Cost-benefit Analysis of the Tiffin River Drainage Improvement[1]

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ABSTRACT. **A two million dollar drainage improvement was proposed for the Tiffin River in 1983. Its objective was to reduce the amount of flooded land and, thereby, improve farming. The professional engineer's estimate of improvement, cost, and maintenance and additional reliable estimates of increased crop production, depreciation, inflation, and financing were collected. These estimates were analyzed by computer to determine the financial merit of the proposal. Questionable estimates were resolved in favor of the project. A cost-benefit schedule was developed which revealed that a negative financial benefit would be incurred each year and which would accumulate to nearly $6 million in 30 years. The drainage improvement project was rejected in 1988, with the rejection in part attributable to the analysis.**

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INTRODUCTION

The Tiffin River, commonly known as Bean Creek, has its major beginning at Devils Lake, MI, meanders southward through northwest Ohio, and empties into the Maumee River west of Defiance, OH. Its total length is 137.1 km (85.3 mi). The entire, Ohio part of the river consists of a length of 100.2 km (62.3 mi) which varies in width from 13.7 m (45 ft) at the northern Ohio end to 36.6 m (120 ft) at the Maumee River. It is characterized by its low slope, 0.15 m/km (0.8 ft/mi) to 0.38 m/km (2 ft/mi), and by its relatively unconfined flooding which may extend over 1.6 km (1 mi) in width. The maximum flooded area is about 3,887 ha (9,600 a). The land in the watershed is used for farming, and there are no cities or large towns on the river (Mekus 1976, 1988; Slocum 1905).

Eighteenth century French maps labeled the Tiffin River as Crique Fève or Anse des Fèves or, literally, Creek of Beans or Cove of Beans. Locally the entire river is still known as Bean Creek. Officially its northern length is named Bean Creek, but it is named the Tiffin River shortly after it enters Fulton County, OH. In early times a naturally occurring prairie existed on Bean Creek in Fulton County (Fulton County 1858). Known locally as Goose Pond, it was typically 1.2 m (4 ft) to 2.4 m (8 ft) deep, with an area of about 11.6 km^2 (4.5 mi^2). In 1903, Goose Pond was drained by digging and diking a straight channel through it (Mohr 1972). The drained area has been farmed ever since. However, the tendency of this area to flood has prompted petitions/proposals from time to time to channel the entire, Ohio part of the river.

The most recent petition was made in 1983 by residents of the Goose pond area. To accomplish the objective of the petition the professional engineer (Mekus 1988) proposed:

A. snagging and clearing 457 m (1,500 ft) of the river,
B. removing 98 log jams,
C. excavating 89,500 m^3 (117,000 yd^3) of sandbar material,
D. cutting selected trees and brush,
E. constructing 5,790 m (19,000 ft) of tree and brush revetments, and
F. placing 620 m^3 (810 ft^3) of rock channel.

The proposed construction cost was $1,996,954.33, with a first year's maintenance cost of $621.50 per km ($1,000 per mi) (Mekus 1988). The subsequent maintenance schedule was not specified. However, Ohio Ditch Law (RC 6137.02) provides that a ditch improvement must be permanently maintained.

The amount of improvement (the reduction in flooded area) was not specified in the most recent proposal. However, the professional engineer providing the current proposal had indicated previously the reduction in flooded area and the cost for each of three plans (Mekus 1976). These plans, adjusted for the intervening inflation, permit a cost-benefit determination to be made. Ohio Ditch Law (RC 6131.12) provides that the benefits must exceed the cost.

In times past the merit or benefit of a ditch improvement has been a "seat of the pants" decision. