor for the degree of problem correction by the project. This factor based on the possible need for additional private drainage for each parcel and the proportion of the improvement actually located on the parcel. Assign factors as follows:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 8</td>
<td>Project will correct subwatershed acreage drainage needs 100%.</td>
</tr>
<tr>
<td>8 - 6</td>
<td>Project will correct subwatershed acreage drainage needs 75%.</td>
</tr>
<tr>
<td>6 - 4</td>
<td>Project will correct subwatershed acreage drainage needs 50%.</td>
</tr>
<tr>
<td>4 - 2</td>
<td>Project will correct subwatershed acreage drainage needs 25%.</td>
</tr>
<tr>
<td>2 - 1</td>
<td>Project will correct subwatershed acreage drainage needs 5-10%</td>
</tr>
<tr>
<td>1 - 0</td>
<td>Project will correct subwatershed acreage drainage needs 0%.</td>
</tr>
</tbody>
</table>

Continued
Exhibit C.3. (continued)

H. Determine sample assessment value for each parcel.
   Calculate total units for each parcel on calculation sheet.
   Add total units for all parcels.
   Divide total units by project costs (total) that are to be distributed among all property
   owners. This is the cost per unit.
   Total project costs include engineering, advertising, inspection, construction
   costs, and for sample assessments, first year’s maintenance costs.
   Do not include any special costs that are to be assessed to a parcel individually.
   These costs are to be assessed separately and are not to be included in the
   calculation.
   Multiply the total units for each parcel by the cost per unit to arrive at the sample
   assessment.

After the first hearing, record any changes in factors that may have been requested and justified.
After the final estimated cost is made, use the factors developed for the sample assessments, and
any changes noted, to complete the calculation sheet for the preliminary assessments.
Complete the preliminary assessments in the same manner as for sample assessments.
Transfer preliminary assessments to Schedule “B”, “Estimated Amount Said Land Should Be
Assessed”.
After final contract payments are made, calculate final assessments. Final assessments reflect all
costs except anticipated first year’s maintenance costs. The final assessment is considered
the base assessment on which future maintenance costs are to be determined.

   Total all project costs except first year’s maintenance.
   Calculate cost per unit.
   Calculate final “base” assessment by multiplying cost per unit by the total units
   for each parcel and enter on schedule under “Assessment After Sale”.
   To determine first year’s maintenance assessment, multiply the final “base”
   assessment by the required percentage based on total cost and enter on
   schedule.

Submit Schedule “B” to county commissioners and auditor.

Continued
## ASSESSMENT CALCULATION SHEET

<table>
<thead>
<tr>
<th>NAME</th>
<th>Lot #</th>
<th>Acres Owned</th>
<th>Degree</th>
<th>Benefited Of</th>
<th>Reach x Use x (Slope + Soil) x (Need + Correction)</th>
<th>Acres</th>
<th>Total Units</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>385</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exhibit C.3. (continued)
Putnam County has basically used the same method of assessing group drainage projects for the past hundred years. The formula consists of determining the number of acres benefited into the project by each individual by using the previous ditch record from the last time the ditch was petitioned. The percentage of the ditch that each parcel is benefited by length is then calculated and multiplied into the Number of benefited acres. The results are then added together and divided into the total cost of the project to get a rate per 100% acres. This rate is then multiplied to the 100% acres for each parcel to determine the assessment due.

In 1985 a land use factor was added to the formula to address some concerns that residential and commercial lots were receiving more benefit from the increased drainage than agricultural land and that woodlands and waste ground were less benefited. The land codes on record at the Auditor’s office were utilized to come up with three basic categories: Agricultural, Residential, and Commercial. Tillable agricultural ground was given a factor of 1.0 with woodland, waste, and pastures given a factor of 0.1. Residential and Commercial properties were given a factor of 2.0 due to accelerated runoff from roofs and parking areas along with the constant flow from everyday usage.

This land use factor is then multiplied to the 100% acres in the original formula to determine the actual assessment. This is the method that is presently being used and the landowners have been agreeable to the change.

The biggest problem that arises in the assessment procedure has do with the removal of brush and who should be responsible for the cost. One argument is that the individual who has the brush and trees on their property should be assessed for the removal since its on their property and they are liable for their maintenance. The other argument is that trees are an act of God and nature and everyone should share costs for their removal. If trees are in the bottom of the channel and causing an obstruction, some views are that this is nature at work and others that it is negligence of the landowner. We have figured the brush many different ways depending on the views of the landowners involved.

Continued
MIAMI COUNTY
BENEFIT COST PROCEDURE

The following is a attempt to establish a procedure to calculate dollar benefits for Group Drainage projects. The Miami County Engineer and the Miami Soil & Water Conservation District intend to use this procedure for Agricultural Group drainage projects petitioned under Ohio Revised Code Section 6131 and Section 1515 respectively.

In determining a group drainage project's economic feasibility it is necessary to have a procedure to calculate agricultural benefits. Our procedure uses documented data provided by the following publications:

- The Miami County Soil Survey
- The Ohio Drainage Guide
- The Ohio Agronomy Guide (recent & past editions)
- USDA Soil Conservation Service Technical Guide
- The Ohio State University Cooperative Extension Service
  (various drainage publications)
- The United States Geological Survey
- Ohio Crop Reporting Service – Ohio Agricultural Statistics

The agricultural benefits for each parcel are related to it's location in the watershed, distance from the improvement, soil drainage characteristics, percent of tile installed, and the percent tile impaired. By utilizing these factors and this procedure Agricultural benefits in dollars can be calculated.

Developed By
Terry E. Wackler
District Drainage Coordinator Miami SWCD

Mark A. Adams
District Drainage Technician Miami SWCD

Ed Everman
Pollution Abatement Specialist ODNR

February 1989
Exhibit C.5. (continued)

Compare the following table with Table F7.1
(See third thru fifth pages of Charts & Tables)

<table>
<thead>
<tr>
<th>TILE INSTALLED</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMPAIRED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D</td>
</tr>
<tr>
<td>26 - 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>51 - 75%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>76 - 100%</td>
<td>A4</td>
<td>A3</td>
<td>A2</td>
<td>A1</td>
<td>A</td>
</tr>
</tbody>
</table>

To calculate the following:

A – Use the combined weighted average of Corn, Soybeans, and Wheat for a specific Drainage Class from Table F4.

Example: $48.65 for Very Poorly and Somewhat Poorly Drained Soils.

B – Multiply A by 75%  
Example: $48.65 x .75 = $36.49

C – Multiply A by 50%  
Example: $48.65 x .50 = $24.33

D – Multiply A by 25%  
Example: $48.65 x .25 = $12.16

A1 – Subtract from A 25% of the value from Table F6

Example:  
$14.67 \times .25 = 3.67$  
$48.65 - 3.67 = 44.98 = A1$

A2 – Subtract from A 50% of the value from Table F6

Example:  
$14.67 \times .50 = 7.34$  
$48.65 - 7.34 = 41.31 = A2$

Continued

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Exhibit C.5. (continued)

A3 – Subtract from A 75% of the value from Table F6

Example:  
$14.67 \times .75 = $11.00  
$48.65 - $11.00 = $37.65 = A3

A4 – Subtract from A 100% of the value from Table F6

Example:  
$14.67 \times 1.00 = $14.67  
$48.65 - $14.67 = $33.98 = A4

Follow steps A1 thru A4 to complete Table F7.1, substituting the A value with B, C, & D.

Use this procedure to construct Table F7.2 and Table F7.3.

Explanations of tables for the Benefit Cost Procedure

[See second page of Charts & Tables]

Table F1  Average crop price – Current local average price of  
5 year average price from Ohio Crop  
Reporting Service statistic

– Variable Production cost* – Taken from SCS Technical  
Guide Section V-C Cost  
Return Estimates

= Net Return to the Land

Table F2  Watershed average crop rotation – Taken from Ohio Crop  
and yield in percent & acres Reporting Service statistic  
respectively.

Table F3  Yield reductions – Information from a early agronomy  
in percent guide; the Ohio Drainage Guide, and the Miami County Soil Survey.  (This  
table will need to tailored to the soil association in your county)

Table F4  Calculated weighted average – The formula to this chart is;  

This Example is for Corn:  
Table F1 – Net Return to Land (NRL) = $1.49  
Table F2 – County average bu./ac. = x 127  
Table F2 – Percent planted to crop = x .42  
Table F3 – Yield reduction VPD soil = x .30  
Table F4 – Agri. benefits for VPD soil = $23.84

Continued
Repeat these steps for Soybeans & Wheat then add together to attain a total weighted average for a Very Poorly Drained soil.

**Table F5** Percent tile – A standardized table of estimated tile installed for a given drainage class. You may use actual tile installed if records are available for the watershed.

**Table F6** Cost per acre to install tile

- An estimation of the cost to install a systematic subsurface drainage system – $450.00 per acre at 10% interest amortized over 10 years**
- divided by life-span of system, 50 years.
- $450.00 + $283.50 = $733.50
- $733.50 / 50 years = $14.67/ac./yr.

**Tables F7.1 - F7.3** Agricultural benefit tables according to soil drainage classes. The dollar benefit per acre is derived from this chart by determining the tile impairment (far left side of table vertical) and percent tile installed (top of table horizontal). See next page for instructions.

* Land cost not included.
** Estimated number of years for benefits to pay for investment
1 Interest paid for 10 years at 10% on $450.00

**Table F8** This table establishes each parcel’s annual agricultural benefits and the total annual agricultural benefits for the project. Each parcel is listed vertically at the far left side of the table. Tile impairment for each parcel is then determined by a location elevation factor. This factor accounts for a parcel’s relative location to the improvement. The closer a parcel is to the improvement or the elevation of the improvement (Ditch bank elevation) the higher the percent tile impairment is likely to be. Below is a graph to relate location and elevation to percent tile impairment:

Continued
The horizontal range of the graph represents the distance from the center of the parcel to the point where the water enters the improvement. The vertical range represents the elevation difference between the center of the parcel and the point where the water enters the improvement. This graph will need to be adapted to the topography of each watershed. The scales can be changed by measuring the distance of the parcel furthest away from the improvement and using this as the top distance and using the parcel center point with the highest elevation difference between it and the improvement as the top elevation. The values of 17,000 and 20 feet were used for this graph, respectfully.

To determine a parcel’s percent tile impairment follow these steps;

Locate the center of the parcel’s benefited watershed acreage on a scaled U.S.G.S. or soils map.

Determine difference in elevation from center of parcel and the ditch bank elevation at which point the parcel’s drainage enters the improvement.

Measure the distance from the center of parcel along the approximate drainage way to the point where it enters the improvement.

Take the difference in elevation and the distance from the improvement and apply to the graph to find factor. Multiply the factor by 10 to get a percent of tile impaired. Example: a factor of 8.5 would be 85% tile impairment for a parcel.

To complete Table F8, determine the acres of each soil type located within the parcel. Categorize the soil types according to drainage classes. From Table F5 the estimated percent tile installed can be found for each drainage class. This data can then be used to
Exhibit C.5. (continued)

Table F8. To understand the completion of this table refer to Table F8 for the corresponding letters:

- 100% percent tile impaired
- 75% percent tile installed
- Bs soil type for column
- $44.98 dollar benefit per acre (Table F7.1)
- 13.830 benefited acres of soil type for parcel
- $622.07 benefits in dollars for Bs soil type (d x e = f)
- 58.673 benefited agricultural acres of parcel
- 81,807.57 total agricultural benefits for parcel
- $6,421.08 total agricultural benefits for project

The total agricultural benefits for project can now be applied to calculating the benefit / cost ratio.

Table F1
1988 Average Grain Prices

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Variable</th>
<th>Net Return To Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>$2.65</td>
<td>$1.16</td>
<td>$1.49</td>
</tr>
<tr>
<td>Soybeans</td>
<td>$7.60</td>
<td>$2.76</td>
<td>$4.84</td>
</tr>
<tr>
<td>Wheat</td>
<td>$3.75</td>
<td>$1.69</td>
<td>$2.06</td>
</tr>
</tbody>
</table>

Table F2

<table>
<thead>
<tr>
<th></th>
<th>Average Bushels</th>
<th>Percent Planted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>127</td>
<td>42%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>42</td>
<td>42%</td>
</tr>
<tr>
<td>Wheat</td>
<td>56</td>
<td>10%</td>
</tr>
</tbody>
</table>

Table F3
Yield Reductions

<table>
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<tr>
<th></th>
<th>Corn</th>
<th>Soybeans</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Drained -</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Moderately Well Drained -</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Somewhat Poorly Drained -</td>
<td>30</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Very Poorly Drained -</td>
<td>30</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>Table F4</th>
<th>Well Drained</th>
<th>Moderately Well</th>
<th>Very &amp; Somewhat Poorly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>3.97</td>
<td>7.95</td>
<td>23.84</td>
</tr>
<tr>
<td>Soybeans</td>
<td>4.27</td>
<td>8.54</td>
<td>21.35</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.58</td>
<td>1.15</td>
<td>3.46</td>
</tr>
<tr>
<td>Average</td>
<td>8.82</td>
<td>17.64</td>
<td>48.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table F5</th>
<th>Percent Tile Installed</th>
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</thead>
<tbody>
<tr>
<td>Well Drained -</td>
<td>0%</td>
</tr>
<tr>
<td>Moderately Well Drained -</td>
<td>25%</td>
</tr>
<tr>
<td>Somewhat Poorly Drained -</td>
<td>50%</td>
</tr>
<tr>
<td>Very Poorly Drained -</td>
<td>75%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table F6</th>
<th>Cost Per Acre To Install Tile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$14.67</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>Table F7.1</th>
<th>TILE INSTALLED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
</tr>
<tr>
<td><strong>Impaired</strong></td>
<td></td>
</tr>
<tr>
<td>0 – 25%</td>
<td>($2.51)</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>$9.66</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>$21.82</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>$33.98</td>
</tr>
</tbody>
</table>

Soil Types for this Table:

- Somewhat Poorly Drained
- Very Poorly Drained

- Algiers
- Blount
- Crosby
- Odell
- Randolph
- Shoals
- Shoals Variant
- Sleeth
- Brookston
- Edwards
- Linwood
- Millsdale
- Montgomery
- Pewamo
- Wallkill
- Westland

Continued
### Exhibit C.5. (continued)

**Table F7.2**

<table>
<thead>
<tr>
<th>Tile Impaired</th>
<th>0%</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 25%</td>
<td>($10.26)</td>
<td>($8.79)</td>
<td>($6.59)</td>
<td>($2.93)</td>
<td>$0.74</td>
<td>$4.41</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>($5.85)</td>
<td>($4.83)</td>
<td>($2.18)</td>
<td>$1.49</td>
<td>$5.15</td>
<td>$8.82</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>($1.44)</td>
<td>$0.03</td>
<td>$2.23</td>
<td>$5.90</td>
<td>$9.56</td>
<td>$13.23</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>$2.97</td>
<td>$4.44</td>
<td>$6.64</td>
<td>$10.31</td>
<td>$13.97</td>
<td>$17.64</td>
</tr>
</tbody>
</table>

**Soil Types for this Table:**

**Moderately Well Drained**

Celina
Corwin
Eel
Glynwood
Medway

---

Continued
### Exhibit C.5. (continued)

#### Table F7.3

<table>
<thead>
<tr>
<th></th>
<th>0%</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impaired</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 – 25%</td>
<td>($12.46)</td>
<td>($10.99)</td>
<td>($8.79)</td>
<td>($5.13)</td>
<td>($1.46)</td>
<td>$2.21</td>
</tr>
<tr>
<td>26 – 50%</td>
<td>($10.26)</td>
<td>($8.79)</td>
<td>($6.59)</td>
<td>($2.93)</td>
<td>$0.74</td>
<td>$4.41</td>
</tr>
<tr>
<td>51 – 75%</td>
<td>($8.05)</td>
<td>($6.58)</td>
<td>($4.38)</td>
<td>($0.72)</td>
<td>$2.95</td>
<td>$6.62</td>
</tr>
<tr>
<td>76 – 100%</td>
<td>($5.85)</td>
<td>($4.38)</td>
<td>($2.18)</td>
<td>$1.49</td>
<td>$5.15</td>
<td>$8.82</td>
</tr>
</tbody>
</table>

**Soil Types for this Table:**

- **Well Drained**
  - Eldean
  - Genesee
  - Hennepin
  - Lorenzo
  - Martinsville
  - Miamian
  - Milton
  - Ockley
  - Ritchey
  - Rodman
  - Ross
  - Stonelick
  - Warsaw
  - Wea
  - Ross Variant

---

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Table F8

<table>
<thead>
<tr>
<th>Parcel Installed Landowner</th>
<th>Percent</th>
<th>B = 75%</th>
<th>C = 50%</th>
<th>D = 25%</th>
<th>E = 0%</th>
<th>F = 0%</th>
<th>G = 50%</th>
<th>H = 50%</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parcel A</td>
<td>100%</td>
<td>$44.98</td>
<td>$41.32</td>
<td>$6.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$58.67</td>
</tr>
<tr>
<td>Parcel B</td>
<td>30%</td>
<td>$20.66</td>
<td>$17.00</td>
<td>$2.18</td>
<td>$10.26</td>
<td></td>
<td></td>
<td></td>
<td>$17.00</td>
</tr>
<tr>
<td>Parcel C</td>
<td>70%</td>
<td>$32.82</td>
<td>$29.16</td>
<td>$2.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$45.03</td>
</tr>
<tr>
<td>Parcel D</td>
<td>100%</td>
<td>$44.98</td>
<td>$41.32</td>
<td>$6.64</td>
<td>$5.85</td>
<td>$5.85</td>
<td>$41.32</td>
<td></td>
<td>$41.32</td>
</tr>
<tr>
<td>Parcel E</td>
<td>70%</td>
<td>$29.16</td>
<td>$29.16</td>
<td>$2.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$47.19</td>
</tr>
<tr>
<td>Parcel F</td>
<td>70%</td>
<td>$32.82</td>
<td>$29.16</td>
<td>$2.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$54.18</td>
</tr>
</tbody>
</table>

Total Cropland Acres = 254.390
Total Annual Dollar Benefit = $6,421.08

Continued
Procedures for the completion of a Benefit / Cost Analysis
(As defined by the Miami SWCD Drainage Department)

[See first page of Charts & Tables]

A.) $45,000.00  Total Estimated Construction Cost of Project
B.) $8,463.24  Five-year loan at 7% interest financed through
               County Commissioners
C.) $53,463.24  Construction Cost plus interest amortized over
               five years
D.) Annual Maintenance Costs – Open Ditch = 5% /
                   Subsurface Drainage = 2%
E.) Estimated Life Span – Open Ditch = 25 years /
               Subsurface Drainage ~ 50 years
F.) $6,421.08  Annual Agricultural Benefit (See Table F1 – F6)
G.) $5,700.00  Total Annual House hot Benefit. This is calculated at 1% of
               the True Market Value* for each house within the
               watershed.
H.) $12,121.08 Total Annual Benefit  (F + G = H)
I.) $2,250.00  Annual Maintenance  (D x A = I)
J.) $9,871.08  Annual Benefits minus Annual Maintenance
               (H – I = J)
K.) 4.62 : 1  Benefit Cost Ratio
               (C ÷ 8 = Annual Cost: for Life span)
               (J ÷ Annual Cost for Life-span = K)

*The True Market Value may be acquired from the County Auditor.
Exhibit C.5. (continued)

THIS CHART SHOWS THE LENGTH OF TIME NEEDED TO RECOVER MONEY PAID OUT TO THE PROPOSED IMPROVEMENT

PROPOSAL #1 – OPEN DITCH

<table>
<thead>
<tr>
<th>LIFE SPAN OF PROJECT</th>
<th>LIFE SPAN OF PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>($ 43,592.16)</td>
<td>$ 203,184.84</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>($ 33,721.08)</td>
<td>$ 213,055.92</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>($ 23,850.00)</td>
<td>$ 222,927.00</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>($ 13,978.92)</td>
<td>$ 232,798.08</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>($ 4,107.84)</td>
<td>$ 242,669.16</td>
</tr>
<tr>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>$ 5,763.24</td>
<td>$ 252,540.24</td>
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<tr>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>$ 15,634.32</td>
<td>$ 262,411.32</td>
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<tr>
<td>8</td>
<td>33</td>
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<tr>
<td>$ 25,505.40</td>
<td>$ 272,282.40</td>
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<tr>
<td>9</td>
<td>34</td>
</tr>
<tr>
<td>$ 35,376.48</td>
<td>$ 282,153.48</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>$ 45,247.56</td>
<td>$ 292,024.56</td>
</tr>
<tr>
<td>11</td>
<td>36</td>
</tr>
<tr>
<td>$ 55,118.64</td>
<td>$ 301,895.64</td>
</tr>
<tr>
<td>12</td>
<td>37</td>
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<tr>
<td>$ 64,989.72</td>
<td>$ 311,766.72</td>
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<tr>
<td>13</td>
<td>38</td>
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<td>$ 74,860.80</td>
<td>$ 321,637.80</td>
</tr>
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<td>14</td>
<td>39</td>
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<td>$ 84,731.88</td>
<td>$ 331,508.88</td>
</tr>
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<td>15</td>
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<td>$ 94,602.96</td>
<td>$ 341,379.96</td>
</tr>
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<td>16</td>
<td>41</td>
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<tr>
<td>$104,474.04</td>
<td>$ 351,251.04</td>
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<td>17</td>
<td>42</td>
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<td>$114,345.12</td>
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<td>18</td>
<td>43</td>
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<td>$124,216.20</td>
<td>$ 370,993.20</td>
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<td>$134,087.28</td>
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<td>45</td>
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<tr>
<td>$143,958.36</td>
<td>$ 390,735.36</td>
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<td>21</td>
<td>46</td>
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<tr>
<td>$153,829.44</td>
<td>$ 400,606.44</td>
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<td>22</td>
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<td>23</td>
<td>48</td>
</tr>
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<td>$173,571.60</td>
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</tr>
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<td>24</td>
<td>49</td>
</tr>
<tr>
<td>$183,442.68</td>
<td>$ 430,219.68</td>
</tr>
<tr>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>$193,313.76</td>
<td>$ 440,090.76</td>
</tr>
</tbody>
</table>

A – CONSTRUCTION COST = $45,000.00  F – ANNUAL AGR. BENEFIT = $6,421.08

B – INTEREST FOR 5 YEAR
LOAN AT 7% = $8,463.24

G – ANNUAL HOUSE LOT

H – TOTAL ANNUAL
BENEFIT = $12,121.08

C – CONSTRUCTION COST W/ INTEREST = ($53,463.24)

D – ANNUAL MAINTENANCE
PERCENTAGE = 5.0%
MAINTENANCE = $2,250.00

I – ANNUAL

Continued
Exhibit C.5. (continued)

| INTEREST RATE | = | 7.0% | J – ANNUAL BENEFITS
| YEARS IN TERM OF LOAN | = | 5 |
| E – ESTIMATED LIFE SPAN (Years) | = | 25 |

MINUS YEARLY MAINTENANCE = $9,871.08

K – BENEFIT : COST RATIO = 4.62 : 1

AGRICULTURAL BENEFITS ARE BASED ON AVERAGE 1988 GRAIN PRICES
Exhibit C.6. Assessment Method provided by Paulding County Engineer.

ASSESSMENT PROCEDURE FOR PETITIONED DITCH PROJECTS
PAULDING COUNTY, OHIO

Introduction
Each county has developed a system of assessment for drainage projects over the course of many years. What worked thirty years ago is no longer viable; what seems to work today may need to be redefined thirty years hence. What follows is a brief discussion of the procedure that has evolved in Paulding County, a procedure that is still being refined in order to keep pace with the changes in agriculture and the methods of financing improvements.

Preliminary work
The first step in the procedure is to investigate the written records of drainage assessment with the watershed in question and all adjoining or outlet watersheds in order to determine the historic basis for assessment. Often, contradictory records among adjacent watersheds are discovered, so a decision must be made as to which acreage figure will be used (usually the latest is accepted). At this point, any anecdotal information supplied by farmers, landowners or other interested parties is considered. Often, an onsite inspection will provide the answer to the question. In many cases, it is necessary to survey the land in order to ascertain the current watershed. If it is found that current drainage watersheds differ from prior assessments, the assessment may be either eliminated or reduced, depending on how much past benefit can be determined. Thus, a person who was assessed into a watershed for 50 years and who has only recently retiled a field into an adjacent, watershed may be required to pay all or a portion of his current assessment before he can be removed from the watershed. On the other hand, a farm that has obviously receive little or no benefit from a watershed for many years may be dropped from the assessment list.

Assigning Percent of Benefit Values
Once a watershed has been determined, a percentage of benefit is assigned to each property using the following criteria:

1) Percentage of the improvement used. This was the basic determinant of assessment in our county for years. The percentage of the project below the middle of the property is determined. In the case of tile entry only, the percentage of the project below the outlet is used. Location of specific tile outlets or surface drains are determined and used as a basis for adjusting the original percentage figure to obtain an average percent of usage for the property.

2) Remoteness from an improvement along a lateral or overland. Depending on the size of the project and the size of the lateral, a reduction in percent of benefit is used, often 2% per quarter mile for the distance upstream on the lateral where water from a farm enters the lateral. Thus, a farm whose main outlet enters a lateral to the petitioned project at a point one mile upstream of the main ditch would receive a reduction of 8% in calculated percent of benefit.

3) Land use. Land use currently falls into five categories, with a "Use Factor" assigned to each category as follows:
   Farmland (Use Factor = 1)
   Roads (Use Factor = 1.5)
   Residential (Use Factor = 2.0)
   Commercial or industrial (Use Factor = 4.0)
   Woodlots (Use Factor = 0.5)

Continued
Exhibit C.6. (continued)

Where there is multiple land use on a single property, an average adjusted use factor is determined. For example, an 80-acre farm with a 20-acre woodlot would consist of 60 acres with a use factor of 1 and 20 acres with a use factor of 0.5, or 80 acres with an adjusted average of 0.875.

4) Drainage use reduction factors. If a farm drains only surface water into a ditch, but the tile water goes another direction, there is usually a 50% reduction in assessment. On the other hand, if there is only surface drainage on the farm, the rate is not reduced, because the possibility of adding tile drainage is still available as a potential benefit. Another case for reduction might be a property where land use is such that drainage improvements are not, feasible or possible, such as an area of waste ground near the lower end of a project. In such a case, assessment would be reduced drastically or entirely eliminated.

5) Special assessments. The most basic principle underlying special benefit is to be found by answering the question “Who will benefit by this particular structure or practice?” If the answer to the question points to one or two individuals or to a government agency, then a “special assessment” is calculated for that particular item. Thus, a new driveway pipe is assessed to the owner; the amount of fill and extra excavation needed to lay a ditch away from a road is assessed to the agency whose road is involved; the cost of any additional deepening of a ditch to accommodate one farmer would be assessed to that farmer alone. Sometimes, the question of who would benefit is not easily answered. When a sewer is installed to enclose an open ditch through a house lot along a public road in order to accomplish the layover of that ditch, our policy over the last eight years has been to assess this cost at 1/3 to the owner, 1/3 to the project, and 1/3 to the government agency.

The rationale is as follows:
The landowner will benefit from having an improved property
Since the project needs to have this work done in order to be completed, the other owners should share in part of the cost (Indeed, the owner may not wish to spend the money to install a sewer)
The government agency will benefit by the improvement of the road shoulder through the yard. This solution will not satisfy all concerned, and it is possible that through further discussion and evaluation, a new method will be devised to improve on this formula.

Calculation of Assessments
First, percent acres of benefit are determined by using the values derived from the following formula:

\[ \text{Acres benefited} \times \% \text{ of improvement used} \times (\text{less remoteness factor, if any}) \times \text{land use factor} \times \text{drainage use reduction factor} = \text{percent acres of benefit.} \]

Examples:

An 80 acre farm using 66% of the improvement would be assessed for the following: 80 acres \( \times \) 66\% \( \times \) 1.0 \( \times \) 1.0 = 52.80 per cent acres.

A road consisting of 4.84 acres of roadway using 50% of the improvement would be assessed: 4.84 acres \( \times \) 50\% \( \times \) 1.5 \( \times \) 1.0 = 3.63 per cent acres.

A woodlot on the final 10% of the project would not be assessed.

Continued
Exhibit C.6. (continued)

A 2.00 acre house lot using 90% of the improvement would be assessed:  
\[2.00 \text{ acres} \times 90\% \times 2.0 \times 1.0 = 3.60 \text{ per cent acres.} \]

When the time has come to determine actual assessments, the sum of all special benefit assessments is subtracted from the total cost, leaving the remainder as "cost assessable to owners."

Next, the "cost assessable to owners" is divided by the the sum of all percent acres of benefit to obtain the Rate per percent acre, which is used to figure individual assessments.

A typical example follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost of project</td>
<td>$80,242.22</td>
</tr>
<tr>
<td>less special assessments</td>
<td>- 5,105.00</td>
</tr>
<tr>
<td>Amount assessable to owners</td>
<td>= $75,137.22</td>
</tr>
<tr>
<td>$75,137.22 (amount assessable)</td>
<td>= $109,654.2, Rate per percent acre of benefit</td>
</tr>
<tr>
<td>685.22 total percent acres</td>
<td></td>
</tr>
</tbody>
</table>

Assessments are then calculated by multiplying the Rate per percent acre times the number of percent acres assigned to each property. Two of the examples given above to show determination of percent acres of benefit would be assessed as follows:

The 52.80 acre farm assessed for 52.80 acres would have an assessment of 52.80 x $109,654.2 = $5,789.74.

The road right-of-way assessed at 3.63 percent acres would have an assessment of 3.63 x $109,654.2 = $398.04.

Summary

As has been written elsewhere, assessments should always and everywhere be both logical and consistent within the framework of the general assessment procedure; however, within the scope of a particular project, where circumstances call for a different approach in order to establish benefits on that project, the special circumstances of that project may dictate that a new approach be applied to provide a rational and consistent assessment of benefits. As an example, we constructed a small surface ditch several years ago at the edge of one of our towns; since our normal assessment procedure was not designed to assess house lots for increased value due to flood reduction, we had to employ a new assessment method based on estimated increase in value to the properties. So the need for flexibility remains an important component of the assessment procedure.

Assessors of drainage improvements in Paulding County have traditionally used a fixed, non-changing set of criteria to produce benefit figures, and it is only during the last 10 to 15 years that such considerations as land usage and special benefit have been employed to refine the assessment procedure. This process of adaptation to new and valuable ideas continues, and it is the intent of those currently involved in this process to remain open to any new practices that will better suit the needs of the times.
Exhibit C.7. Assessment Method provided by Defiance Soil & Water Conservation District.

INDIVIDUAL ASSESSMENT FACTORS

The considerations that we use to determine individual assessments are as follows:

Acres Drained – Only the physical acreage of land within the actual watershed boundary is considered in making assessments.

Land Use – Each tract of land contributing runoff water to the proposed improvement is assessed according to the amount of water that is actually being generated from that tract of land. High runoff areas such as roads, parking lots, residential areas, etc., are assessed at a higher rate than the lower runoff areas such as farm ground and woodland regions, due to the fact that more runoff water is being produced from those higher runoff areas.

Soil Type – The soil type of your land draining into the project is determined using the Defiance County Soil Survey. Soils in Defiance County have been classified into four hydrologic soil groups. These four groups range from soils having low runoff potential and high infiltration rates even when thoroughly wetted (these consist mainly of sands and gravels that are deeply subsoil) to soils having high runoff potential that have very low infiltration rates when thoroughly wetted (these consist mainly of clay soils with a high swelling potential, a permanent high water table, and a claypan or clay layer at or near the surface).

Tile Drainage – This takes in account whether the land in the watershed area is tiled and whether or not the time drains to or away from the open ditch project.

Topography/Remoteness Consideration – The actual distance your runoff water must first travel before even reaching the ditch improvement is a determining factor on how your land is assessed. The longer the distance it takes for your water to reach the ditch improvement, the lower that ground is assessed.

Use of the Ditch Improvement – Your ground is assessed only on the amount of the ditch project that your runoff water actually travels through. You will have no responsibility to help share the cost of construction being done upstream from where your water enters the ditch. You only help share the cost of the ditch improvement that your runoff water travels through.

PAYMENT OF ASSESSMENTS UNDER S.B. 160

Assessment notice is sent to each landowner involved. An account is set up at the County Auditors office under the name of your ditch project. Assessments are paid to the County Auditors office and deposited into this account.

Landowners will have 21 days from the receipt of assessment notice to pay assessment. Those that have not paid by the due date will have money borrowed for them by the County Commissioners to cover their assessment. Landowners that have this money borrowed will then repay it in annual equal installments to the county, with interest at the same rate the county gets it for, through their real estate taxes. Interest rate at this time is approximately 4%.

Installment payments are figured as follows:
Where assessments are from $0.00 to $500.00 the property owner has one year to pay.
Where assessments are from $500.00 to $1,000.00 the property owner has two years to pay.
Where the assessments are from $1,000.00 to $5,000.00 the property owner has five years to pay.
Where assessments are over $5,000.00 the property owner has ten years to pay.
### Exhibit C.7. (continued)

**Drainage Benefit**

<table>
<thead>
<tr>
<th>Ditch Name:</th>
<th>County:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tax Parcel No.:</strong></td>
<td><strong>Address:</strong></td>
</tr>
<tr>
<td><strong>Landowner:</strong></td>
<td><strong>Reach:</strong></td>
</tr>
<tr>
<td><strong>Total Cost:</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>Land Use</th>
<th>Factor</th>
<th>Acres</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highways</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivated</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture, Woods</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buildings</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. = Units/Acres</td>
<td>Factor</td>
<td>Acres</td>
<td>Units</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Soils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrologic D</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. = Units/Acres</td>
<td>Factor</td>
<td>Acres</td>
<td>Units</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Tile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrologic A</td>
<td>1.20</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1.13</td>
<td>0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1.07</td>
<td>0.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1.01</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Tile</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. = Units/Acres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Topography</td>
<td>Factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 10ft.</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 - 20ft.</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 - 30ft.</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 - 40ft.</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41 - 50ft.</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51 +</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. = Units/Acres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Percent At Outlet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL BENEFITS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sum Total Benefits:** Main 100% Lateral 100%

**Cost Per Acre:** Main $ Lateral $

**Tile:**
- size: ________ total cost $ ________
- size: ________ total cost $ ________

**RipRap:**
- amount: ________ cost $ ________
- Total RipRap Assessment $ ________

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405
MONTGOMERY COUNTY
DRAINAGE ASSESSMENT PROCEDURE

This is the procedure for distributing the costs of a drainage petition project among the affected landowners. The Montgomery County Engineer and the Montgomery Soil and Water Conservation District intend to use this assessment procedure for drainage projects petitioned under Ohio Revised Code Section 6131 and ORC Section 1515 respectively.

In order to distribute the costs of a drainage project, it is necessary to compare the parcels of land within the drainage area. ORC Section 6131 outlines the possible "benefits" that could be assigned to a parcel due to a drainage improvement. In this procedure, each "benefit" category has been given a numerical range of 1 to 10. Each parcel is then ranked against the other parcels in the drainage area on the 1 to 10 scale for each "benefit" category. The projects costs are then distributed among the parcels according to their "benefits" relative to the other parcels in the drainage area.

A committee of persons involved in petitioned drainage projects was formed to develop this assessment procedure for Montgomery County.

The agencies represented on this committee are:

The Ohio State University Cooperative Extension Service Montgomery County Extension Service
Ohio Department of Natural Resources - Division of Soil & Water Conservation
U.S.D.A Soil Conservation Service
Montgomery County Farm Bureau
Montgomery Soil and Water Conservation District
Montgomery County Engineer
<table>
<thead>
<tr>
<th>Benefits under O.R.C. Sec. 6131</th>
<th>VI - A</th>
<th>VI - B</th>
<th>VI - H</th>
<th>V</th>
<th>VI - C</th>
<th>VI - D</th>
<th>VI - E</th>
<th>VI - F</th>
<th>VI - G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benefitted Acres</td>
<td>Reach Factor</td>
<td>Volume of Runoff Factor</td>
<td>Location/Elevation Factor</td>
<td>Potential Increase in Productivity Factor</td>
<td>Flood protection/Property Enhancement Factor</td>
<td>Special Assessment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Parcel Units = (1 x 2 x 3 x 4 x 5 x 6)

Parcel Assessment = (Units x $/Unit) + 7

Total Units = Σ Parcel units

$/Unit = Total assessed project cost / Total Units

Continued
DRAINAGE PROJECT BENEFITS
PER OHO REVISED CODE SECTION 6131
In determining drainage assessments the County Engineer shall give primary consideration to:
I. Potential increase in productivity.
   He shall also give consideration to:
II. Quantity of drainage contributed
III. Relative location of property to the project
IV. Portion of project through which drainage from the parcel flows
V. Value of the project to the watershed
VI. Benefits as defined in 6131.01. "Benefit" or "benefits" means advantages to land and owners, to public
    corporations as entities, and to the State, resulting from drainage, conservation, control and
    management of water, and environmental, wildlife, and recreational improvements.
Factors relevant to whether such advantages result include:
The watershed or entire land area drained or affected by the improvement.
The total volume of water draining into or through the improvement and the amount of water contributed
by each landowner.
The use to be made of the improvement by any owner, public corporation, or the State. Also, benefits
include any or all of the following factors:
Elimination or reduction of damage from flooding.
Removal of water conditions that jeopardize public health, safety, or welfare.
Increased value of land resulting from the improvement.
Use of water for irrigation, storage, regulation of stream flow, soil, conservation, water supply, or any other
purpose incidental thereto.
Providing an outlet for the accelerated runoff from artificial drainage whenever the stream, watercourse,
channel, or ditch under improvement is called upon to discharge functions for which it was not designed by
nature; it being the legislative intent that uplands which have been removed from their natural state by
deforestation, cultivation, artificial drainage, urban development, or other man-made causes will be
considered as benefitted by an improvement required to dispose of the accelerated flow of water from said
uplands.

Assessment Categories
Benefited Acres: The total acreage contributing stormwater runoff to the improvement

Reach Factor: The percentage of the improvement through which runoff from a parcel flows, measured
from the point the runoff from the parcel enters the improvement. For example:

<table>
<thead>
<tr>
<th>Percent of</th>
<th>Reach Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement used</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>.1</td>
<td></td>
</tr>
</tbody>
</table>

Volume of Runoff Factor: Relative measure of the amount of direct runoff from a parcel. Volume of runoff
can be found using the methods of Soil Conservation Service TR-55. Knowing the land use and soil type
for a parcel the Runoff Curve Number can be found, leading to a volume of runoff described in inches over
the entire parcel.

Continued
Exhibit C.8. (continued)

For example:

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Runoff from 10-year storm</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4.00&quot;</td>
<td>10.0</td>
</tr>
<tr>
<td>95</td>
<td>3.43&quot;</td>
<td>8.6</td>
</tr>
<tr>
<td>90</td>
<td>2.92&quot;</td>
<td>7.3</td>
</tr>
<tr>
<td>85</td>
<td>2.46&quot;</td>
<td>6.2</td>
</tr>
<tr>
<td>80</td>
<td>2.04&quot;</td>
<td>5.1</td>
</tr>
<tr>
<td>75</td>
<td>1.67&quot;</td>
<td>4.2</td>
</tr>
<tr>
<td>70</td>
<td>1.33&quot;</td>
<td>3.3</td>
</tr>
</tbody>
</table>

An example of how some typical land uses compare, assuming Class “C” soils and worst case hydrologic conditions is:

<table>
<thead>
<tr>
<th>Land use</th>
<th>Curve Number</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>40’ road right-of-way</td>
<td>92</td>
<td>7.8</td>
</tr>
<tr>
<td>60’ road right-of-way</td>
<td>90</td>
<td>7.3</td>
</tr>
<tr>
<td>Row crops</td>
<td>88</td>
<td>6.8</td>
</tr>
<tr>
<td>1 acre residential</td>
<td>79</td>
<td>4.9</td>
</tr>
<tr>
<td>Woods</td>
<td>77</td>
<td>4.6</td>
</tr>
</tbody>
</table>

When surface runoff from a parcel enters an improvement but the subsurface drainage is directed to a different drainage area, the volume of runoff factor may be reduced by 20%.

**Location / Elevation Factor**: This factor accounts for a parcel’s relative location to the improvement. The closer a parcel is to the improvement, the easier its access to that improvement is and the more it is benefitted by the improvement. Also, the closer a parcel’s elevation is to that of the improvement (eg. Ditch bank elevation), the more that parcel will benefit from the improvement. A graph to relate location and elevation to the location/Elevation Factor is:

<table>
<thead>
<tr>
<th>Elevation above Design flow water Surfaces or ditch Bank, feet</th>
<th>0 to 2000</th>
<th>2000 to 7000</th>
<th>7000 to 12,000</th>
<th>12,000 to 17,000</th>
<th>17,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5 – 10</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>10 – 15</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15 – 20</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Potential Increase in Productivity Factor**: This applies to agricultural ground which has the potential for increased productivity due to improved drainage. It is measured using the Current Agricultural Use Values for each agricultural parcel. The CAU values measure the potential of a parcel given its soil type and land use assuming good management practices and good drainage. With a present high CAU value of $1050 per acre in this area, the POTENTIAL INCREASE IN PRODUCTIVITY FACTOR will be calculated as follows:

\[
\text{Parcel CAUV} \times 10 = \text{Potential increase in Productivity Factor}
\]

For example, a parcel with a CAU value of $690/acre will have a factor of:

\[
\text{$690/acre} \times 10 = 6.6
\]

Non-agricultural ground will be assigned a factor of one.

Continued
**Exhibit C.8. (continued)**

**Flood Protection/Property Enhancement Factor:** This factor is used to measure the relative benefit to the respective parcels due to relief from flood damage and/or increase in property value due to the drainage improvement. Generally, agricultural ground will be given a factor of one because its economic benefit was considered in the Potential Increase in Productivity Factor, unless the land suffers from ponded surface water or seasonal flooding.

<table>
<thead>
<tr>
<th>Description</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief from potential or actual flooding with inundated structures, and health and safety hazards. Substantial increase in property value.</td>
<td>4 to 5</td>
</tr>
<tr>
<td>Relief from potential or actual occasional flooding, such water in basement or garage, including flooding which causes crop damage or erosion of the land. Moderate increase in property value.</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Relief from potential or actual ponding of water near structures or on cropland. Better use of property due to improvement. Increase in property value due to improved neighborhood reputation.</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Little need for improved drainage. Small effect on property value.</td>
<td>1 to 2</td>
</tr>
</tbody>
</table>

**Special Assessment:** Any items which affect or benefit only an individual parcel such as fence, cattle gate, tile outlet pipe, field access crossings, etc. Also any specific work due to property owners negligence, such as excessive tree and brush clearing beyond what is typical for the balance of the project.
Drainage Benefit Factors

Project Name: 

Landowner: 

Address: 

Total acres of Parcel: 

Parcel I.D. Number: 

CAUV Application Number: 

Prepared By: ___________________________ Date: ___________________________

1. Benefitted Acres: 

2. Reach Factor: 

3. Volume of Runoff: 

4. Location Elevation: 

5. Potential Productivity Increase: 

6. Flood Protection & Property Enhancement: 

Total Parcel Units = 1 x 2 x 3 x 4 x 5 x 6 

Parcel Assessment = (Units x $/Unit) + Special Assessments 

= __________ x __________ + __________ 

= __________________________

Elevation of Ditch Bank at Entrance: 

Elevation of Watershed Center Point of Parcel: 

Distance from Center Point to Ditch Entrance: 

Continued
### Calculations

#### Factor 3: Runoff Computation

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Acres</th>
<th>Curve No.</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>40' Road R/W</td>
<td></td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>60' Road R/W</td>
<td></td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Row Crops-conventional</td>
<td></td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Row Crops-conservation</td>
<td></td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td></td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>1 Acre Residential</td>
<td></td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Woods</td>
<td></td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Meadow</td>
<td></td>
<td>71</td>
<td></td>
</tr>
</tbody>
</table>

**Total Acres** = 

**Total Product** =

**Volume Runoff Factor**

#### Factor 5: Potential Increase in Productivity

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Acres</th>
<th>Benefited Soil Types</th>
<th>Per Acre Value</th>
<th>CAUV Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - P - W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Parcel CAUV Total** =

**Parcel CAUV** x 10 = **Potential Productivity Increase**

$1050/Acre

**$1050/Acre** x 10 =

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SUMMARY OF ASSESSMENT METHOD

Assessments are computed by the procedure developed by the Preble County Soil and Water Conservation District. This procedure takes into consideration the following three physical features of a watershed: land use, soils, and topography and how they are affected by any drainage work being completed within the watershed.

Land Use  The importance of land use will vary whether the land is in cropland, woodland, residential, highway or industrial uses. Since the amount of runoff on a particular parcel of land is directly related to the amount of impervious areas (pavements and roof areas) which it has, there is a greater need for drainage for those parcels of land with a large amount of impervious areas. Those land uses with large amounts of impervious areas are highway, industry, and business and these land uses are given at 70% to 100% drainage need factor. Land used as residential generally does not create as much runoff, since it has fewer impervious areas, and is given a 40% to 60% drainage need factor. By the same reasoning cropland is given a 20% drainage need factor, while woodland and pasture land which generally creates a small amount of runoff is given a 10% to 20% drainage need factor.

Land uses for each tract within the watershed are determined from aerial photographs or from field observation.

Soils  The U.S. Department of Agriculture, Soil Conservation Service has classified has into four hydrologic soil groups. These groups, according to their infiltration and transmission rates, are:
Soils having high infiltration rates and consisting primarily of deep, well to excessively drained sands and gravels. These soils have a high rate of water transmission.
Soils having moderate infiltration rates, when thoroughly wetted and consisting of moderately well drained to well drained soils. These soils have a moderate rate of water transmission.
Soils having slow infiltration rates, when thoroughly wetted and consisting of somewhat poorly drained soils. These soils have a slow rate of water transmission.
Soils having very slow infiltration rates and consisting of very poorly drained soils having a high clay content. These soils have a very slow rate of water transmission.

Since the "D" soils have the greatest need for artificial drainage, this group is rated at 100% drainage need. Consequently, the "C" soils are rated at 70%, "B" soils at 40%, and "A" soils at 10%. Soils maps and tables for Logan County are on file in the Engineer's Office.

Topography  The direct benefits obtained from drainage projects vary in a watershed in relation to the difference in elevation between portions of the watershed and the project area. For example, land located fifty feet higher than a tile outlet would not receive the same benefits from a ditch cleanout as land adjacent to the outlet. As the elevation above the project increases the benefits derived from the improvement generally decrease.

Topographical information for determining the elevation factor is obtained from the U.S.G.S. Topo Maps on file in the Engineer's Office. All land adjacent to the project improvement or within ten feet in elevation is considered to be 100% benefited. Each ten foot increase in elevation above the improvement would then be benefited less than the preceding ten foot interval. An example is shown below:
<table>
<thead>
<tr>
<th>Elevation Range</th>
<th>% Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 15'</td>
<td>100%</td>
</tr>
<tr>
<td>15 - 25'</td>
<td>80%</td>
</tr>
<tr>
<td>25 - 35'</td>
<td>50%</td>
</tr>
<tr>
<td>35 - 45'</td>
<td>30%</td>
</tr>
<tr>
<td>45 - 55'</td>
<td>20%</td>
</tr>
<tr>
<td>55+</td>
<td>1%</td>
</tr>
</tbody>
</table>

Considering the three major factors, land use, soils, and topography, assessments are then computed by the following method. First the Drainage Need Units or DNU are computed. To find the DNU for the factor, land use, one multiplies the number of acres for each land use within the watershed on a tract of land by the appropriate percentage factor (10-100%). This DNU is then divided by the number of acres in that tract of land within the watershed to obtain the average land use DNU per acre. The procedure for obtaining the soils DNU and topographical DNU is the same as for land use.

The next step is to determine the adjusted DNU or ADNU for each tract of land within the watershed. This is determined by multiplying (Total Acres)(Land Use DNU)(Soils DNU)(Topographical DNU) for each tract of land within the watershed. After the ADNU for each tract is computed, they are added to obtain the total ADNU for the watershed. The total ADNU is then divided into the total cost of the project to determine the cost per ADNU. In order to obtain the assessment for each individual tract of land the cost per ADNU is multiplied by the individual tract's ADNU.

At this time special assessments can be added. Additional assessments can be considered for areas subject to excessive flooding or for any improvements to individual landowners, which tend to be more for convenience or beautification than for drainage need. Such improvements would be improving field layouts or providing stream crossings. Likewise special allowances can be made for those tracts which do not obtain full benefits.

SUMMARY OF ASSESSMENT FACTORS

The factors shown below were primarily used for calculating the assessments.

A) Land Use:
   - Roads: 70%
   - Residential: 50%
   - Cultivated: 20%
   - Pasture: 20%
   - Woodland: 5%

B) Soils:
   - Group D: 100%
   - Group C: 70%
   - Group B: 40%

C) Topography: Elevation Range Factor
   - 0' - 10': 100%
   - 10' - 20': 80%
   - 20' - 30': 50%
   - 30' - 40': 40%
   - 40' - 50': 20%

Continued...
The following sample assessment calculation is for Belle Mathys' 0.13 acre tract on the corner of Main St. and Foundry St.

Total Acres = 0.13
Benefited Acres (excluding road right of way) = 0.08

**LAND USE**

<table>
<thead>
<tr>
<th>Type</th>
<th>Acres</th>
<th>Factor</th>
<th>DNU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0.08</td>
<td>0.50</td>
<td>0.04</td>
</tr>
<tr>
<td>Cultivated</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Average DNU = 0.04/0.08 = 0.50**

**TOTAL 0.04 acres**

**B) SOILS**

<table>
<thead>
<tr>
<th>Hydrologic Group</th>
<th>Acres</th>
<th>Factor</th>
<th>DNU</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.08</td>
<td>1.00</td>
<td>0.08</td>
</tr>
<tr>
<td>C</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Average DNU = 0.08/0.08 = 1.00**

**TOTAL 0.08**

**TOPOGRAPHY:**

<table>
<thead>
<tr>
<th>Elevation Range</th>
<th>Acres</th>
<th>Factor</th>
<th>DNU</th>
</tr>
</thead>
<tbody>
<tr>
<td>30' - 40'</td>
<td>0.08</td>
<td>0.40</td>
<td>0.032</td>
</tr>
</tbody>
</table>

**Average DNU = 0.032/0.08 = 0.40**

Tract ADNU = (0.50)(1.00)(0.40)(0.0800) = 0.016*

Total ADNU for the watershed = 9.003

Cost for watershed assessments = $56,809.79

Cost per ADNU = $56,809.79/9.003 = $6,310.35

Tract Assessment = (0.016)($6,310.35) = $100.97*

*Note: The assessments are calculated by a computer which carries the calculations out to 10 decimal places. The figures shown above were calculated using 3 decimal places and do not exactly match the actual final figures. The actual Tract ADNU is 0.0154 with an actual tract cost of $97.18.
Exhibit C.10. Assessment Method provided by Pickaway Soil and Water Conservation District.

MONTGOMERY COUNTY
DRAINAGE ASSESSMENT PROCEDURE

The following is an attempt to establish a procedure for distributing the costs of a drainage petition project among the affected landowners. The Montgomery County Engineer and the Montgomery Soil and Water Conservation District intend to use this assessment procedure for drainage projects petitioned under Ohio Revised Code Section 6131 and ORC Section 1515 respectively.

In order to distribute the costs of a drainage project, it is necessary to compare the parcels of land within the drainage area. ORC Section 6131 outlines the possible "benefits" that could be assigned to a parcel due to a drainage improvement. In this procedure, each "benefit" category has been given a numerical range of 1 to 10. Each parcel is then ranked against the other parcels in the drainage area on the 1 to 10 scale for each "benefit" category. The projects costs are then distributed among the parcels according to their "benefits" relative to the other parcels in the drainage area.

A Committee of persons involved in petitioned drainage projects was formed to develop this assessment procedure for Montgomery County.

The agencies represented on this committee are:

The Ohio State University Cooperative Extension Service Montgomery County
Extension Service
Ohio Department of Natural Resources - Division of Soil & Water Conservation
U.S.D.A Soil Conservation Service
Montgomery County Farm Bureau
Montgomery Soil and Water Conservation District
Montgomery County Engineer

Continued
### Exhibit C.10. (continued)

<table>
<thead>
<tr>
<th>Benefits under O.R.C. Sec. 6131</th>
<th>VI – A</th>
<th>IV</th>
<th>VI – B</th>
<th>VI – H</th>
<th>III</th>
<th>I</th>
<th>V</th>
<th>VI – C</th>
<th>VI – D</th>
<th>VI – E</th>
<th>VI – F</th>
<th>VI – G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>VI – A</td>
<td>1</td>
<td>Benefitted Acres</td>
<td>2</td>
<td>Reach Factor</td>
<td>3</td>
<td>Volume of Runoff Factor</td>
<td>4</td>
<td>Location/Elevation Factor</td>
<td>5</td>
<td>Potential Increase in Productivity Factor</td>
<td>6</td>
</tr>
</tbody>
</table>

Parcel Units = (1 x 2 x 3 x 4 x 5 x 6)

Parcel Assessment = (Units x $/Unit) + 7

Total Units = $/Unit = Total assessed project cost / Total Units
DRAINAGE PROJECT BENEFITS
PER OHIO REVISED CODE SECTION 6131

In determining drainage assessments the County Engineer shall give primary consideration to:

Potential increase in productivity,
He shall also give consideration to:
Quantity of drainage contributed
Relative location of property to the project
Portion of project through which drainage from the parcel flows
Value of the project to the watershed
Benefits as defined in 6131.01. "Benefit" or "benefits" means advantages to land and owners, to public corporations as entities, and to the State, resulting from drainage, conservation, control and management of water, and environmental, wildlife, and recreational improvements. Factors relevant to whether such advantages result include:
The watershed or entire land area drained or affected by the improvement,
The total volume of water draining into or through the improvement and the amount of water contributed by each landowner.
The use to be made of the improvement by any owner, public corporation, or the State. Also, benefits include any or all of the following factors:
Elimination or reduction of damage from flooding.
Removal of water conditions that jeopardize public health, safety, or welfare.
Increased value of land resulting from the improvement.
Use of water for irrigation, storage, regulation of stream flow, soil, conservation, water supply, or any other purpose incidental thereto.
Providing an outlet for the accelerated runoff from artificial drainage whenever the stream, watercourse, channel, or ditch under improvement is called upon to discharge functions for which it was not designed by nature; it being the legislative intent that uplands which have been removed from their natural state by deforestation, cultivation, artificial drainage, urban development, or other man-made causes will be considered as benefited by an improvement required to dispose of the accelerated flow of water from said uplands.

Assessment Categories
Benefited Acres: The total acreage contributing stormwater runoff to the improvement

Reach Factor: The percentage of the improvement through which runoff from a parcel flows, measured from the point the runoff from the parcel enters the improvement. For example:

<table>
<thead>
<tr>
<th>Percent of Improvement used</th>
<th>Reach Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>.1</td>
</tr>
</tbody>
</table>

Continued
Exhibit C.10. (continued)

Volume of Runoff Factor: Relative measure of the amount of direct runoff from a parcel. Volume of runoff can be found using the methods of Soil Conservation Service TR-55. Knowing the land use and soil type for a parcel the Runoff Curve Number can be found, leading to a volume of runoff described in inches over the entire parcel. For example:

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Runoff from 10-year storm</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4.00”</td>
<td>10.0</td>
</tr>
<tr>
<td>95</td>
<td>3.43”</td>
<td>8.6</td>
</tr>
<tr>
<td>90</td>
<td>2.92”</td>
<td>7.3</td>
</tr>
<tr>
<td>85</td>
<td>2.46”</td>
<td>6.2</td>
</tr>
<tr>
<td>80</td>
<td>2.04”</td>
<td>5.1</td>
</tr>
<tr>
<td>75</td>
<td>1.67”</td>
<td>4.2</td>
</tr>
<tr>
<td>70</td>
<td>1.33”</td>
<td>3.3</td>
</tr>
</tbody>
</table>

An example of how some typical land uses compare, assuming Class “C” soils and worst case hydrologic conditions is:

<table>
<thead>
<tr>
<th>Land use</th>
<th>Curve Number</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>40’ road right-of-way</td>
<td>92</td>
<td>7.8</td>
</tr>
<tr>
<td>60’ road right-of-way</td>
<td>90</td>
<td>7.3</td>
</tr>
<tr>
<td>Row crops</td>
<td>88</td>
<td>6.8</td>
</tr>
<tr>
<td>1 acre residential</td>
<td>79</td>
<td>4.9</td>
</tr>
<tr>
<td>Woods</td>
<td>77</td>
<td>4.6</td>
</tr>
</tbody>
</table>

When surface runoff from a parcel enters an improvement but the subsurface drainage is directed to a different drainage area, the volume of runoff factor may be reduced by 20%.

Location / Elevation Factor: This factor accounts for a parcel’s relative location to the improvement. The closer a parcel is to the improvement, the easier its access to that improvement and the more it is benefited by the improvement. Also, the closer a parcel’s elevation is to that of the improvement (e.g., Ditch bank elevation), the more that parcel will benefit from the improvement. A graph to relate location and elevation to the location/Elevation Factor is:

<table>
<thead>
<tr>
<th>Elevation above</th>
<th>0 to2000</th>
<th>2000 to 7000</th>
<th>7000 to 12,000</th>
<th>12,000 to 17,000</th>
<th>17,000 to 17,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design flow water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface or ditch Bank, feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 – 5</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5 – 10</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>10 – 15</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15 – 20</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Continued
Exhibit C.10. (continued)

Potential Increase in Productivity Factor: This applies to agricultural ground which has the potential for increased productivity due to improved drainage. It is measured using the Current Agricultural Use Values for each agricultural parcel. The CAU values measure the potential of a parcel given its soil type and land use assuming good management practices and good drainage. With a present high CAU value of $1050 per acre in this area, the POTENTIAL INCREASE IN PRODUCTIVITY FACTOR will be calculated as follows:

Parcel CAUV
$1050/Ac. \times 10 = \text{Potential increase in Productivity Factor}

For example, a parcel with a CAU value of $690/acre will have a factor of:

$690/Ac. \times 10 = 6.6

Non-agricultural ground will be assigned a factor of one.

Flood Protection/Property Enhancement Factor: This factor is used to measure the relative benefit to the respective parcels due to relief from flood damage and/or increase in property value due to the drainage improvement. Generally, agricultural ground will be given a factor of one because its economic benefit was considered in the Potential Increase in Productivity Factor, unless the land suffers from ponded surface water or seasonal flooding.

<table>
<thead>
<tr>
<th>Description</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief from potential or actual flooding with inundated structures, and health and safety hazards. Substantial increase in property value.</td>
<td>4 to 5</td>
</tr>
<tr>
<td>Relief from potential or actual occasional flooding, such water in basement or garage, including flooding which causes crop damage or erosion of the land. Moderate increase in property value.</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Relief from potential or actual ponding of water near structures or on cropland. Better use of property due to improvement. Increase in property value due to improved neighborhood reputation.</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Little need for improved drainage. Small effect on property value.</td>
<td>1 to 2</td>
</tr>
</tbody>
</table>

Special Assessment: Any items which affect or benefit only an individual parcel such as fence, cattle gate, tile outlet pipe, field access crossings, etc. Also any specific work due to property owners negligence, such as excessive tree and brush clearing beyond what is typical for the balance of the project.
Exhibit C.11. Assessment Method Provided by Miami Soil and Water Conservation District.

MONTGOMERY COUNTY
DRAINAGE ASSESSMENT PROCEDURE

This is the procedure for distributing the costs of a drainage petition project among the affected landowners. The Montgomery County Engineer and the Montgomery Soil and Water Conservation District intend to use this assessment procedure for drainage projects petitioned under Ohio Revised Code Section 6131 and ORC Section 1515 respectively.

In order to distribute the costs of a drainage project, it is necessary to compare the parcels of land within the drainage area. ORC Section 6131 outlines the possible "benefits" that could be assigned to a parcel due to a drainage improvement. In this procedure, each "benefit" category has been given a numerical range of 1 to 10. Each parcel is then ranked against the other parcels in the drainage area on the 1 to 10 scale for each "benefit" category. The project's costs are then distributed among the parcels according to their "benefits" relative to the other parcels in the drainage area.

A committee of persons involved in petitioned drainage projects was formed to develop this assessment procedure for Montgomery County.

The agencies represented on this committee are:

The Ohio State University Cooperative Extension Service Montgomery County Extension Service
Ohio Department of Natural Resources - Division of Soil & Water Conservation
U.S.D.A Soil Conservation Service
Montgomery County Farm Bureau
Montgomery Soil and Water Conservation District
Montgomery County Engineer

Continued
### Exhibit C.11. (continued)

<table>
<thead>
<tr>
<th>Category</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits under O.R.C. Sec. 6131</td>
<td>VI - A</td>
<td>VI - B</td>
<td>VI - H</td>
<td>VI - C</td>
<td>VI - D</td>
</tr>
<tr>
<td></td>
<td>VI - E</td>
<td>VI - F</td>
<td>VI - G</td>
<td>V</td>
<td>VI - C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefitted Acres</td>
<td>Reach Factor</td>
<td>Volume of Runoff Factor</td>
<td>Location/Elevation Factor</td>
<td>Potential Increase in Productivity Factor</td>
<td>Flood protection/Property Enhancement Factor</td>
<td>Special Assessment</td>
</tr>
</tbody>
</table>

Parcel Units = \((1 \times 2 \times 3 \times 4 \times 5 \times 6)\)

Parcel Assessment = \((\text{Units} \times \$/\text{Unit}) + 7\)

Total Units = \(\sum\ \text{Parcel units}\)

\$/\text{Unit} = \frac{\text{Total assessed project cost}}{\text{Total Units}}

Continued
Exhibit C.11. (continued)

DRAINAGE PROJECT BENEFITS
PER OHIO REVISED CODE SECTION 6131

In determining drainage assessments the County Engineer shall give primary consideration to:
Potential increase in productivity.
He shall also give consideration to:
Quantity of drainage contributed
Relative location of property to the project
Portion of project through which drainage from the parcel flows
Value of the project to the watershed
Benefits as defined in 6131.01. "Benefit" or "benefits" means advantages to land and owners, to public corporations as entities, and to the State, resulting from drainage, conservation, control and management of water, and environmental, wildlife, and recreational improvements. Factors relevant to whether such advantages result include:
The watershed or entire land area drained or affected by the improvement.
The total volume of water draining into or through the improvement and the amount of water contributed by each landowner.
The use to be made of the improvement by any owner, public corporation, or the State. Also, benefits include any or all of the following factors:
Elimination or reduction of damage from flooding.
Removal of water conditions that jeopardize public health, safety, or welfare.
Increased value of land resulting from the improvement.
Use of water for irrigation, storage, regulation of stream flow, soil, conservation, water supply, or any other purpose incidental thereto.
Providing an outlet for the accelerated runoff from artificial drainage whenever the stream, watercourse, channel, or ditch under improvement is called upon to discharge functions for which it was not designed by nature; it being the legislative intent that uplands which have been removed from their natural state by deforestation, cultivation, artificial drainage, urban development, or other man-made causes will be considered as benefitted by an improvement required to dispose of the accelerated flow of water from said uplands.

Assessment Categories

Benefitted Acres: The total acreage contributing stormwater runoff to the improvement

Reach Factor: The percentage of the improvement through which runoff from a parcel flows, measured from the point the runoff from the parcel enters the improvement. For example:

<table>
<thead>
<tr>
<th>Percent of Improvement used</th>
<th>Reach Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>.1</td>
</tr>
</tbody>
</table>

Continued
Exhibit C.11. (continued)

Volume of Runoff Factor: Relative measure of the amount of direct runoff from a parcel. Volume of runoff can be found using the methods of Soil Conservation Service TR-55. Knowing the land use and soil type for a parcel the Runoff Curve Number can be found, leading to a volume of runoff described in inches over the entire parcel. For example:

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Runoff from 10-year storm</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4.00&quot;</td>
<td>10.0</td>
</tr>
<tr>
<td>95</td>
<td>3.43&quot;</td>
<td>8.6</td>
</tr>
<tr>
<td>90</td>
<td>2.92&quot;</td>
<td>7.3</td>
</tr>
<tr>
<td>85</td>
<td>2.46&quot;</td>
<td>6.2</td>
</tr>
<tr>
<td>80</td>
<td>2.04&quot;</td>
<td>5.1</td>
</tr>
<tr>
<td>75</td>
<td>1.67&quot;</td>
<td>4.2</td>
</tr>
<tr>
<td>70</td>
<td>1.33&quot;</td>
<td>3.3</td>
</tr>
</tbody>
</table>

An example of how some typical land uses compare, assuming Class "C" soils and worst case hydrologic conditions is:

<table>
<thead>
<tr>
<th>Land use</th>
<th>Curve Number</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>40&quot; road right-of-way</td>
<td>92</td>
<td>7.8</td>
</tr>
<tr>
<td>60&quot; road right-of-way</td>
<td>90</td>
<td>7.3</td>
</tr>
<tr>
<td>Row crops</td>
<td>88</td>
<td>6.8</td>
</tr>
<tr>
<td>1 acre residential</td>
<td>79</td>
<td>4.9</td>
</tr>
<tr>
<td>Woods</td>
<td>77</td>
<td>4.6</td>
</tr>
</tbody>
</table>

When surface runoff from a parcel enters an improvement but the subsurface drainage is directed to a different drainage area, the volume of runoff factor may be reduced by 20%.

Location / Elevation Factor: This factor accounts for a parcel’s relative location to the improvement. The closer a parcel is to the improvement, the easier its access to that improvement is and the more it is benefitted by the improvement. Also, the closer a parcel’s elevation is to that of the improvement (eg. Ditch bank elevation), the more that parcel will benefit from the improvement. A graph to relate location and elevation to the location/Elevation Factor is:

<table>
<thead>
<tr>
<th>Elevation above Design flow water</th>
<th>Surface or ditch Bank, feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 to 2000</td>
</tr>
<tr>
<td>0 - 5</td>
<td>10</td>
</tr>
<tr>
<td>5 - 10</td>
<td>7</td>
</tr>
<tr>
<td>10 - 15</td>
<td>5</td>
</tr>
<tr>
<td>15 - 20</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>1</td>
</tr>
</tbody>
</table>

Potential Increase in Productivity Factor: This applies to agricultural ground which has the potential for increased productivity due to improved drainage. It is measured using the Current Agricultural Use Values for each agricultural parcel. The CAU values measure the potential of a parcel given its soil type and land use assuming good management practices and good drainage. With a present high CAU value of $1050 per acre in this area, the POTENTIAL INCREASE IN PRODUCTIVITY FACTOR will be calculated as follows:
Exhibit C.11. (continued)

Parcel CAUV

\[ \frac{\$1050/\text{Ac.}}{} \times 10 = \text{Potential increase in Productivity Factor} \]
For example, a parcel with a CAU value of $690/acre will have a factor of:

\[ \frac{\$690/\text{Ac.}}{} \times 10 = 6.6 \]

Non-agricultural ground will be assigned a factor of one.

**Flood Protection/Property Enhancement Factor:** This factor is used to measure the relative benefit to the respective parcels due to relief from flood damage and/or increase in property value due to the drainage improvement. Generally, agricultural ground will be given a factor of one because its economic benefit was considered in the Potential Increase in Productivity Factor, unless the land suffers from ponded surface water or seasonal flooding.

<table>
<thead>
<tr>
<th>Description</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief from potential or actual flooding with inundated structures, and health and safety hazards.</td>
<td>4 to 5</td>
</tr>
<tr>
<td>Substantial increase in property value.</td>
<td></td>
</tr>
<tr>
<td>Relief from potential or actual occasional flooding, such as water in basement or garage, including flooding which causes crop damage or erosion of the land. Moderate increase in property value.</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Relief from potential or actual ponding of water near structures or on cropland. Better use of property due to improvement. Increase in property value due to improved neighborhood reputation.</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Little need for improved drainage. Small effect on property value.</td>
<td>1 to 2</td>
</tr>
</tbody>
</table>

**Special Assessment:** Any items which affect or benefit only an individual parcel such as fence, cattle gate, tile outlet pipe, field access crossings, etc. Also any specific work due to property owners negligence, such as excessive tree and brush clearing beyond what is typical for the balance of the project.

**Volume of runoff factors**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>6.8</td>
<td>77</td>
</tr>
<tr>
<td>87</td>
<td>6.7</td>
<td>76</td>
</tr>
<tr>
<td>86</td>
<td>6.5</td>
<td>75</td>
</tr>
<tr>
<td>85</td>
<td>6.2</td>
<td>74</td>
</tr>
<tr>
<td>84</td>
<td>6.0</td>
<td>73</td>
</tr>
<tr>
<td>83</td>
<td>5.8</td>
<td>72</td>
</tr>
<tr>
<td>82</td>
<td>5.5</td>
<td>71</td>
</tr>
<tr>
<td>81</td>
<td>5.3</td>
<td>70</td>
</tr>
<tr>
<td>80</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>4.75</td>
<td></td>
</tr>
</tbody>
</table>

425
VARIED ASSESSMENT METHOD

(100% ACRE METHOD)

A parcel assessment is based on the number of acres that will benefit, where water enters along the ditch, and the proximity of the benefited acres to the ditch (remoteness factor).

The ditch is divided into reaches with 100% at the upper end and theoretically, 0% at the outlet (usually 10-20%). We use any available information to determine the drainage area, and where the water enters the ditch, old watershed maps, topographic surveys, county records, landowner interviews, aerial photos and actually walking over the watershed, especially the boundary areas.

The percentages assigned to each parcel are determined from the reach and remoteness factors. We mainly use our experience and knowledge of the area to assign these percentages.

The benefited acres are multiplied by the percentage to determine the individual 100% acre amount. These amounts are added together for all the landowners. This is the total, 100% acre amount. The total project amount to be assessed is divided by the total 100% acres. This is a dollar amount or factor to be multiplied by each individual parcel’s 100% acre value to determine the cost.

See the example assessment sheet.
Exhibit C.13. Assessment Method provided by Prebic Soil and Water Conservation District

**Benefitted Acres:** The total acreage contributing stormwater runoff to the improvement

**Reach Factor:** The percentage of the improvement through which runoff from a parcel flows, measured from the point the runoff from the parcel enters the improvement. For example:

<table>
<thead>
<tr>
<th>Percent of Improvement used</th>
<th>Reach Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Volume of Runoff Factor:** Relative measure of the amount of direct runoff from a parcel. Volume of runoff can be found using the methods of Soil Conservation Service TR-55. Knowing the land use and soil type for a parcel the Runoff Curve Number can be found, leading to a volume of runoff described in inches over the entire parcel. For example:

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Runoff from 10-year storm</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4.00&quot;</td>
<td>10.0</td>
</tr>
<tr>
<td>95</td>
<td>3.43&quot;</td>
<td>8.6</td>
</tr>
<tr>
<td>90</td>
<td>2.92&quot;</td>
<td>7.3</td>
</tr>
<tr>
<td>85</td>
<td>2.46&quot;</td>
<td>6.2</td>
</tr>
<tr>
<td>80</td>
<td>2.04&quot;</td>
<td>5.1</td>
</tr>
<tr>
<td>75</td>
<td>1.67&quot;</td>
<td>4.2</td>
</tr>
<tr>
<td>70</td>
<td>1.33&quot;</td>
<td>3.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Land use</th>
<th>Curve Number</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>40' road right-of-way</td>
<td>92</td>
<td>7.8</td>
</tr>
<tr>
<td>60' road right-of-way</td>
<td>90</td>
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<tr>
<td>Row crops</td>
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<td>6.8</td>
</tr>
<tr>
<td>1 acre residential</td>
<td>79</td>
<td>4.9</td>
</tr>
<tr>
<td>Woods</td>
<td>77</td>
<td>4.6</td>
</tr>
</tbody>
</table>

When surface runoff from a parcel enters an improvement but the subsurface drainage is directed to a different drainage area, the volume of runoff factor may be reduced by 20%.

**Location/Elevation Factor:** This factor accounts for a parcel's relative location to the improvement. The closer a parcel is to the improvement, the easier its access to that improvement is and the more it is benefitted by the improvement. A graph to relate location factor is:

<table>
<thead>
<tr>
<th>Location:</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Lower portion of watershed)</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
</tr>
</tbody>
</table>

| (Upper portion of watershed)| 2.0    |
|                            | 1.0    |

Continued
Exhibit C.13. (continued)

Potential Increase in Productivity Factor: This applies to agricultural ground which has the potential for increased productivity due to improved drainage. It is measured using the Current Agricultural Use Values for each agricultural parcel. The CAU values measure the potential of a parcel given its soil type and land use assuming good management practices and good drainage. With a present high CAU value of $1050 per acre in this area, the POTENTIAL INCREASE IN PRODUCTIVITY FACTOR will be calculated as follows:

Parcel CAUV
$1050/Ac. \times 10 = \text{Potential increase in Productivity Factor}

For example, a parcel with a CAU value of $690/acre will have a factor of:

$690/Ac. \times 10 = 6.6

Flood Protection/Property Enhancement Factor: This factor is used to measure the relative benefit to the respective parcels due to relief from flood damage and/or increase in property value due to the drainage improvement. Generally, agricultural ground will be given a factor of one because its economic benefit was considered in the Potential Increase in Productivity Factor, unless the land suffers from ponded surface water or seasonal flooding.

<table>
<thead>
<tr>
<th>Description</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief from flooding with inundated structures, and health and safety hazards. Substantial increase in property value.</td>
<td>7 to 10</td>
</tr>
<tr>
<td>Relief from occasional flooding, such water in basement or garage. Moderate increase in property value.</td>
<td>5 to 7</td>
</tr>
<tr>
<td>Relief from ponding of water near structures better use of property due to improvement. Increase in property value due to improved neighborhood reputation.</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Little need for improved drainage. Small effect on property value.</td>
<td>1 to 3</td>
</tr>
</tbody>
</table>

Special Assessment: Any items which affect or benefit only an individual parcel such as fence, cattle gate, tile outlet pipe, field access crossings, etc. Also any specific work due to property owners negligence.

Continued
Exhibit C.13. (continued)

Assessment Categories

Benefitted Acres: The total acreage contributing stormwater runoff to the improvement.

Reach Factor: The percentage of the improvement through which runoff from a parcel flows, measured from the point the runoff from the parcel enters the improvement. For example:

<table>
<thead>
<tr>
<th>Percent of Improvement Used</th>
<th>Reach Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

(Percent of Improvement use) x (5) = Farm Factor
Established $50.00 Assessment minimum.

Volume of Runoff Factor: Relative measure of the amount of direct runoff from a parcel. Volume of runoff can be found using the methods of Soil Conservation Service TR-55. Knowing the land use and soil type for a parcel the Runoff Curve Number can be found, leading to a volume of runoff described in inches over the entire parcel. For example:

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Runoff from 10 Year Storm</th>
<th>Volume of Runoff Factor</th>
<th>Curve Number</th>
<th>Runoff from 10 Year Storm</th>
<th>Volume of Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4.1</td>
<td>10</td>
<td>79</td>
<td>2.04</td>
<td>5.0</td>
</tr>
<tr>
<td>99</td>
<td>3.87</td>
<td>9.4</td>
<td>78</td>
<td>1.97</td>
<td>4.8</td>
</tr>
<tr>
<td>98</td>
<td>3.76</td>
<td>9.2</td>
<td>77</td>
<td>1.89</td>
<td>4.6</td>
</tr>
<tr>
<td>97</td>
<td>3.65</td>
<td>8.9</td>
<td>76</td>
<td>1.81</td>
<td>4.4</td>
</tr>
<tr>
<td>96</td>
<td>3.52</td>
<td>8.6</td>
<td>75</td>
<td>1.74</td>
<td>4.2</td>
</tr>
<tr>
<td>95</td>
<td>3.42</td>
<td>8.3</td>
<td>74</td>
<td>1.68</td>
<td>4.1</td>
</tr>
<tr>
<td>94</td>
<td>3.32</td>
<td>8.1</td>
<td>73</td>
<td>1.60</td>
<td>3.9</td>
</tr>
<tr>
<td>93</td>
<td>3.22</td>
<td>7.9</td>
<td>72</td>
<td>1.53</td>
<td>3.7</td>
</tr>
<tr>
<td>92</td>
<td>3.11</td>
<td>7.6</td>
<td>71</td>
<td>1.46</td>
<td>3.6</td>
</tr>
<tr>
<td>91</td>
<td>3.02</td>
<td>7.4</td>
<td>70</td>
<td>1.40</td>
<td>3.4</td>
</tr>
<tr>
<td>90</td>
<td>2.92</td>
<td>7.1</td>
<td>69</td>
<td>1.35</td>
<td>3.2</td>
</tr>
<tr>
<td>89</td>
<td>2.82</td>
<td>6.9</td>
<td>68</td>
<td>1.26</td>
<td>3.1</td>
</tr>
<tr>
<td>88</td>
<td>2.73</td>
<td>6.7</td>
<td>67</td>
<td>1.21</td>
<td>3.0</td>
</tr>
<tr>
<td>87</td>
<td>2.65</td>
<td>6.4</td>
<td>66</td>
<td>1.15</td>
<td>2.8</td>
</tr>
<tr>
<td>86</td>
<td>2.55</td>
<td>6.2</td>
<td>65</td>
<td>1.09</td>
<td>2.7</td>
</tr>
<tr>
<td>85</td>
<td>2.46</td>
<td>6.0</td>
<td>64</td>
<td>1.03</td>
<td>2.5</td>
</tr>
<tr>
<td>84</td>
<td>2.37</td>
<td>5.8</td>
<td>63</td>
<td>0.98</td>
<td>2.4</td>
</tr>
<tr>
<td>83</td>
<td>2.29</td>
<td>5.6</td>
<td>62</td>
<td>0.91</td>
<td>2.2</td>
</tr>
<tr>
<td>82</td>
<td>2.20</td>
<td>5.4</td>
<td>61</td>
<td>0.86</td>
<td>2.1</td>
</tr>
<tr>
<td>81</td>
<td>2.12</td>
<td>5.2</td>
<td>60</td>
<td>0.81</td>
<td>2.0</td>
</tr>
</tbody>
</table>

When surface runoff from a parcel enters an improvement but the subsurface drainage is directed to a different drainage area, the volume of runoff factor may be reduced by 20%.

Location/Elevation Factor: This factor accounts for a parcel's relative location to the improvement. The closer a parcel is to the improvement, the easier its access to that improvement is and the more it is benefited by the improvement. Also, the closer a parcel's elevation is to that of the improvement (e.g. Ditch bank elevation), the more that parcel will benefit from the improvement. A graph to relate location and elevation to the location/Elevation Factor is:

Continued
Exhibit C.13. (continued)

<table>
<thead>
<tr>
<th>Elevation Above</th>
<th>Design Flow Water</th>
<th>Surface or Ditch</th>
<th>Bank, Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 – 1000'</td>
<td>1000 – 2000'</td>
<td>2000 – 3000'</td>
</tr>
<tr>
<td>0 – 10'</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>11 – 20'</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 20'</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Potential Increase in Productivity Factor: This applies to agricultural ground which has the potential for increased productivity due to improved drainage. It is measured using the Current Agricultural Use Values for each agricultural parcel. The CAU values measure the potential of a parcel given its soil type and land use assuming good management practices and good drainage. With a present high CAU value of $1050 per acre in this area, the POTENTIAL INCREASE IN PRODUCTIVITY FACTOR will be calculated as follows:

Parcel CAUV

$1050/Ac. \times 10 = \text{Potential increase in Productivity Factor}

For example, a parcel with a CAU value of $690/acre will have a factor of:

$690/Ac. \times 10 = 6.6

Non-agricultural ground will be assigned a factor of one.

Flood Protection/Property Enhancement Factor: This factor is used to measure the relative benefit to the respective parcels due to relief from flood damage and/or increase in property value due to the drainage improvement. Generally, agricultural ground will be given a factor of one because its economic benefit was considered in the Potential Increase in Productivity Factor, unless the land suffers from ponded surface water or seasonal flooding.

<table>
<thead>
<tr>
<th>Description</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief from potential or actual flooding with inundated structures, and health and safety hazards. Substantial increase in property value.</td>
<td>4 to 5</td>
</tr>
<tr>
<td>Relief from potential or actual occasional flooding, such as water in basement or garage, including flooding which causes crop damage or erosion of the land. Moderate increase in property value.</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Relief from potential or actual ponding of water near structures or on cropland. Better use of property due to improvement. Increase in property value due to improved neighborhood reputation.</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Little need for improved drainage. Small effect on property value.</td>
<td>1 to 2</td>
</tr>
</tbody>
</table>

Special Assessment: Any items which affect or benefit only an individual parcel such as fence, cattle gate, tile outlet pipe, field access crossings, etc. Also any specific work due to property owners negligence, such as excessive tree and brush clearing beyond what is typical for the balance of the project.
PRELIMINARY INVESTIGATION
Assemble records and maps of pertinent previous petitions and prepare preliminary map of the project drainage area showing tributaries, land ownership, property lines, section lines, highways, watershed boundary, etc.
Interview landowners or tenants or best other available sources of information for each tract of land to verify the acreage, ownership, and location of property lines and to ascertain and tabulate the details of the existing drainage system for each tract, including the location of outlets and courses for both surface and subsurface drainage.

DETERMINATION OF DRAINAGE LAND CLASSIFICATION AND LOCATION REMOTENESS
CLASSIFICATION OF DRAINAGE LANDS
From the data collected by interviews, each tract is divided up into classes of drainage land and the acreage of each class tabulated for each tract. The classes of drainage land are as follows:
CLASS I. Land which has both surface and tile drainage flowing into the project.
CLASS II. Land which has only surface drainage flowing into the project, but which could also be tiled to discharge into the project. (Tillable land.)
CLASS III. Tillable land with surface drainage only into project. No existing tile and cannot be tiled to project.
CLASS IV. Land which has only tile drainage emptying into the project and for which the surface drainage flows into another watershed.
CLASS V. Land which has only surface drainage flowing into the project and for which tile drainage discharges into another watershed.
CLASS VI. Land which has only surface drainage flowing into the project and for which tile drainage is impractical or not feasible to drain into the project. (ie: woods, permanent pastures due to stone being near surface, etc.; basins which overflow to project.)
CLASS VII. Land which has no natural or tile drainage, for which drainage is not practical or feasible; and land which has not been removed from its natural state.

LOCATION REMOTENESS GROUPING.
After the tracts of land have been classified in the above drainage categories, they are then divided into two general groups. Group One includes all land draining directly into the project and into tributaries within one mile* of the project. Group Two includes all other lands draining into the project thru tributaries or up-stream on the main channel beyond the 1-mile limit.

*This may vary depending on the rate of descent of the lands into the Project and the designed depth of flow. Generally in Sandusky County a major stream will flow about 5-feet deep and the rate of descent of the lands is about 0.10% thus, the one-mile wide flood plain.

Continued
Exhibit C.14. (continued)

RATES OF BENEFITS

GROUP ONE

The benefit to each class of drainage in each tract of land in Group One is next computed. It is estimated that the benefit derived from the establishment of an adequate outlet for each acre of land by classification is as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Rate per Acre</th>
<th>Total Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>$40.00</td>
<td>$160.00</td>
</tr>
<tr>
<td>Class II</td>
<td>$30.00</td>
<td>$120.00</td>
</tr>
<tr>
<td>Class III</td>
<td>$25.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Class IV</td>
<td>$15.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Class V</td>
<td>$15.00</td>
<td>$60.00</td>
</tr>
<tr>
<td>Class VI</td>
<td>$15.00</td>
<td>$60.00</td>
</tr>
<tr>
<td>Class VII</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

The above values of benefits for the several classifications of land drainage are those estimated for land used for agricultural purposes. If land is used for other purposes, such as residential lots, manufacturing, rock quarrying, etc., then these values must be adjusted to proportionately reflect the benefits to be derived. Also, lands which are subject to flooding which would be relieved entirely or in part by the project would be adjusted to include this benefit.

The gross benefit for any tract of land thus becomes the sum of the benefits assigned to all classes of land within that tract. The resulting values of benefits in Group 1 are tabulated for each tract of land.

* These rates are used when the greater rates would produce an astronomical grand total of net benefits (same as “appraised benefits”)

GROUP TWO

The benefit to each class of drainage land in each tract of land in Group Two is next computed. The benefits derived from the establishment of an adequate outlet for each acre of land in group two is the same as for land in group one, except that, because the project does not provide a direct outlet for these lands, a percentage reduction is made in the benefits depending upon the remoteness of the land from the project. In this way, land within one mile of the project carries the same dollar benefits as land draining directly into the project. Lands lying more than 6 miles from the project are estimated to receive 15% of the benefits of land draining directly into the project. Lands lying in the area between 1 mile and 6 miles from the project have benefits reduced in proportion to their distance from the project. (1) The resulting values of benefits in group two are tabulated for each tract of land.

APPLIED FACTOR FOR PERCENTAGE OF PROJECT USED

Because it is not reasonable that benefits should be assigned to any land for improvements in a project that lie upstream from the drainage outlet of that land, it is necessary to again reduce the benefits for lands lying in both Groups One and Two by reason of the length of the project thru which the drainage of each tract flows. To accomplish this, the location of the outlet into the project of each tract or tributary is determined and its distance from the downstream terminus of the project. This distance divided by the entire length of the project is the percentage of the project that is used by each tract. The tabulated benefits for Groups One and Two are then multiplied by this percentage of project used, resulting in net benefits to each tract by reason of the project.

Continued
Exhibit C.14. (continued)
For some tracts of land, there may be special benefits which are not common to the project as a whole, such as local control or erosion and improvement of farming operations. These benefits are evaluated and added to the benefits for the pertinent tracts determined above to give the total benefits for each tract in the watershed. These benefits are tabulated and the total of these benefits for all tracts in the watershed is the total benefit from the project.

SUMMARY
Drainage assessments as estimated by the Engineer are computed by the process of dividing the estimated cost of the project exclusive of special assessments by the total net benefits which gives a ratio or percentage by which the net benefit of any one tract of land can be multiplied to determine the estimated assessment for that tract.
The following percentages are applied for major streams: 0 to 1 mile = 100%; 1 to 2 miles = 90%; 2 to 3 miles = 80%; 3 to 4 miles = 60%; 4 to 5 miles = 40%; 5 to 6 miles = 25%; 6 miles plus is 15%. These percentages may be refined for minor streams on half-mile increments with percentages proportioned. The special assessments mentioned above are those made against any tract of land for special structures or work within that tract which is a special benefit to that tract, such as the removal of man-made obstructions, construction or repair of bridges or culverts, or special work requested by the owner.
The total assessment for any tract then becomes the sum of the drainage assessment plus the special assessments, if any.

Brush and trees located between the tops of the banks are generally removed at the expense of the owner of the land. Brush and tree removal outside of the ditch which are required to be removed for the operation of equipment and leveling spoils are charged to the whole project.

Procedure for assessing brush and tree removals on major streams may be assessed against the project as a whole, depending chiefly upon whether or not the lands are in their natural state. Other factors which should be considered on a specific project generally weigh heavily toward assessing the brush and tree removals to the project as a whole.

TILE OR STORM SEWER INSTALLATION ASSESSMENTS
Existing open ditches petitioned for closure
The chief benefit of closing an open ditch are derived by the property upon which the tile is placed. Therefore, the assessments are computed for open ditch reconstruction in the manner outlined above with the difference between the cost of open ditch reconstruction and tile construction being borne by the property receiving the tile.

Existing Tile or Storm Sewers presently inadequate
Assessments for replacing a tile or storm sewer, which was adequate at the time of installation, are computed in the same manner as for an open ditch. The reasoning being that (1) the increased runoff from uplands necessitates the larger conduit; (2) the original closure of the ditch was approved by upstream owners by acquiescence or by court order.

Certainly the peculiar circumstances of a project must be considered in working out the detailed assessments. This county has one project which the peculiar circumstances almost completely governed the compiling of the assessments.
Moral and equitable judgment is basic to the composition of assessments.

MAINTENANCE ASSESSMENT
The "net benefit" determined for the computation of the construction drainage assessment becomes the "appraisal of benefit" for the purposes of Chapter 6137 of the Ohio Revised Code.
The six year reappraisals occur to those lands whose classification of drainage are changed and/or the development of which necessitates an adjustment in proportion to the increased rate of runoff.

Continued
Exhibit C.15. Seneca SWCD Assessment Method

Seneca County Ditch Assessments* Procedure Used in Group Projects
Based on Materials Provided by Bill Smith, Seneca SWCD
August, 1982

Part 1. Small projects with a straight-line ditch one or two miles in length with no laterals.

The assessment on each owner is based upon the number of runoff units for his/her property. The total cost of the project is divided by the total number of runoff units in the watershed to determine the cost per runoff unit. Then, the number of runoff units for each property is multiplied by the cost per unit to determine the total cost for each property owner. Runoff units are assigned using the runoff factors in Table 1.

Table 1. Runoff units assigned according to land use.

<table>
<thead>
<tr>
<th>Runoff Factor Units</th>
<th>Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>One acre or less surrounding a livable dwelling</td>
</tr>
<tr>
<td>1 per acre</td>
<td>Agricultural</td>
</tr>
<tr>
<td>2 per acre</td>
<td>Road or utilities right-of-way</td>
</tr>
<tr>
<td>8 per acre</td>
<td>Commercial</td>
</tr>
<tr>
<td>10 per acre</td>
<td>Industrial, using large quantity of water</td>
</tr>
</tbody>
</table>

For example, a 40 acre farm with one house would have a total of (39 x 1) plus (1 x 4) = 43 units. If the value of a unit for the total project was $12.50, then the assessment for the 40 acre property would be $12.50 x 43 units = $537.50.

Part 2. Intermediate size projects that include several miles of ditch and one or more laterals.

Assessments are estimated using a step-by-step procedure that builds upon the runoff factor units outlined in Part 1. The project is divided into reaches and the watershed area is divided into zones. A reach begins or ends at each change in conditions along the improvement such as a junction with a lateral or major change in grade. An outline of the steps to estimate assessments follows.

*Group projects in Seneca County are done on a voluntary basis, so the SWCD refers to the landowners’ “agreed on share of costs”, rather than assessments. Projects are carried out by mutual agreement as authorized in Ohio Revised Code Section 6131.63 which provides for maintenance assessments.
Compute units per landowner as in Part 1.

Estimate construction cost for each reach.

Determine unit cost for each Zone.

\[
\text{Unit cost Zone 1} = \frac{\text{Cost of Reach 1}}{\text{Sum of units in all zones}}
\]

\[
\text{Unit cost Zone 2} = \text{Unit cost Zone 1} + \frac{\text{Cost of Reach 2}}{\text{Sum of units in Zones 2 & 3}}
\]

\[
\text{Unit cost Zone 3} = \text{Unit cost Zone 1} + \text{Unit cost Zone 2} + \frac{\text{Cost of Reach 3}}{\text{Sum of units in Zone 3}}
\]

\[
\text{Unit cost Zone 4} = \text{Unit cost Zone 1} + \frac{\text{Cost of Lateral}}{\text{Sum of units in Zone 4}}
\]

Compute the cost for each owner, which is equal to the number of runoff units for his property times the cost per unit of the zone where the property is located.

Example computation:

Our example owner has 50 units

Costs of the project and units per zone are as follows:

| Reach 1 | $50,000  | 4,000 units Zone 1 |
| Reach 2 | 30,000   | 3,000 units Zone 2 |
| Reach 3 | 10,000   | 1,000 units Zone 3 |
| Lateral | 20,000   | 4,000 units Zone 4 |
| Total   | $110,000 | 12,000 units Total |

Unit costs are as follows:

Zone 1 \[
\frac{\$50,000}{12,000} = \$4.17
\]

Zone 2 \[
\frac{\$4.17 + \frac{\$30,000}{3,000 \times 1000}}{1000} = \$4.17 + \frac{\$11.67}{10.00} = \$11.67
\]

Zone 3 \[
\frac{\$4.17 + \$11.67 + \$10,000}{1000} = \frac{\$4.17 + \$11.67 + \$10.00}{10.00} = \$25.84
\]

Lateral \[
\frac{\$4.17 + \$20,000}{4,000} = \frac{\$4.17 + \$5.00}{4.00} = \$9.17
\]

If our example owner has his property in Zone 2, his cost will be 50 times \$11.67 = \$583.50.
APPENDIX D

PROPOSED CONTROL SHEETS
Exhibit D.1. Instructions for completing group drainage project control sheets.

Entries must be completed for column headings in bold face type. Agencies could complete other entries in as much detail as is useful to them, once the basics are completed.

Type of request uses CP for county petition; MA for mutual agreement; SB for Senate Bill 160.

The components and ID codes used are defined in the following table. A project request is identified by its primary component for comparison purposes. We could use one or more mixed categories if it appears it would be useful for analysis.

For project construction purposes, the use of components would be helpful for those projects that contain more than one component which is useful to track for analysis, such as a project that contains and open ditch as well as a subsurface drain. I would expect to have few of these. However, most open ditch projects may contain erosion control structures which I feel it would be useful to track, since these may provide off-site benefits and may be cost-shared.

We may need to discuss with the agencies their needs so we can complete these forms with as much consistency as possible.

Table 1. Components and IDs used in control sheets.

<table>
<thead>
<tr>
<th>Component</th>
<th>ID used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open ditch</td>
<td>OPEN</td>
</tr>
<tr>
<td>Subsurf drain</td>
<td>SUBSURF</td>
</tr>
<tr>
<td>Grass w/w</td>
<td>GRASS</td>
</tr>
<tr>
<td>Pump station</td>
<td>PUMP</td>
</tr>
<tr>
<td>Surf drain</td>
<td>SURF</td>
</tr>
<tr>
<td>Subdiv main</td>
<td>SUBDIV</td>
</tr>
<tr>
<td>Detention basin</td>
<td>DETENT</td>
</tr>
<tr>
<td>Retention basin</td>
<td>RETENT</td>
</tr>
<tr>
<td>Erosion control structure</td>
<td>OTHER</td>
</tr>
<tr>
<td>Other</td>
<td>OTHER</td>
</tr>
</tbody>
</table>
**Exhibit D.2.** Draft worksheet for tracking the fate of requests for group drainage project assistance.

<table>
<thead>
<tr>
<th>Project Name or ID</th>
<th>Type of Request (CP, MA, SB)</th>
<th>Primary Component</th>
<th>First Hearing or Meeting</th>
<th>Second Hearing or Meeting</th>
<th>Final Hearing or Meeting</th>
<th>Approved for Construction</th>
<th>Rejected</th>
<th>Withdrawn</th>
<th>Date Action Was Taken on Request</th>
<th>Date Placed on Construction</th>
<th>Date Placed on Maintenance Program</th>
</tr>
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<tbody>
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</table>

**Exhibit D.3.** Draft worksheet for tracking construction costs of group drainage projects constructed under the authority of the Ohio drainage laws.

<table>
<thead>
<tr>
<th>Project Name or ID</th>
<th>Total Length (feet)</th>
<th>Total Area Benefited (acres)</th>
<th>Costs Paid by Landowners</th>
<th>Costs Paid by Special Charges</th>
<th>Costs Incurred By Agency Not Jointly Assessed To Individuals</th>
<th>Costs Assessed To Local Government (including cost-share)</th>
<th>Costs Assessed To State Government (including cost-share)</th>
<th>Costs Paid By Federal Government (including cost-share)</th>
<th>Costs Paid By Other Entities (grants)</th>
<th>Project Expenditures</th>
</tr>
</thead>
<tbody>
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APPENDIX E

FORTTRAN SOURCE CODE
Exhibit E.1. FORTRAN program to calculate drain spacing based on the Hooghoudt, Donnan, and Ernst steady state equations.

```fortran
C SPACING8.FOR
C 12/14/98

$debug
$large
$nofloatcalls
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
CCCCCCCCCCCCC Ellipse Equation Drain Spacing Program
CCCCCCCCCCCCCCCCC
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C Based on a program by Eric Desmond, USDA-ARS, 1988-89
C Further comments and changes by Bruce Atherton, December 1996
C Adjustment made in impermeable layer calculation, April 25, 1998
C Major changes made starting April 26, 1998. Changed Hooghoudt
C equation form, plus hope to add Ernst equation.
C Input inits are inches & in/hr.
C Output units are selected by user.
C
8/13/98 - BCA
C
Additions made to allow selection of either 1-layer or
C 2-layer profile for running Hooghoudt, and for 2-layer profile
when
C using Ernst to calculate drain spacing for profiles where there
is a
C higher conductivity layer below a lower conductivity layer.
C
PROGRAM SPACING8

EXTERNAL CASE1, CASE2, CASE3

C
COMMON AFAC(7,6),A

C
COMMON SCILN(1600), RESTRI(1600), EQMINT(1600), EQMAXT(1600),
C +SPMIN(1600), SPMAX(1600),
ASTRIX(1600), SOILID(1600), SURETEX(1600),
C +EQMINB(1600), EQMAXB(1600), AMIN(1600), AMAX(1600), DIFACE(1600)
CHARACTER*25 MSG
CHARACTER*14 SOILN
CHARACTER*6 SOILID
CHARACTER*10 SURETEX
REAL RESTRO(1600), EQMINT(1600), EQMAXT(1600),
+C+SPMIN(1600), SPMAX(1600), AMIN(1600), AMAX(1600),
+E+EQMINB(1600), EQMAXB(1600), DMIN(1600), DMIN(1600), DMAX(1600)
DIMENSION SOILN(1600), SOILID(1600), SURETEX(1600), DMAX(1600)
DIMENSION DPLAYER(6), CONMIN(6), CONMAX(6), CONK(6), LENDN(1600)
C
DIMENSION AFAC(7,6),
CHARACTER*14 SOIL
CHARACTER*6 VSOILID
```

440
CHARACTER*10 VSURTAX
REAL DC,M,RF,RESTRI,QUADA,QUADB,QUADC,DFT,F,ADF,T
COMMON PI,DRAIN,M,CHOICE
INTEGER*2 P
INTEGER OUTFLG,MFLAG,CHOICE,SFLAG,TEST2,EFLAG,DFLAG,TEST3
WTD=30.0
RESTRI=120.0
DINTER=0.0
MFLAG=0
OUTFLG=0
DDEPTH=0.00
DC=0.00
DIADR=10.4

C Units of variables:
C DLAYER - cm
C CONMIN(I), CONMAX(I), CONK(I) - cm/hr
C DIADR - cm

OPEN(1,FILE='SOILTST.INP',STATUS='OLD')
OPEN(2,FILE='LOKSPACE.OUT',STATUS='UNKNOWN')
OPEN(3,FILE='SOIL_K.OUT',STATUS='UNKNOWN')
OPEN(4,FILE='HIKSPACE.OUT',STATUS='UNKNOWN')
PRINT *, 'This program calculates minimum and maximum drain
spaci
+ng'
PRINT *, 'Based on minimum and maximum permeability values.'
PRINT *,
PRINT *, 'Enter the depth to drain for this run (cm):'
READ (*,4) DDEPTH
4
PRINT *, 'Enter the drainage coefficient x.xx (cm/day):'
READ(*,2)DC
PRINT *, 'Enter the steady-state water table depth xx.x (cm):'
READ(*,3)WTD
2
3
PRINT *
C PRINT *, 'Default output is metric.'
C PRINT *, 'Do you wish english output instead? (Y/N)'
C READ(*,')TEST
C IF (TEST.EQ.'Y') OUTFLG=1
C IF (TEST.EQ.'y') OUTFLG=1
C
PRINT *,''
PRINT *, 'Enter the number corresponding with your choice of valu
+1 es to use for depth to restrictive layer.'
PRINT *, '1. Use depth of soil profile from soil survey'
PRINT *, '2. Use value contained in the input file'
READ(*,5)TEST2
C
PRINT *,

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PRINT *, 'Enter the number corresponding with your choice of valu
C +1 as to use for interface depth.'
C PRINT *, '1. Use depth calculated in program, if any'
C PRINT *, '2. Use value contained in the input file'
C READ(*,5)TEST3
C TEST3=1
C
C PRINT *, '
C PRINT *, 'Enter the number corresponding with your choice of soil
C + profile simulations.'
C PRINT *, '1. Single layer profile using Hooghoudt'
C PRINT *, '2. Two layer profile, interface at drain depth using
C Hooghoudt'
C PRINT *, '3. Two layer profile Using Ernst'
C PRINT *, '4. One layer profile using Donnan'
C READ(*,5)CHOICE
C
5
C FORMAT (I1)
C DC=DC/24.0
C PI=3.14159
C
C Would be good to position pointer to first valid data record, so
C there could be a header file on the input file.
C
1 DO 9999 P=1,53
C CONKT=0.0
C CONKB=0.0
C CONKAD=0.0
C
C PRINT *, 'PROGRAM IS RUNNING'
C DO 10 I=1,6
C DLAYER(I)=0.0
C CONMIN(I)=0.0
C CONMAX(I)=0.0
C CONK(I)=0.0
C 10 CONTINUE
C MFLAG=0
C SFLAG=0
C K=1
C DDRAIN=DDEPTH
C CONL=0.0
C CONKAD=0.0
C ADEPTH=0.0
C SPACE1=1000.0
C M=DDRAIN-30
C
C DC set to cm/hr
C
C Read in the conductivity (CONK) and layer depth (DLAYER) information
C from input file
C
C READ(1,200,END=1001)VSOLID,SOIL,VSURTEX,RESTRI,DINTER,
C + (DLAYER(I),CONMIN(I),CONMAX(I), I=1,6)
C 200 FORMAT(A6,A14,A10,2(F5.1),6(F4.1,F5.2,F5.2))
C IF SOIL=0 EXIT
SOILN(P)=SOIL
SOILD(P)=VSOILD
SUREX(P)=VSUREX

PRINT *, 'SOILD(P)= ', SOILD(P)
C IF (P.LT.12) GO TO 9999
C Find number of soil layers (LEND) for this soil.
C Change units from inches to cm, and from in/hr to cm/hr.
RESTRI=RESTRI*2.54
DINTER=DINTER*2.54
DO 17 I=1,6
   IF (DLAYER(I).EQ.0.0) GO TO 17
   DLAYER(I)=DLAYER(I)*2.54
   CONMIN(I)=CONMIN(I)*2.54
   IF (CONMIN(I).EQ.0.0) CONMIN(I)=0.001
   CONMAX(I)=CONMAX(I)*2.54
   IF (CONMAX(I).EQ.0.0) CONMAX(I)=0.001
   CONK(I)=CONMIN(I)
C IF(DLAYER(I).EQ.0.0) GO TO 17
17 LEND=I
CONTINUE
C Here we will have to direct function to appropriate module.

IF ((CHOICE.EQ.1).OR.(CHOICE.EQ.4)) GO TO 1100
IF (CHOICE.EQ.2) GO TO 2100
IF (CHOICE.EQ.3) GO TO 3100
STOP

C CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C C Alternative 1, calculate conductivity for single layer profile.
C C Calculate CONKAD for additive layers going down from the surface.
C C If the next layer has a CONK value less than 1/5th of CONKAD then
C C it is an impermeable layer (ADEPTH). If not ADEPTH is set to the
C C depth of the last layer.
C BCA The top 30 cm is not counted in CONKAD calculations.
C BCA IFLAG=1 runs the equation for minimum conductivity value from
C input file.
C IFLAG=2 runs the equation for maximum conductivity value.
C BCA Change units to cm from inches, feet to meters
C
C CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

1100 IFLAG=1
   KK=0
1111 IF(IFLAG.EQ.1) GO TO 1114
   DORAIN=ADEPTH
   CONL=0.0
CONKAD=0.0
ADEPTH=0.0
SFLAG=0
DO 1112 I=1,LEND
CONK(I)=CONMAX(I)

1112 CONTINUE
KK=0
LENDN(P)=LEND
1114 DO 1120 I=1,LEND
C IF(DLAY(I).EQ.0.0) THEN
C ADEPTH=DLAY(I-1)
C GO TO 1125
C ENDIF
C IF(CONK(I).EQ.0.0) GO TO 1125

C BCA Skip layers less than 30 cm deep and do not use top 30 cm of
C profile for conductivity calculations.
C PRINT *,SOILN(P),' I= ',I,' KK=',KK,' DLAY=',DLAY(I)
C IF (I.LE.5) THEN
PRINT *, ' CONK(I)= ',CONK(I),' CONK(I+1)= ',CONK(I+1)
ENDIF
IF (LEND.EQ.1) THEN
CONKAD=CONK(I)
ADEPTH=DLAY(I)
GO TO 1124
ENDIF
IF(DLAY(I).LE.WTD) GO TO 1120
KK=KK+1
IF(I.EQ.1) THEN
CONL=CONL + (CONK(I)*(DLAY(I)-WTD))
ENDIF
IF(I.GT.1) THEN
IF (KK.EQ.1) THEN
CONL=CONL + CONK(I)*(DLAY(I)-WTD)
ELSE
CONL=CONL + CONK(I)*(DLAY(I)-DLAY(I-1))
ENDIF
ENDIF
CONKAD=CONL/(DLAY(I)-WTD)

PRINT *, 'I= ',I,' CONL=',CONL,' CONKAD=',CONKAD

C BCA Check for restrictive layer.
C If below drain depth, do spacing calculation.
C If above drain depth, quit if above 50 cm, or set drain depth
to restrictive layer depth.
C IF (I.LT.LEND) THEN
X = CONK(I+1)/CONKAD
IF(X.LT.0.2) THEN
   SFLAG=1
   ADEPTH=DLAYER(I)
   IF(ADEPTH.GT.DDRAIN) GO TO 1124
   IF(ADEPTH.GE.50.0) THEN
      DDRAIN=DLAYER(I)
      GO TO 1124
   ELSE
      DDRAIN=999.9
      GO TO 1160
   ENDIF
ELSE
   GO TO 1124
ENDIF
1120 CONTINUE
C
C BCA (11/98) Restrictive layer depth is depth of last layer
DLAYER(END)
C or value read from file (RESTRI), as selected at startup(RESTRI).
C
1124 IF(SFLAG.NE.1) THEN
   ADEPTH=DLAYER(END)
   IF(TEST2.EQ.2) ADEPTH=RESTRI
   IF(ADEPTH.LT.DDRAIN) DDRAIN=ADEPTH
ENDIF
C
C BCA (11/98) This is one-layer profile.
C
1123 CONKT=CONKAD
   CONKB=CONKAD
C PRINT *, ' DDRAIN= ', DDRAIN, ' CHOICE= ', CHOICE, ' ADEPTH= ', ADEPTH
C PAUSE
1125 IF (CHOICE.EQ.1) THEN
   CALL CASE2 (ADEPTH, DDRAIN, DC, DIADR, CONKT, CONKB, RFLAG, WTD, SPACE1)
ELSE
   CALL CASE1 (ADEPTH, DDRAIN, DC, DIADR, CONKT, CONKB, RFLAG, WTD, SPACE1)
ENDIF
C IF (RFLAG.EQ.999.0) RESTRI(P)=RFLAG
C IF (IFLAG.EQ.1) EQMINT(P)=CONKAD
C IF (IFLAG.EQ.1) AMIN(P)=ADEPTH
C IF (IFLAG.EQ.2) EQMAXT(P)=CONKAD
C IF (IFLAG.EQ.2) AMAX(P)=ADEPTH
C Skip this section SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C***********************************************************
C BCA Units changed to feet, inches/hour if OUTFLG is set to Y.
C
IF (OUTFLG.NE.1) GO TO 1160
ADEPTH = ADEPTH / 30.48
SPACE1 = SPACE1 / .3048
CONKAD = CONKAD / 2.54
DRAIN = DRAIN / 2.54

C******************************************************************************
C SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C Store values and record K as units/hr
C 60 RESTRI(P) = ADEPTH
1160 IF(IFLAG.EQ.1) THEN
    SPMIN(P) = SPACE1
    EQMIN(P) = CONKAD
    AMIN(P) = ADEPTH
    DMIN(P) = DRAIN
    IFLAG = IFLAG + 1
    CONK = 0.0
    CONKB = 0.0
    CONKAD = 0.0
    GO TO 1111
ENDIF
IF(IFLAG.EQ.2) THEN
    SPMAX(P) = SPACE1
    EQMAX(P) = CONKAD
    AMAX(P) = ADEPTH
    DMAX(P) = DRAIN
    GO TO 9999
ENDIF

C End section for calculating 1-layer average conductivity over entire layer.
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
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C
C
CCerdings 2, calculating Kt and Kb, with interface at drain depth.
C
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C
C Calculate CONKAD for additive layers going down from the surface. If the next layer has a CONK value less than 1/5th of CONKAD then it is an impermeable layer (ADEPTH). If not ADEPTH is set to the depth of the last layer.
C
BBA The top 30 cm is not counted in CONKAD calculations.
C
BBA IFLAG=1 runs the equation for minimum conductivity value from input file.
C
BBA 2 runs the equation for maximum conductivity value.
C
BBA Change units to cm from inches, feet to meters
C
CCCCCC

446
2100 IFLAG=1
   MFLAG=0
   KK=0
   J=11
2111 IF(IFLAG.EQ.1) GO TO 2114
   SFLAG=0
   MFLAG=0
   DDRAIN=DDEPTH
   CONL=0.0
   CONKAD=0.0
   ADEPTH=0.0
   DO 2112 I=1,LEN
   CONK(I)=CONMAX(I)
2112 CONTINUE
   LENDN(P)=LEN
   KK=0
   IF (LEND.EQ.1) THEN
   CONKT=CONK(LEND)
   CONKB=CONK(LEND)
   ADEPTH=DLAYER(LEND)
   DINTFC=DDRAIN
   GO TO 2123
   ENDIF
C
C Calculate K(t)
C
2114 DO 2120 I=1,LEN
C
C BCA Skip layers less than 30 cm deep and do not use top 30 cm of
C profile for conductivity calculations.
C
   PRINT *,SOILN(P),' I=',I,' KK=',KK,' DLAYER=',DLAYER(I)
   IF (I.LE.5) THEN
   PRINT *," CONK(I)='",CONK(I)," CONK(I+1)='",CONK(I+1)
   ENDIF
   IF(DLAYER(I).LE.WTD) GO TO 2120
   KK=KK+1
   IF (DLAYER(I).LE.DDRAIN) THEN
   IF (I.EQ.1) THEN
   CONL=CONL+CONK(I)*(DLAYER(I)-WTD)
   GO TO 2120
   ENDIF
   IF (I.GT.1) THEN
   IF (KK.EQ.1) THEN
   CONL=CONL+CONK(I)*(DLAYER(I)-WTD)
   ELSE
   CONL=CONL+CONK(I)*(DLAYER(I)-DLAYER(I-1))
   ENDIF
   ENDIF
   ENDIF
   ENDIF
   IF(DLAYER(I).GT.DDRAIN) THEN
MFLAG=MFLAG+1
DINTFC=DDRRAIN
IF (I.EQ.1) THEN
  CONL=CONL+CONK(I)*(DDRAIN-WTD)
ENDIF
IF (I.GT.1) THEN
  IF (K.K.EQ.1) THEN
    CONL=CONL+CONK(I)*(DDRAIN-WTD)
  ELSE
    CONL=CONL+CONK(I)*(DDRAIN-DLAYER(I-1))
  ENDIF
ENDIF
ENDIF
CONKT=CONL/(DDRAIN-WTD)
GO TO 2121
ENDIF
CONKT=CONL/(DLAYER(I)-WTD)

PRINT *, 'I= ', I, ' CONL = ', CONL, ' CONKT = ', CONKT
C
C BCA Check for restrictive layer above drain depth.
C BCA At this point, DLAYER(I) is above drain depth.
C
C
IF (MFLAG.GE.1) GO TO 2121
IF (I.LEN) THEN
  X=CONK(I+1)/CONKT
  IF (X.LEN 0.2) THEN
    SFLAG=1
    ADEPTH=DLAYER(I)
    IF (ADEPTH.GE.50) THEN
      DDRAIN=DLAYER(I)
      GO TO 2121
    ELSE
      DDRAIN=999.9
      GO TO 2160
    ENDIF
  ENDIF
ELSE
  ENDIF
ENDIF
GO TO 2124
ENDIF
2120 CONTINUE
C
C Calculate K of bottom layer.
C
2121 IF (DLAYER(I).EQ.DDRRAIN) I=I+1
CONKE=0.0
CONL=0.0
DO 2122 J=I,LEND

  IF (MFLAG.GE.1) THEN
    CONL=CONL+CONK(J)*(DLAYER(J)-DDRRAIN)
  ELSE
    CONL=CONL+CONK(J)*(DLAYER(J)-DLAYER(J-1))
  ENDIF

448
PRINT *, 'J= ',J,' DLAYER(J)= ',DLAYER(J)
PRINT *, 'I= ',I,' CONL=',CONL,' CONKT=',CONKT

CONKB=CONL/(DLAYER(J)-DDRAIN)
MFLAG=MFLAG+1
IF (SFLAG.EQ.1) GO TO 2122
IF (J.LT.LEND) THEN
   X=CONK(J+1)/CONKB
   IF(X.LT.0.2) THEN
      ADEPTH=DLAYER(J)
   ENDIF
   PRINT *, ',SOILN(P),', ADEPTH= ',ADEPTH,' RATIO= ',X
   GO TO 2125
ENDIF
ENDIF
2122 ENDDO

2123 CONTINUE

C
C BCA Restrictive layer depth is depth of last layer DLAYER(LEND)
C or value read from file (RESTRI), as selected at startup(TEST2).
C
2124 IF(SFLAG.NE.1) THEN
   ADEPTH=DLAYER(LEND)
   IF(TEST2.EQ.2) ADEPTH=RESTRI
   IF(ADEPTH.LT.DDRAIN) THEN
      DDRAIN=ADEPTH
      CONT=0.0
      GO TO 2160
   ENDIF
ENDIF

C
C BCA Do separate runs for minimum and maximum conductivity values.
C
PRINT *, ',DDRAIN= ',DDRAIN,' CHOICE= ',CHOICE,' DDEPTH= ',DDEPTH

2125 CALL CASE2 (ADEPTH,DDRAIN,DC,DIAWR,CONKT,CONKB,RFLAG,WTD,SPACE1)

C
C IF (RFLAG.EQ.999.0) RESTRI(P)=RFLAG

C
C Skip this section SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C**********************************************
C BCA Units changed to feet, inches/hour if OUTFLG is set to Y.
C
C
C IF (OUTFLG.NE.1) GO TO 2160
ADEPHT=ADEPHT/30.48
SPACE1=SPACE1/.3048
CONKAD=CONKAD/2.54
C**********************************************
C SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C Store values and record K as units/hr
C
449
2160 IF(IFLAG.EQ.1) THEN
  SPMIN(P)=SPACE1
  EQMINT(P)=CONKT
  EQMINB(P)=CONKB
  AMIN(P)=ADEPHT
  OMINT(P)=DRAIN
  IFLAG=IFLAG+1
  I=1
  J=1
  GO TO 2111
ENDIF
IF(IFLAG.EQ.2) THEN
  SPMAX(P)=SPACE1
  EQMAXT(P)=CONKT
  EQMAXB(P)=CONKB
  AMAX(P)=ADEPHT
  DMAX(P)=DRAIN
  GO TO 9999
ENDIF

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C End section for calculating average conductivity for two layer profile.
C interface occurs at drain depth.
C
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C Alternative 3: 2-layer profile with interface coinciding with change from lower conductivity to higher conductivity layer.
C
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C Calculate CONKAD for additive layers going down from the surface. If the next layer has a CONK value less than 1/5th of CONKAD then it is an impermeable layer (ADEPHT). If not ADEPHT is set to the depth of the last layer.
C BCA The top 30 cm is not counted in CONKAD calculations.
C
C BCA IFLAG=1 runs the equation for minimum conductivity value from input file.
C IFLAG=2 runs the equation for maximum conductivity value.
C
C BCA Change units to cm from inches, feet to meters
C
CCCCCCCC

3100 IFLAG=1
  MFLAG=0
  KK=0
  J=11

450
PRINT *, 'MINIMUM K RUN'
3111 IF (IFLAG.EQ.1) GO TO 3114
PRINT *, 'MAXIMUM K RUN'
   SFLAG=0
   MFLAG=0
   MSG=0
   DRAIN=DDEPHT
   CONL=0.0
   CONKAD=0.0
   ADEPHT=0.0
   DO 3112 I=1,6
      CONK(I)=CONMAX(I)
      PRINT *, 'I=', I, ', CONK(I)= ', CONK(I), ', DLAYER(I)= ', DLAYER(I)
   3112 CONTINUE
   LENDN(P)=LEND
C PAUSE
   KK=0
C
C Calculate K(t)
C
3114 IF (LEND.EQ.1) THEN
   DRAIN=777.7
   GO TO 3160
ENDIF
EFLAG=0
C
C Find interface where conductivity increases.
C
   DO 3118 I=1,LEND
      PRINT *, 'CONK(I)= ', CONK(I), ', CONK(I+1)= ', CONK(I+1)
      IF (DLAYER(I).LE.WTD) THEN
         GO TO 3118
      ENDIF
      IF (CONK(I+1).GT.CONK(I)) THEN
         DINTFC=DLAYER(I)
         EFLAG=I
         GO TO 3119
      ENDIF
3118 ENDDO
   IF ((TEST3.EQ.2).AND.(LEND.GT.2)) THEN
      DINTFC=DINTER
   ELSE
      DRAIN=888.8
      GO TO 3160
   ENDIF
3119 DO 3120 I=1,EFLAG
C
C BCA Skip layers less than 30 cm deep and do not use top 30 cm of
C profile for conductivity calculations.
C
C   PRINT *, SOILN(P), ' I= ', I, ', KK= ', KK, ', DLAYER= ', DLAYER(I)
   IF (I.LE.5) THEN
C PRINT ' ,CONK(I) = ',CONK(I) ,',' CONK(I+1) = ',CONK(I+1)
C ENDIF

IF(DLAYER(I).LE.WTD) GO TO 3120
KK=KK+1
C IF(DLAYER(I).LE.DDRAIN) THEN
  IF (I.EQ.1) THEN
    CONL=CONL+CONK(I)*(DLAYER(I)-WTD)
    GO TO 3131
  ENDIF
  IF (I.GT.1) THEN
    IF (KK.EQ.1) THEN
      CONL=CONL+CONK(I)*(DLAYER(I)-WTD)
    ELSE
      CONL=CONL+CONK(I)*(DLAYER(I)-DLAYER(I-1))
    ENDIF
  ENDIF
C ENDIF
C IF (DLAYER(I).GT.DDRAIN) THEN
  MFLAG=MFLAG+1
  DINTFC=DDRAIN
  C IF (I.EQ.1) THEN
    CONL=CONL+CONK(I)*(DDRAIN-WTD)
  C ENDIF
  C IF (I.GT.1) THEN
    IF (KK.EQ.1) THEN
      CONL=CONL+CONK(I)*(DDRAIN-WTD)
    ELSE
      CONL=CONL+CONK(I)*(DDRAIN-DELAYER(I-1))
    ENDIF
  C ENDIF
C ENDIF
3131 CONK=CONL/(DLAYER(I)-WTD)

C PRINT ' ,I= ',I,COLN = ',CONL = ',CONK = ',CONK ,',' EFLAG= '
C EFLAG
C BCA Check for restrictive layer above drain depth.
C BCA At this point, DLAYER(I) is above drain depth.
C IF (MFLAG.GE.1) GO TO 3121
IF (I.LT.LEND) THEN
  X=CONK(I+1)/CONK
  IF (X.LT.0.2) THEN
    SFLAG=1
    ADEPTH=DLAYER(I)
    IF (ADEPTH.GE.50) THEN
    DDRAIN=DLAYER(I)
    GO TO 3121
    ELSE
      DDRAIN=999.9
      GO TO 3160
    ENDIF
    ENDIF
C ENDIF

452
ELSE
    GO TO 3124
ENDIF
3120 CONTINUE
C
Calculate K of bottom layer.
C
3121 IF (DLAYER(J).EQ.DDRAIN) I=I+1
    CONKB=0.0
    CONL=0.0
    PRINT *, 'JUST PASSED LINE 3121', DINTFC=',DINTFC,' J=', I
    DO 3122 J=I,LEND
C
    IF (MFLAG.EQ.1) THEN
        CONL=CONL + CONK(J)*(DLAYER(J)-DINTFC)
    C
    ELSE
        PRINT *, 'J=', J, ' CONK(J) =', CONK(J), ' DINTFC(J) =', DLAYER(J)
        CONL=CONL + CONK(J)*(DLAYER(J)-DLAYER(J-1))
    ENDIF
    C
    CONKB=CONL/(DLAYER(J)-DINTFC)
C
MFLAG=MFLAG+1
IF (SFLAG.EQ.1) GO TO 3122
IF (J.LT.LEND) THEN
    X=CONK(J+1)/CONKB
    IF (X.LT.0.2) THEN
        ADEPTH=DLAYER(J)
        PRINT *, ' ', 'SOILN(P)', ' ADEPTH=', ADEPTH, ' RATIO=', X
        GO TO 3125
    ENDIF
ENDIF
ENDIF
3122 ENDDO
3123 CONTINUE
C
BCA Restrictive layer depth is depth of last layer DLAYER(LEND)
C
or value read from file (RESTRI), as selected at startup(REST2).
C
3124 IF (SFLAG.NE.1) THEN
    ADEPTH=DLAYER(LEND)
    IF (TEST2.EQ.2) ADEPTH=RESTRI
    IF (ADEPTH.LT.DDRAIN) GO TO 3160
ENDIF
C
BCA Do separate runs for minimum and maximum conductivity values.
C
    PRINT *, ' DDRAIN=', DDRAIN, ' CHOICE=', CHOICE, ' DDEPTH=', DDEPTH
    PRINT *, 'J=', J, ' DLAYER(J)=', DLAYER(J), ' CONKB=', CONKB
    PRINT *, 'I=', I, ' CONL=', CONL, ' CONKB=', CONKB
3125 CALL CASE3 (ADEPTH, DDRAIN, DC, DIADR, CONKT, CONKB, DINTFC, WTD, SPACE1)
C IF (RFLAG.EQ.999.0) RESTRI(P)=RFLAG

C
C Skip this section SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C*************************************************************************
C BCA Units changed to feet, inches/hour if OUTFLG is set to Y.
C
IF (OUTFLG.NE.1) GO TO 3160
ADEPTH=ADEPTH/30.48
SPACE1=SPACE1/.3048
CONKAD=CONKAD/2.54
C*************************************************************************
C SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C Store values and record K as units/hr
C
3160 IF(IFLAG.EQ.1) THEN
  SPMIN(P)=SPACE1
  EQMINT(P)=CONKT
  EQMINB(P)=CONKB
  AMIN(P)=ADEPTH
  DMIN(P)=DDRAIN
  DMIN(P)=DINTFC
  DINTFC=0.0
  IFLAG=IFLAG+1
C DO 3170 K=1,6
C CONK(K)=0.0
C 3170 ENDDO
I=1
J=1
IF (LEND.LE.5) THEN
  WRITE(3,206) SOILN(P),SOILID(P),CONK(LEND),CONK(LEND+1)
ENDIF
206 FORMAT(1X,A14,1X,A6,1X,2(F6.1))
GO TO 3111
ENDIF
IF(IFLAG.EQ.2) THEN
  SPMAX(P)=SPACE1
  EQMAXT(P)=CONKT
  EQMAXB(P)=CONKB
  AMAX(P)=ADEPTH
  DMAX(P)=DDRAIN
  DIMAX(P)=DINTFC
  DINTFC=0.0
  IF (LEND.LE.5) THEN
    WRITE(3,206) SOILN(P),SOILID(P),CONK(LEND),CONK(LEND+1)
  ENDIF
  GO TO 9999
ENDIF

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CCCCCCC

454
End section for calculating average conductivity for two layer profile,
interface occurs at drain depth.

BCA Units of SPACE1=cm
TEST PRINTING
PRINT *, 'CONKAD=', CONKAD, ', ADEPT=', ADEPT, ', DDRAIN=', DDRAIN
PRINT *
PRINT *, 'LAYER ', I, ': ', DLAYER(I), CONMIN(I), CONMAX(I)

BCA Units changed to cm
BCA Following line not needed if previous unit conversion
is not done.
IF (OUTFLG.EQ.1) ADEPT=ADEPT+30.48

PRINT *, 'SPACE1 =', SPACE1
IF (IFLAG.EQ.2) GO TO 9999
IFLAG=IFLAG+1
GO TO 3111

If there is bedrock ...
666 RESTRI(P)=999.0

9999 ENDDO

1001 DC=DC*24
WRITE(2,703)
WRITE(4,706)
IF (CHOICE.EQ.1) THEN
WRITE(2,711)
WRITE(4,711)
ENDIF
IF (CHOICE.EQ.2) THEN
WRITE(2,712)
WRITE(4,712)
ENDIF
IF (CHOICE.EQ.3) THEN
WRITE(2,713)
WRITE(4,713)
ENDIF
IF (CHOICE.EQ.4) THEN
WRITE(2,714)
WRITE(4,714)
ENDIF

703 FORMAT('Output of Program SPACING8.FOR. Low permeability values +used.')
706 FORMAT('Output of Program SPACING8.FOR. High permeability values +used.')
WRITE(2,701)DC
WRITE(2,702)DDRAIN
WRITE(2,705)DIADR
WRITE(2,707)WTD
WRITE(4,701)DC
WRITE(4,702)DDRAIN
WRITE(4,705)DIADR
WRITE(4,707)WTD

701 FORMAT(' Design Drainage Rate = ',F5.2,' cm/day')
702 FORMAT(' Depth to drain= ',F5.1,' cm')
705 FORMAT(' Drain diameter= ',F5.1,' cm')
707 FORMAT(' Steady-state water table depth= ',F5.1,' cm')
711 FORMAT(' Hooghoudt with single layer profile')
712 FORMAT(' Hooghoudt with 2 layer profile')
713 FORMAT(' Ernst with 2 layer profile')
714 FORMAT(' Donnan with single layer profile')

WRITE(2,*),' Surface
+Equivalent K Interface'
WRITE(2,*),' Soil Name Texture ID Layer Depth
+Top Bottom Spacing Depth'

WRITE(4,*),' Surface
+Equivalent K Interface'
WRITE(4,*),' Soil Name Texture ID Layer Depth
+Top Bottom Spacing Depth'

IF (OUTFLG.EQ.1)GO TO 700
WRITE(2,*),(cm (cm)
WRITE(2,*),(cm/hr) (cm/hr) (meters)
WRITE(4,*),(cm (cm)
WRITE(4,*),(cm/hr) (cm/hr) (meters)

GO TO 800
700 WRITE(2,*),(ft (in)
WRITE(2,*),(in/hr) (in/hr) (Feet)
WRITE(2,*),(ft (in)
WRITE(4,*),(in/hr) (in/hr) (Feet)
WRITE(4,*),(ft (in)

800 DO 888 I=1,P-1
IF (I.EQ.1)GO TO 820
IF (SOILD(I).NE.SOILD(I-1))GO TO 820
IF (SPMIN(I).NE.SPMIN(I-1))GO TO 820
IF (SPMAX(I).EQ.SPMAX(I-1))GO TO 888
C820 IF (RESTRI(I).EQ.999.0) THEN
C     GO TO 888

456
ADD soil id number AND surface texture values in printout.

WRITE (2, 209) SOILN(I), SURTEX(I), SOILB(I), AMIN(I), DMIN(I),
  +EQMIN(I), EQMINB(I), SPMIN(I), LENH(I), DIMN(I)
WRITE (4, 209) SOILN(I), SURTEX(I), SOILB(I), AMAX(I), DMAX(I),
  +EQMAX(I), EQMAXB(I), SPMAX(I), LENH(I), DIMN(I)

207 FORMAT (1X, A14, 1X, A10, 1X, A6, 2X, F6.1, 2X, 'Restrictive layer found above drain depth')
209 FORMAT (1X, A14, 1X, A10, 1X, A6, 1X, F6.1, 6X, F5.1, 2(2X, F6.3), 3X, F7.1, 2X,
  +1I, F6.1)
850 FORMAT (6F5.1, 2X)
888 CONTINUE

WRITE out meaning of no output flags such as 999.9

WRITE (2, 210)
WRITE (2, 211)
WRITE (2, 212)
WRITE (2, 213)
WRITE (2, 214)
WRITE (4, 210)
WRITE (4, 211)
WRITE (4, 212)
WRITE (4, 213)
WRITE (4, 214)

210 FORMAT (5X)
211 FORMAT (2X, 'Drain depth = 666.6 (Ernst equation): Db and/or Dr is less than 1/4 of the calculated spacing.')
212 FORMAT (2X, 'Drain depth = 777.7 (Ernst equation): This soil has a single layer profile; use Hooghoudt.')
213 FORMAT (2X, 'Drain depth = 888.8 (Ernst equation): This soil has no deep layer with conductivity higher than the layers above.')
214 FORMAT (2X, 'Drain depth = 999.9: A restrictive layer was at least 50 cm depth.')
215 FORMAT (2X, 'This is the matrix used to solve for A.')

IF (CHOICE, EQ, 3) THEN
  WRITE (2, 210)
  WRITE (2, 215)
  WRITE (4, 210)
  WRITE (4, 213)
  DO 860 I = 1, 7
    WRITE (2, 850) (AFACT(I, J), J = 1, 6)
    WRITE (4, 850) (AFACT(I, J), J = 1, 6)
860   ENDDO
ENDIF

ENDIF

END
END

BLOCK DATA
COMMON AFAC(7,6)

DATA ((AFAC(I,J),J=1,6),I=1,7) /
+2.0,3.0,5.0,9.0,15.0,30.0,
+2.4,3.2,4.6,6.2,8.0,10.0,
+2.6,3.3,4.5,5.5,6.8,8.0,
+2.8,3.5,4.4,4.8,5.6,6.2,
+3.2,3.6,4.2,4.5,4.8,5.0,
+3.6,3.7,4.0,4.2,4.4,4.6,
+3.8,4.0,4.0,4.0,4.2,4.6/
END

C

SUBROUTINE CASE1 - HOOGHOUDT/DONNAN EQUATION

SUBROUTINE CASE1 (ADEPTH, DDRAIN, DC, DIADR, CONKT, CONKB, RFLAG, WTD, 
+SPACE1)
    SPACE1=1000.0
    PI=3.14157
    RFLAG=0.0
    D=ADEPTH- DDRAIN+(DIADR/2.0)
    IF(D.LT.0.0) THEN
        RFLAG=999.0
        SPACE1=0.0
    RETURN
ENDIF
B=ADEPTH-WTD
M=DDRAIN-WTD-(DIADR/2.0)

C
Calculate AND SPACING based on initial spacing estimate.
Reiterate until spacing does not change.

GO TO 40
C
30 DE=SPACE1/(8./PI*(LOG(SPACE1/.51)-1.15))
C
WRITE(*,*),'D/L > 0.3'
C
GO TO 45
C
40 ALPHA=3.55 - 1.6*D/SPACE1 + 2.0*D*D/(SPACE1*SPACE1)
C
DE=D/(1.0 + (D/SPACE1) *(8.0/PI*LOG(D/.51)-ALPHA))
C
45 B=DE+M
C
PRINT *, 'B= ',B,' DDRAIN= ',DDRAIN,' D= ',D,DC
C
BCA CHANGE FORMULA FROM HOOGHOUDT/DONNAN TO HOOGHOUDT
40 SPACE2=SQRTR(4.0*CONKT*(B**2.0-D**2.0)/DC)
C SPACE2=SQRT((2*CONKAD*DE+M + 4*CONKAD*M*+2)/DC)
C write(*,46) d, de, alpha, space1, space2, b, conkad
C 46
format(1x,'d=',f5.1,3x,'de=',f4.1,3x,'alpha=',f4.2,3x,'sp1=',f6.1,
C +3x,'sp2=',f6.1,3x,'b=',f5.1,3x,'k=',f4.3)
C DIFF=ABS(SPACE2-SPACE1)
C IF(DIFF.LE.0.5) GO TO 50
    SPACE1=SPACE2
C
C Is there a check that must be made?
C
C    FLAG=DE/SPACE1
C    IF(FLAG.GT.0.3) GO TO 30
C    GO TO 40
C 50 CONTINUE
C
C PRINT *, 'SPACE1 = ', SPACE1, 'RESTRI(F) = ', RESTRI(F)
C Change units from cm to m.
C
    SPACE1=SPACE1/100.0
C
END

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C END OF SUBROUTINE CASE1
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C SUBROUTINE CASE2 - HOOGHOUDT EQUATION WITH EQUIVALENT DEPTH
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C SUBROUTINE CASE2 (ADEPTH, DDRAIN, DC, DIADR, CONKTD, CONKB, RFLAG, WTD, +SPACE1)
C
C PRINT *, ' DDRAIN= ', DDRAIN, ' CHOICE= ', CHOICE, ' ADEPTH= ', ADEPTH
C
    SPACE1=1000.0
    PI=3.14157
    D=ADEPTH-DDRAIN+(DIADR/2.0)
    IF(D.LT.0.0) THEN
        RFLAG=999.0
        SPACE1=0.0
        RETURN
    ENDIF
    B=ADEPTH-WTD
    M=DDRAIN-WTD-(DIADR/2.0)
C
C Calculate AND SPACING based on initial spacing estimate.
C Reiterate until spacing does not change.
C
    GO TO 40
C 30 DE=SPACE1*PI/(8.0*(LOG(SPACE1/.51)-1.15))
WRITE(*,*) 'D/L > 0.3'
GO TO 45
ALPHA=3.55 - 1.6*D/SPACE1 + 2.0*D*SPACE1/(SPACE1**2)
DE=D/(1.0 + (D/SPACE1)**((8.0/PI)*LOG(D/.51)-ALPHA))
B=DE+M
PRINT *, 'M= ', M, ' DDRAIN= ', DDRAIN, ' DE= ', DE, 'CONKB= ', CONKB
C C BCA CHANGE FORMULA FROM HOOGHOUDE/DONNAN TO HOOGHOUDE
C OLD FORMULA-> SPACE2=SQR((B**2.0 - DE**2.0)/DC)
C SPACE2=SQR(((B**2.0*DE**2 - DC*DE**2)/DC)
C write('*,46) d, de, alpha, spacel, space2, b, conkad
C 46 format(1x,'d=',f5.1,3x,'de=',f4.1,3x,'alpha=',f4.2,3x,'sp1=',f6.1,
C +3x,'sp2=',f6.1,3x,'b=',f5.1,3x,'k=',f4.3)
DIFF=ABS(SPACE2-SPACE1)
IF(DIFF.LE.0.5) GO TO 50
SPACE1=SPACE2
FLAG=D/SPACE1
IF(FLAG.GT.0.3) GO TO 30
GO TO 40
50 CONTINUE
C PRINT *, 'SPACE1 = ', SPACE1, ' RESTRI(P) = ', RESTRI(P)
C Change units from cm to m.
SPACE1=SPACE1/100.0
IF (D.LT.0.0) SPACE1=0.0
END

C END OF SUBROUTINE CASE2
C
C END OF SUBROUTINE CASE3 - ERNST EQUATION
C
C ERNST EQUATION
C INPUT FROM PROGRAM 'ELLIPSE'
C
C
SUBROUTINE CASE3(ADEPTH, DDRAIN, DC, DIADR, CONKT, CONKB, DINTFC, WTD,
+SPACE1)
COMMON AFACT(7,6),A
A=0.0
PI=3.14159
ECOUNT=0
C Determine which layer contains drain
C
C C Drain is in upper layer

460
C
3500 IF(DDRAIN.GT.DINTFC)GO TO 3550
DFLAG=1
   IF (ECOUNT.LT.1) THEN
      DR=DINTFC-DDRAIN+(DIADR/2.0)
      DB=ADEPHT-DINTFC
   ELSE
      IF(DB.GT.SCHECK) DB=0.25*SPACE1
      IF(DR.GT.SCHECK) DR=0.25*SPACE1
   ENDFI
   SMALLH=DDRAIN-WTD-(DIADR/2.0)
   DV=DDRAIN-WTD
3505 DT=DR+(0.5*SMALLH)
RATIOK=CONKB/CONKT
RATIOD=DB/DT
C
   IF(RATIOI.LT.1.0)THEN
      A=1
      C
      GO TO 3575
      C
      ENDFI
   GO TO 3560

C
C Drain is in lower layer
C
3550 DFLAG=0
   IF (ECOUNT.LT.1) THEN
      DR=ADEPHT-DDRAIN
      DB=ADEPHT-DINTFC
   ELSE
      IF(DB.GT.SCHECK) DB=0.25*SPACE1
      IF(DR.GT.SCHECK) DR=0.25*SPACE1
   ENDFI
   SMALLH=DDRAIN-WTD
   DV=DINTFC-WTD
3560 DT=0.0
   A=1.0
   GO TO 3575

C
C CALCULATE a
C
3560 IF(RATIOK.LT.0.1) THEN
   A=1.0
   GO TO 3575
ENDIF
IF(RATIOK.GT.50.0) THEN
   A=4.0
   GO TO 3575
ENDIF

   IF(RATIOK.GT.0.1) II=1
   IF(RATIOK.GT.2) II=2
   IF(RATIOK.GT.3) II=3
IF(RATIOK.GT.5) II=4
IF(RATIOK.GT.10) II=5
IF(RATIOK.GT.20) II=6

   IF(RATIOI.GT.0.1) JJ=1
   IF(RATIOI.GT.2.0) JJ=2
   IF(RATIOI.GT.4.0) JJ=3
   IF(RATIOI.GT.8.0) JJ=4
   IF(RATIOI.GT.16.0) JJ=5

A=(AFACT(II, JJ)+AFACT(II+1, JJ)+AFACT(II+1, JJ+1)+
   +AFACT(II, JJ+1))/4

3575 SUMKD=(CONKB*DB+CONKT*DT)
   U=PI*DIADR/2
C
C SOLVE QUADRATIC EQUATION
C
C   PRINT *, 'DFLAG= ', DFLAG
C   PRINT *, ' DIADR= ', DIADR
C   PRINT *, ' DC= ', DC
C   PRINT *, ' DDRAIN= ', DDRAIN
C   PRINT *, ' WT= ', WT
C   PRINT *, ' ADEPH= ', ADEPH
C   PRINT *, ' DINTFC= ', DINTFC
C   PRINT *, ' U= ', U
C   PRINT *, ' PI= ', PI
C   PRINT *, ' A= ', A
C   PRINT *, ' CONKT= ', CONKT
C   PRINT *, ' CONKB= ', CONKB
C   PRINT *, ' RATIOI= ', RATIOI
C   PRINT *, ' RATIO= ', RATIO
C   PRINT *, ' DR= ', DR
C   PRINT *, ' DV= ', DV
C   PRINT *, ' SMALLH= ', SMALLH
C   PRINT *, ' DT= ', DT
C   PRINT *, ' DB= ', DB
C   PRINT *, ' SUMKD= ', SUMKD

3580 QUADA=1/(8*SUMKD)
   IF(DFLAG.EQ.1) THEN
      QUADB=(1/(PI*CONKB))*LOG(A*DR/U)
   ELSE
      QUADB=(1/(PI*CONKB))*LOG(A*DR/U)
   ENDIF
   QUADC=-(SMALLH/DC)+(DV/CONKT)
   PRINT *, ' QUADA= ', QUADA
   PRINT *, ' QUADB= ', QUADB
   PRINT *, ' QUADC= ', QUADC

   SPACE1=(-QUADB+SQRT((QUADB*QUADB-4*QUADA*QUADC)))/(2*QUADA)
   PRINT *, ' SPACE= ', SPACE1
C
C CHECK THAT BOTH DB AND DR ARE LESS THAN 0.25*SPACE
C
SCHECK=0.25*SPACE1
ECOUNT=ECOUNT+1
IF((DB.LE.SCHECK).AND.(DR.LE.SCHECK)) THEN
  SPACE1=SPACE1/100.0
  RETURN
C ELSE
C  DR=0.25*SPACE1
C  ENDF
C ELSE
C  DB=0.25*SPACE1
C  DDRAIN=666.6
ENDF
IF (ECOUNT.GT.5) THEN
  DDRAIN=666.6
  RETURN
ENDF
ENDF
GO TO 3500

C CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCYYYYY
C
C END OF SUBROUTINE CASE3
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
END
Exhibit E.2. FORTRAN Program to create input file for SPACING8.FOR.

C SIR2ELPS.FOR
C Bruce Atherton, OSU-FABE, 4/26/99
C Program to create input file for SPACING8.FOR.
C Program to convert linear list of soil with one layer per line from
C NRCS soils database to one soil per line with up to 5 layers and
C permeabilities for input to ELLIPSE.FOR program.
C ELLIPSE.FOR takes input and determines minimum and maximum drain
spacing based on minimum and maximum permeabilities.
C
C Program Variables have the following meanings:
C soilid(i) soil id number, soil i
C soilna(i) soil name, soil i
C surtex(i) surface texture, soil i
C dlayer(i,j) depth of layer j for soil i
C conmin(i,j) minimum permeability for layer j, soil i
C conmax(i,j) maximum permeability for layer j, soil i
C iflag number of different surface textures for soilid(i)
C
C CHARACTER*6 SOILID(3)
C CHARACTER*14 SOILNA(3)
C CHARACTER*10 SURTEX(3)
C DIMENSION DLAYER(3,5)
C DIMENSION CONMIN(3,5)
C DIMENSION CONMAX(3,5)
C
C CHARACTER*14 VSOSILNA
C CHARACTER*6 VSOILID
C CHARACTER*10 VSURTEX
C
C INTEGER*2 N

OPEN (1,FILE='ELL-SOIL.PRN', STATUS='OLD')
OPEN (2,FILE='SOILPARAM.INP', STATUS='NEW')
C
OPEN (3,FILE='DEBUG')
I=1
J=1
IFLAG=1
JFLAG=1

Begin reading data

DO 999 N=1,4090

C Input soils information by layer

READ (1,100,END=1090) VSOILID,VSOILNA,VSURTEX,VLAYER,VCONMIN,
+VCONMAX
100 FORMAT(A6,A14,A10,F5.1,2(F6.2))

C Check for a different soil. If this is a new soil id, print
C variable array to file and reinitialize variables.
C PRINT It,'I,J=' ',I,' ',J
C PRINT It,'SOILIDS= ',VSOILID,' ',SOILID(I)
C PRINT *, 'LAYERS= ',VLAYER,' ',DLAYER(I,J)
C PRINT *
C IF (VSOILID .NE. SOILID(I)) GO TO 190

C Check for more than one surface layer by comparing layer depth. If
C there is more than one surface layer for a particular soil, start a
C new soil variable.
C IF (J .NE. 1) GOTO 120
C IF (VLAYER .EQ. DLAYER(I,J)) GO TO 150
120 J=J+1
JFLAG=JFLAG+1
GO TO 170

C Loop to save variables for the surface layer when there is more than
C one surface layer.
150 I=I+1
IFLAG=IFLAG+1
SOILID(I)=VSOILID
SOILNA(I)=VSOILNA
SURTEX(I)=VSURTEX
DLAYER(I,J)=VLAYER
CONMIN(I,J)=VCONMIN
CONMAX(I,J)=VCONMAX
GO TO 999

C Loop to save layer variables for subsurface layers, for each type of
C surface layer.
170 DO 180, K=1,IFLAG
DLAYER(K,J)=VLAYER
CONMIN(K,J)=VCONMIN
CONMAX(K,J)=VCONMAX
180 CONTINUE
GO TO 999

C WRITE PARAMETERS TO FILE AND INITIALIZE ARRAY AND VARIABLES

190 DO 195, K=1,IFLAG
WRITE(2,191) SOILID(K),SOILNA(K),SURTEX(K),(DLAYER(K,L),
+CONMIN(K,L),CONMAX(K,L),L=1,JFLAG)
191 FORMAT(A6,A14,A10,5(F4.1,F5.2,F5.2))
195 CONTINUE
I=1
J=1
IFLAG=1
JFLAG=1
DATA ((CONMIN(K,L),L=1,5),K=1,5) / 25*0.0 /
DATA ((CONMAX(K,L),L=1,5),K=1,5) / 25*0.0 /
DATA ((DLAYER(L,L),L=1,5),K=1,5) / 25*0.0 /
SOILID(I)=VSOILID
SOILNA(I)=VSOILNA
SURTEX(I)=VSURTEX
DLAYER(I,J)=VLAYER
CONMIN(I,J)=VCONMIN
CONMAX(I,J)=VCONMAX

465
GOTO 999
C Messages
999    CONTINUE

1090   DO 1095, I=1,IFLAG
        WRITE(2,191) SOILID(I),SOILNA(I),SURTEX(I),(DLAYER(I,J),
        +CONMIN(I,J),CONMAX(I,J),J=1,JFLAG)
1095   CONTINUE
        PRINT '(A33)',' Program execution ended normally.'

1100   END
APPENDIX F

MODELING OUTPUT
Table F.1. Drain spacing values estimated using the Donnan and Hooghoudt equations for a drain depth of 60cm and other parameter values as listed.

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Restrictive Layer Depth (cm)</th>
<th>Drain Depth (m)</th>
<th>Equivalent hydraulic conductivity 1-layer profile</th>
<th>Calculated spacing DDR=0.95 cm/d</th>
<th>Calculated spacing DDR=1.27 cm/d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Conductivity (cm/hr)</td>
<td>Top layer 1 (cm/hr)</td>
<td>Bottom layer 1 (cm/hr)</td>
</tr>
<tr>
<td>ADRIAN</td>
<td>Low</td>
<td>304.8</td>
<td>60</td>
<td>8.457</td>
<td>0.508</td>
</tr>
<tr>
<td>ADRIAN</td>
<td>High</td>
<td>304.8</td>
<td>60</td>
<td>34.426</td>
<td>15.24</td>
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<tr>
<td>AVONBURG</td>
<td>Low</td>
<td>53.3</td>
<td>60</td>
<td>1.524</td>
<td>1.524</td>
</tr>
<tr>
<td>AVONBURG</td>
<td>High</td>
<td>94</td>
<td>60</td>
<td>2.821</td>
<td>4.291</td>
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<tr>
<td>BARKCAMP</td>
<td>Low</td>
<td>304.8</td>
<td>60</td>
<td>5.08</td>
<td>5.08</td>
</tr>
<tr>
<td>BARKCAMP</td>
<td>High</td>
<td>304.8</td>
<td>60</td>
<td>50.8</td>
<td>50.8</td>
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<tr>
<td>BENNINGTON</td>
<td>Low</td>
<td>304.8</td>
<td>60</td>
<td>0.152</td>
<td>0.152</td>
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<tr>
<td>BENNINGTON</td>
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<td>1.524</td>
<td>1.524</td>
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<td>BLOUNT</td>
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<td>0.152</td>
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<td>60</td>
<td>5.08</td>
<td>5.08</td>
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<tr>
<td>CANFIELD</td>
<td>Low</td>
<td>66</td>
<td>60</td>
<td>1.524</td>
<td>1.524</td>
</tr>
<tr>
<td>CANFIELD</td>
<td>High</td>
<td>66</td>
<td>60</td>
<td>5.08</td>
<td>5.08</td>
</tr>
<tr>
<td>CARLISLE</td>
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<td>60</td>
<td>0.508</td>
<td>0.508</td>
</tr>
<tr>
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<td>60</td>
<td>15.24</td>
<td>15.24</td>
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<td>0.868</td>
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<td>CLERMONT</td>
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<td>38.1</td>
<td>999.9</td>
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<td>0.152</td>
</tr>
<tr>
<td>CLERMONT</td>
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<td>0.235</td>
<td>0.508</td>
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<td>CONNEAUT</td>
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<td>0.169</td>
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<td>CROSBY</td>
<td>Low</td>
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<td>60</td>
<td>1.524</td>
<td>1.524</td>
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<tr>
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<td>5.08</td>
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<td>1.524</td>
<td>1.524</td>
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<td>60</td>
<td>5.08</td>
<td>5.08</td>
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<td>33.543</td>
<td>5.08</td>
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Continued
### Table F.1 (continued)

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<th>Soil Series</th>
<th>Restrictive Layer Depth (m)</th>
<th>Drain Depth (m)</th>
<th>Equivalent hydraulic conductivity</th>
<th>Calculated spacing</th>
<th>DDR=0.95 cm/d</th>
<th>DDR=1.27 cm/d</th>
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<td></td>
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<td></td>
<td>1-layer profile</td>
<td>2-layer profile</td>
<td>Donnan</td>
<td>Hooghoudt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Conductivity</td>
<td>Top layer</td>
<td>Bottom layer</td>
<td>(m)</td>
</tr>
<tr>
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<td>0.152</td>
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<td>0.508</td>
<td>8.2</td>
<td>2.9</td>
</tr>
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<td>1.524</td>
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<td>0.508</td>
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* 999.9 indicates that a restrictive layer was found above drain depth.

† 1000 indicates that a spacing was not calculated.
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Note: Calculated spacing values are in meters (m).
Table F.5. Drain spacing values estimated using the Donnan and Hooghoudt equations for a drain depth of 60cm and other parameter values as listed.

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<th>Drain Depth (m)</th>
<th>Equivalent hydraulic conductivity 1-layer profile (cm/hr)</th>
<th>Equivalent hydraulic conductivity 2-layer profile (cm/hr)</th>
<th>Top layer Conductivity (cm/hr)</th>
<th>Bottom layer Conductivity (cm/hr)</th>
<th>DDR=0.95 cm/d Calculated spacing (m)</th>
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Table F.6. Drain Spacing values estimated using the Donnan and Hooghoudt equations for a drain depth of 75 cm and other parameter values as listed.

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Table F.7. Drain Spacing values estimated using the Doman and Hooghoudt equations for a drain depth of 90 cm and other parameter values as listed.

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999.9 indicates that a restrictive layer was found above drain depth.

1000 indicates that a spacing was not calculated.

888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.

777.7 indicates a single layer profile.

501
Table F.10. Drain spacing values estimated using the Emst equation for a drain depth of 75 cm and other parameter values as listed.

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<th>Equivalent Hydraulic Top (mm/hr)</th>
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999.9 indicates that a restrictive layer was found above drain depth.

1000 indicates that a spacing was not calculated.

888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.

777.7 indicates a single layer profile.
Table F.11. Drain spacing values estimated using the Ernst equation for a drain depth of 90cm and other parameter values as listed.

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* 999.9 indicates that a restrictive layer was found above drain depth.
* 1000 indicates that a spacing was not calculated.
* 888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.
* 777.7 indicates a single layer profile.
Table F.12. Drain spacing values estimated using the Ernst equation for a drain depth of 120cm and other parameter values as listed.

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999.9 indicates that a restrictive layer was found above drain depth.

* 1000 indicates that a spacing was not calculated.

† 888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.

§ 777.7 indicates a single layer profile.
Table F.13. Drain spacing values estimated using the Ernst equation for a drain depth of 60cm and other parameter values as listed.

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\footnote{1000 indicates that a spacing was not calculated.}  
\footnote{888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.}  
\footnote{777.7 indicates a single layer profile.}
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* 999.9 indicates that a restrictive layer was found above drain depth.
* 1000 indicates that a spacing was not calculated.
* 888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.
* 777.7 indicates a single layer profile.
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* 999.9 indicates that a restrictive layer was found above drain depth.
1 1000 indicates that a spacing was not calculated.
2 888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.
3 777.7 indicates a single layer profile.
Table F.16. Drain spacing values estimated using the Ernst equation for a drain depth of 120cm and other parameter values as listed.

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<th>Equivalent Hydraulic Conductivity (mm/hr)</th>
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* 999.9 indicates that a restrictive layer was found above drain depth.
† 1000 indicates that a spacing was not calculated.
‡ 888.8 indicates that no layer with higher conductivity is below a low conductivity layer for this soil.
§ 777.7 indicates a single layer profile.
APPENDIX G

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<td>MI0034</td>
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<td>32</td>
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<td>60</td>
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<td>0.2</td>
<td>--</td>
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<tr>
<td>OH0077</td>
<td>WOOSTER</td>
<td>S I L</td>
<td>120</td>
<td>90</td>
<td>10</td>
<td>0.6</td>
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<td>27</td>
<td>0.6</td>
<td>2</td>
<td>58</td>
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<td>0.6</td>
<td>85</td>
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<td>2</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>OH0047</td>
<td>BENNINGTON</td>
<td>S I L</td>
<td>120</td>
<td>90</td>
<td>10</td>
<td>0.6</td>
<td>2</td>
<td>54</td>
<td>0.06</td>
<td>0.6</td>
<td>80</td>
<td>0.06</td>
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<td>--</td>
<td>--</td>
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<td>--</td>
</tr>
<tr>
<td>OH0028</td>
<td>LATTY</td>
<td>C S I C</td>
<td>120</td>
<td>90</td>
<td>7</td>
<td>0.06</td>
<td>0.2</td>
<td>42</td>
<td>0.06</td>
<td>0.2</td>
<td>60</td>
<td>0</td>
<td>0.06</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

1 Adrian has six soil layers. For layer six: depth = 90 in; low permeability value = 0.06 in/hr; high permeability value = 0.2 in/hr.

2 No data.
APPENDIX H

1998 SUBSURFACE DRAINAGE SURVEY AND OTHER RELATED MATERIALS

Name
Address
City, State  Zip Code

Date

Dear Mr. Or Mrs. :

Artificial drainage is very important to landowners in Ohio. The 1992 National Resource Inventory found that nearly 3.5 million acres of cropland or potential cropland still need drainage improvements. With the advent of yield monitors and the interest in site specific farming, producers are becoming more aware of the importance of good drainage for high crop yields. Many people are using The Ohio Drainage Guide for design assistance, but it is 25 years old. We are working to update the drainage guide, using computer modeling to produce subsurface drainage recommendations for all 475 Ohio soil series. WE NEED YOUR HELP to validate the results of the modeling and improve the quality of the new Ohio Drainage Guide.

The enclosed questionnaire is part of the process of updating the Ohio Drainage Guide. This study is being sponsored by the Overholt Drainage Research and Education Program, Department of Food, Agricultural and Biological Engineering, Ohio State University Extension, OARDC and The Ohio State University. Our objectives are to confirm that computer simulations of drain depth and spacings are similar to what you, the installer, are actually using. Also, we want to assess the amount of subsurface drainage activity and gather related information to support the future of agriculture in Ohio.

This questionnaire is being mailed to many contractors in Ohio that we believe install subsurface drain pipe. It is very important that each survey be completed and returned, so that we may develop a complete and accurate picture of the practices used by subsurface drain pipe installers. We estimate it will take you less than 30 minutes to complete this questionnaire.

Your response will be completely anonymous; no identification marks are on individual questionnaires. We ask that you mail the enclosed postcard separately when you mail the questionnaire.

Please return the completed survey by April 7, 1998 using the enclosed a self-addressed, stamped envelope. If we receive the completed survey by April 7, we will mail you a coupon worth $10 towards the registration fee for any workshop sponsored by Dr. Brown, including the Overholt Drainage School. If you wish a copy of the summary report of this study, please indicate this by writing your name and address on the back of the return envelope.

Either Bruce or Larry will be most happy to answer any questions you may have about this study. You can reach Bruce by phone at 614-292-1406, by fax at 614-292-9448 or by email at atherton.10@osu.edu. Larry can be reached at 614-292-3826. Thank you for your assistance with this study.

Very Truly Yours,

Bruce Atherton
Graduate Research Associate

Larry C. Brown, Associate Professor
Extension Agricultural Engineer

520
Exhibit H.2. Advance postcard mailed prior to contractor survey instrument.

March 2, 1998

In a few days you will be asked to participate in a study of subsurface drain installation practices by completing a mail questionnaire. This study will help us update the Ohio Drainage Guide, last changed in 1973, and is being conducted by the Overholt Drainage Research and Education Program, Department of Food, Agricultural and Biological Engineering, Ohio State University Extension, OARDC and The Ohio State University. Our objectives are to confirm that computer simulations of drain depth and spacings are similar to what you, the installer, are actually using. Also, we want to assess the amount of subsurface drainage activity and related information to support the future of agriculture in Ohio.

We hope you will be able to take the time to provide the information requested. It should take you less than 30 minutes to complete the questionnaire. Thank you in advance for your participation. Please call Bruce Atherton at 614-292-1406 or Larry Brown at 614-292-3826 if you have any questions about this study.

Bruce Atherton, Graduate Research Associate
Larry C. Brown, Associate Professor and Extension Agricultural Engineer
Exhibit H.3. 1998 contractor survey instrument.

SECTION I. Subsurface Drain Installation Practices

Q-1 Did your firm install any subsurface drain pipe for agricultural cropland or pasture drainage from January 1, 1995 through December 31, 1997? (Please circle one number.)

NO (If no, please go to Section III on Page 7)
YES (If yes, please continue with question Q-2)

Q-2 For the major soil series listed below, please indicate, by soil series, the approximate depth of drain pipe installation you use for lateral drains. Please add any major soil series that are not listed. Please leave the line blank if you do not work with a particular soil series. Enter DK if you don't know.

<table>
<thead>
<tr>
<th>Installation depth</th>
<th>Typical (inches)</th>
<th>Minimum (inches)</th>
<th>Maximum (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVONBURG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BENNINGTON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLOUNT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BROOKSTON (KOKOMO)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTERBURG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLERMONT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CROSBY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FITCHVILLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FULTON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HASKINS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOYTVILLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LATTY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAHONING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MERMILL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIAMIAN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAPPANEE</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ORRVILLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAULDING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLATEA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEWAMO</td>
<td></td>
<td></td>
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<tr>
<td>RAVENNA</td>
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<tr>
<td>ROSELMES</td>
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<td></td>
</tr>
<tr>
<td>SEBRING</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SHEFFIELD</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SHOALS</td>
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<td></td>
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<tr>
<td>SLOAN</td>
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<td></td>
<td></td>
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<tr>
<td>TOLEDO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WADSWORTH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER (Please specify)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>OTHER (Please specify)</td>
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<tr>
<td>OTHER (Please specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued
Q-3 For the major soil series listed below, please indicate, by soil series, the approximate spacing you use for lateral drains. Please leave blank if you do not work with a particular soil type. Enter DK if you don’t know.

<table>
<thead>
<tr>
<th>Lateral Spacing</th>
<th>Typical (feet)</th>
<th>Minimum (feet)</th>
<th>Maximum (feet)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BENNINGTON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLOUNT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BROOKSTON (KOKOMO)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>CENTERBURG</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CLERMONT</td>
<td></td>
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<td></td>
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<tr>
<td>CROSBY</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>FITCHVILLE</td>
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<td></td>
<td></td>
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<tr>
<td>FULTON</td>
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<td>HASKINS</td>
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<tr>
<td>HOYTVILLE</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LATTY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAHONING</td>
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<tr>
<td>MERMILL</td>
<td></td>
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<td>SHEFFIELD</td>
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<tr>
<td>WADSWORTH</td>
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<td></td>
</tr>
</tbody>
</table>

Continued
SECTION I. Subsurface Drain Installation Practices (Continued)

Q-4 Please indicate, to the nearest 1,000 feet, the approximate amount of subsurface drain pipe installed by your firm for agricultural cropland or pasture in Ohio in each of the listed calendar years.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>AMOUNT INSTALLED</th>
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<tbody>
<tr>
<td>1995</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td></td>
</tr>
</tbody>
</table>

Q-5 Please indicate the approximate percentage of the subsurface drain pipe installation for 1995, 1996 and 1997 that was done in each Ohio county. Leave blank if zero. (The numbers should add up to 100%.)

```
ADAMS   HAMILTON   MUSKINGUM
ALLEN   HANCOCK    NOBLE
ASHLAND HARDIN     OTTAWA
ASHTABULA HARRISON  PAULDING
ATHENS   HENRY      PERRY
AUGLAIZE HIGHLAND  PICKAWAY
BELMONT  HOCKING    PIKE
BROWN   HOLMES     PORTAGE
BUTLER   HURON     PREBLE
CARROLL  JACKSON   PUTNAM
CHAMPAIGN JEFFERSON RICHLAND
CLARK   KNOX      ROSS
CLERMONT LAKE     SANDUSKY
CLINTON LAWRENCE  SCIOTO
COLUMBIANA LICKING  SENeca
COSHOCTON LOGAN   SHELBY
CRAWFORD LORAIN   STARK
CUYAHOGA LUCAS    SUMMIT
DARKE   MADISON   TRUMBULL
DEFIANCE MAHONING  TUSCARAWAS
DELAWARE MARION   UNION
ERIE    MEDINA    VINTON
FAIRFIELD MEIGS    VAN WERT
FAYETTE MERCER   WARREN
FRANKLIN MIAMI    WASHINGTON
FULTON   MONROE   WAYNE
GALLIA   MORROW  WILLIAMS
GEauga   MONTGOMERY WOOD
GREENE   MORGAN   WYANDOT
GUERNSEY                        
```
Q-6 How long has your firm been doing subsurface drain installation? (Please enter number of years.)

______ Years

Q-7 Is subsurface drain installation your firm’s primary business? (Please circle one number.)

NO
YES

Q-8 Which type of equipment do you use to install drain pipe? (Please circle all that apply.)

Wheel trencher
chain trencher
plow

Q-9 Please indicate the frequency with which you use the following resources in determining size, depth, spacing and other design considerations prior to installing drain pipe. (Please circle the number best corresponding to your frequency of use.)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Never Use</th>
<th>Use About ¼ of the Time</th>
<th>Use About ½ of the Time</th>
<th>Use About ¾ of the Time</th>
<th>Always Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNTY SOIL SURVEY</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>OHIO DRAINAGE GUIDE</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>HYDRAULIC CONDUCTIVITY TEST</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>DESIGN CRITERIA PROVIDED BY A PRIVATE CONSULTANT</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>DESIGN CRITERIA PROVIDED BY A GOVERNMENT AGENCY</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ELEVATION (CONTOUR) MAP FROM YOUR OWN SURVEY</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>OTHER (PLEASE SPECIFY)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Q-10 How interested would you be in using a consultant to survey and provide an elevation (contour) map of a prospective job site? (Please circle one number.)

NOT INTERESTED (Please go to question Q-12)
SLIGHTLY INTERESTED
NEUTRAL
INTERESTED
VERY INTERESTED
Exhibit H.3. (continued)

Q-11 What would you and your clients be willing to pay for this service? (Please enter an amount.)

You: ______ Dollars per acre       Your Clients: ______ Dollars per acre

Q-12 How interested would you be in using a consultant to design the drainage system for a prospective job site? (Please circle one number.)

not interested (PLEASE GO TO SECTION II ON THE NEXT PAGE)
slightly interested
neutral
interested
very interested

Q-13 What would you and/or your clients be willing to pay for this service? (Please enter an amount.)

You: ______ Dollars per acre       Your Clients: ______ Dollars per acre

Section II. Water Table Management Systems

There is growing interest in water table management in Ohio. Subsurface drains can be used in conjunction with water level control structures (control stands) and water conveyance facilities to manage the free water surface in the soil for subirrigation and controlled drainage. This section is designed to gather information about these systems.

Q-14 A controlled drainage system has water level control structures to control the discharge from the subsurface drains so that the operator can, to some extent, manage the position of the free water surface in the soil upstream of the control structure. Water in the system is from rainfall or wastewater irrigation only. Did your firm install any controlled drainage systems or components for a controlled drainage system from January 1, 1995 through December 31, 1997? (Please circle one number.)

NO (If no, please go to question Q-20 on page 6)
YES (If yes, please continue)

For the following questions, we will define a new controlled drainage system as one that uses little or no existing subsurface drain pipe or tile. A retro-fitted controlled drainage system is one that uses a substantial amount of existing subsurface drain pipe or tile. Please fill in the blanks to the right of the following questions with the appropriate numbers. Enter zero (0) where appropriate. Please circle estimated quantities.

<table>
<thead>
<tr>
<th>New Systems</th>
<th>Retrofit System</th>
</tr>
</thead>
</table>

Q-15 How many controlled drainage (CD) systems did your firm install during the calendar years 1995-1997. (Please enter a number.)

Continued
Exhibit H.3. (continued)

Q-16 What is the total number of acres of cropland that can be managed using all of the CD systems listed in question Q-15? (Please enter a number.)

Q-17 What was the total number of water level control structures installed for all CD systems listed in question Q-15. (Please enter a number.)

Q-18 To your knowledge, how many of the systems listed in question Q-15 are being successfully managed? (Please enter a number; enter DK if you don't know.)

Q-19 For each of the materials listed below, please indicate how many of the systems listed in question Q-15 will receive the material. (Please enter the appropriate number of systems in the blank to the right. Enter zero (0) where appropriate; enter DK if you don't know.)

LIQUID MANURE FROM A PIT

LIQUID MANURE FROM A HOLDING POND

LIQUID FROM AN AEROBIC OR ANAEROBIC LAGOON

MUNICIPAL WASTEWATER EFFLUENT

Section II. Water Table Management Systems (continued)

Q-20 Subirrigation systems have both water level control structures (control stands) and a means of supplying water to the system so that the operator can control the position of the free water surface upstream of the control structure by adding water as needed. Did your firm install any subirrigation systems or components of subirrigation systems from January 1, 1995 through December 31, 1997? (Please circle one number.)

NO (If no, please go to question Q-26 on page 7)
YES (If yes, please continue)

For the following questions, we will define a new subirrigation (SI) system as one that uses little or no existing subsurface drain pipe or tile. A retro-fitted subirrigation (SI) system is one that uses a substantial amount of existing subsurface drain pipe or tile. Please fill in the blanks to the right of the following questions with the appropriate numbers. Enter zero (0) where appropriate. Please circle estimated quantities.

Continued
Exhibit H.3. (continued)

<table>
<thead>
<tr>
<th>Question</th>
<th>New Systems</th>
<th>Retrofit System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-21 How many subirrigation (SI) systems did your firm install during the calendar years 1995-1997. (Please enter a number.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q-22 What is the total number of acres of cropland that can be managed using all of the SI systems listed in question Q-21? (Please enter a number.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q-23 What was the total number of water level control structures installed for all SI systems listed in question Q-21? (Please enter a number.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q-24 To your knowledge, how many of the SI systems listed in question Q-21 are being successfully managed? (Please enter a number; enter DK if you don’t know.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q-25 Please indicate how many of the SI systems listed in question Q-21 had any of the following components as part of the total subirrigation system. (Please enter the appropriate number in the blank to the right. Enter zero (0) where appropriate; enter DK if you don’t know.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXISTING POND OR RESERVOIR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEW POND OR RESERVOIR</td>
<td></td>
<td></td>
</tr>
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Section III. Information Related to Extension Programming

Q-26 Does your firm use a computer in any aspect of your business? (Please circle one number.)

No (IF NO, PLEASE GO TO QUESTION 28)  
Yes (IF YES, PLEASE CONTINUE WITH QUESTION Q-27)

Continued
Q-27 How do you use a computer in your firm? (Please circle all that apply.)

BOOKKEEPING
BUSINESS PLANNING
DRAINAGE DESIGN (For example, drain size, depth and spacing.)
DRAINAGE PLAN DRAWINGS (For example, using computer aided design software.)
PREPARING BIDS AND COST ESTIMATES
FINANCIAL MANAGEMENT
EMAIL
WORLD WIDE WEB
OTHER (Please specify) 

Q-28 The following list of topics could be covered with Extension fact sheets, bulletins or as agenda items at meetings. Please indicate the level of importance of each of the following issues to you. (Please circle one answer for each issue.)

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<thead>
<tr>
<th>Topic</th>
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<th>Somewhat Important</th>
<th>Somewhat Neutral</th>
<th>Important</th>
<th>Very Important</th>
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Continued
### Exhibit H.3. (continued)

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</table>

Section IV. Conclusion

Thank you very much for taking the time to respond to this survey. The information you have provided will be very useful in the development of the Ohio Agricultural Water Management Guide. It will also help us develop relevant extension programming.

If you wish to receive a summary of the results of this survey, please write your name and mailing address on the back of the return envelope. The summary will be mailed to you within 6 months following completion of the study.

Please phone Bruce Atherton at 614-292-1406 with your questions and comments regarding this survey. If you prefer, you can fax Bruce at 614-292-9448 or send email to atherton.10@osu.edu.

If you have additional comments about this subject, please write them below or on a separate paper and enclose them, along with this survey, in the enclosed self-addressed stamped envelope and mail to 1998 Contractors Survey, Overholt Program, 590 Woody Hayes Drive, Columbus, OH 43210-1057.
Exhibit H.4. Return postcard to confirm survey completion or non participation in survey.

April 21, 1998

Please return this postcard after checking the appropriate box.

☐ I have completed and mailed separately the questionnaire for the 1998 Subsurface Drainage Survey.

☐ Our firm installs no subsurface drain pipe for agricultural purposes and we will not be returning the survey.
First name, last name  
Company  
Address  
City, state, zip

Dear Mr. : 

Thank you very much for completing the 1998 Subsurface Drainage Survey and returning it to us in a timely manner. Artificial drainage is very important to landowners in Ohio. Your response will help ensure that the updated drainage guide and future extension programming will meet the needs of subsurface drainage contractors.

To show our appreciation of your effort, we have enclosed a coupon worth $10 towards the registration fee for any workshop sponsored by Dr. Brown. We will mail you a notice of the 1999 Overholt Drainage School later this year. Please check with your county Ohio State University Extension office for other events sponsored by Dr. Brown. If you have internet access, you can also check Dr. Brown's web page by accessing http://www.oardc.ohio-state.edu/fabe for more information.

Either Bruce or Larry will be most happy to answer any questions you may have about this study. You can reach Bruce by phone at 614-292-1406, by fax at 614-292-9448 or by email at atherton.10@osu.edu. Larry can be reached at 614-292-3826. Thank you for your assistance with this study.

Thanks again for your help!

Very Truly Yours, 

Bruce Atherton  
Graduate Research Associate

Larry C. Brown, Associate Professor  
Extension Agricultural Engineer
One week ago a questionnaire seeking information about subsurface drainage installation practices was mailed to you. You were selected to receive this questionnaire because we thought your firm was involved with agricultural subsurface drain installation.

If you have already completed and returned it to us, please accept our sincere thanks. If not, please do so today. Because soil conditions vary widely around the state, it is extremely important that your firm be included in the study if the results are to accurately reflect subsurface drainage practices in Ohio.

If by some chance you did not receive the questionnaire, or it has been misplaced, please call me right now at 614-292-1406 and I will get another one in the mail today.

Very Truly Yours,

Bruce Atherton, Graduate Research Associate, The Ohio State University

March 16, 1998

Two weeks ago a questionnaire seeking information about subsurface drainage installation practices was mailed to you. You were selected to receive this questionnaire because we believe your firm is involved with agricultural subsurface drain installation.

If you have already completed and returned it to us, please accept our sincere thanks. If not, please do so today. Because soil conditions and subsurface drainage activity vary widely around the state, it is extremely important that your firm be included in the study if the results are to accurately reflect subsurface drainage practices in Ohio.

If by some chance you did not receive the questionnaire, or it has been misplaced, please call me right now at 614-292-1406 and I will get another one in the mail today.

Very Truly Yours,

Bruce Atherton, Graduate Research Associate, The Ohio State University

March 23, 1998

Date

<first name> <last name>
<organization>
<address>
<city> <state> <zip>

Dear <prefix> <last name>:

About 6 weeks ago we wrote seeking information about your involvement with the installation of subsurface drains. As of today, we have not received your completed questionnaire. If you do not install subsurface drains, please take a minute to check the appropriate box on the enclosed postcard and return it to us so we may note this information on the database. If you do install subsurface drains, please take a few minutes to complete the enclosed questionnaire and return it to us in the enclosed, postage paid envelope.

The Overholts Drainage Research and Education Program has initiated this study as part of the process to revise the Ohio Drainage Guide. A large part of the new guide will be recommendations for over 475 Ohio soil series. We want to confirm that the computer simulations of drain depth and spacings used to make these recommendations are similar to what you, the installer, are actually using. Also, we want to assess the amount of subsurface drainage activity in Ohio and gather related information to support the future of agriculture in Ohio.

We are writing to you again because of the significance each questionnaire has to the usefulness of this study. Soils and drainage activity vary widely from county to county, and in order for the results of this study to accurately represent subsurface drainage activity in Ohio, it is essential that each person return his or her questionnaire.

In case your questionnaire has been misplaced, a replacement is enclosed. If you have any questions or concerns about completing this questionnaire, please call Bruce Atherton at 614-292-1406 or Larry Brown at 614-292-3826 so we can work together to ensure your participation in this important study. We greatly appreciate your cooperation.

Very Truly Yours,

Bruce Atherton
Graduate Research Associate

Larry C. Brown, Associate Professor
Extension Agricultural Engineer

Encl. 1997 Subsurface Drainage Questionnaire
SASE
Return postcard

February 1, 1998

To: Dale Arnold, OLICA
    Art Brate, State Conservation Engineer
    Kevin Elder, ODNR-DSWC
    Fred Galehouse, Galehouse Drainage
    Scott Ganz, Ganz Tiling

Fr: Bruce Atherton, Graduate Research Associate

Re: Drainage Contractors Survey

I am enclosing a draft copy of a questionnaire we propose to mail to drainage contractors in Ohio as part of the development of the Ohio Agricultural Water Management Guide. I hope you can take the time to review it and provide constructive comments on ways to improve it.

The Ohio SWCDs have been asked to provide us with the names of the five most active drainage contractors in their county which we will use as the mailing list for this survey. We also plan to query the OLICA membership. Responses will be entirely confidential.

The intent of the survey is to determine how well our model predictions of drain depth and spacing we are doing for the Drainage Guide match what is done in practice. We also want to assess the amount of subsurface drain installation being done and get feedback on how these systems are designed. Section II asks about the installation of subirrigation and controlled drainage systems to get an idea of the interest in these types of systems. Section III asks questions that relate to education needs and delivery methods, e.g., the internet.

Please try to return the draft questionnaire with your comments by February 13. We would like to mail this survey no later than February 17 in order to get the survey in the contractors' hands prior to the start of the busy construction season, although if we don't get some wet weather, that may not be a major concern!

Please review each question for clarity and ease of answering. Make note of any question you may have about the interpretation of a particular question. An interpretation that may seem obvious to me may not be obvious to you or a potential respondent. Also note if you feel a question or response could be phrased better. And please make any other comments you feel might be helpful in achieving a good response rate.

Thank you very much for taking a few minutes to review this questionnaire. Your input will help make this a successful survey.

Larry C. Brown, Extension Agricultural Engineer, OSU-FABE
Norm Fausey, Research Leader, USDA-ARS
APPENDIX I

RESPONSES FROM 1998 SUBSURFACE DRAINAGE SURVEY
Table 1.1. Data from 1998 Subsurface drainage survey. Questions 1, 6, 7, 8, 14, 20. *

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<th>Survey ID</th>
<th>Q-1 Drain pipe installed</th>
<th>Q-6 Years in business</th>
<th>Q-7 Is primary business?</th>
<th>Q-8 Type of equipment used</th>
<th>Q-14 CD installed</th>
<th>Q-20 SI installed</th>
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*See Appendix H for the questionnaire and complete question wording.

1 ID numbers were assigned to the questionnaires as they came back.

2 In some cases, there was no response for these questions, although a positive response was made for later questions; in these cases, a "yes" was entered for these questions.

3 No response was made.
Table 1.2. Data from 1998 Subsurface drainage survey. Question 2.*

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† Some names were provided by respondents.
‡ These fields were not on questionnaire.
§ Indicates no response.
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*See Appendix H for the questionnaire and complete question wording.*

1. Estimated percentage of total installed in this county.
2. "-" indicates no response.
3. "DV" indicates a don't know response.
Table 1.4. Data from 1998 Subsurface drainage survey. Question 9.

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*See Appendix H for the questionnaire and complete question wording.

1 = means never use this resource; 2 = use this resource about ¼ of the time; 3 = use this resource about ½ of the time; 4 = use this resource about ¾ of the time; 5 = always use this resource

*"- -" indicates no response.
Table 1.5. Data from 1998 Subsurface drainage survey. Questions 10, 11, 12, 13.

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*See Appendix H for the questionnaire and complete question wording.

Numbers in this column have the following meaning:

1 = not interested
2 = slightly interested
3 = neutral
4 = interested
5 = very interested
6 = "-" indicates no response.

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558
Table I.6. Data from 1998 Subsurface drainage survey. Questions 15, 16, 17, 18.*

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* See Appendix H for the questionnaire and complete question wording.

† " " indicates no response.

‡ "DK" indicates a don’t know response.

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Table I.7. Data from 1998 Subsurface drainage survey. Question 19.*

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* See Appendix H for the questionnaire and complete question wording.

† " " indicates no response.

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559
Table 1.8. Data from 1998 Subsurface drainage survey. Questions 21, 22, 23, 24.

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* See Appendix H for the questionnaire and complete question wording.
† "-" indicates no response.
‡ "DK" indicates a don't know response.

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*See Appendix H for the questionnaire and complete question wording.

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1See Appendix H for questionnaire and complete question wording.
2"-" indicates no response.
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1 see previous tables.
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*See Appendix H for questionnaire and complete question wording.*

*See previous table.*

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*See Appendix H for questionnaire and complete question wording.*

*"--" indicates no response.*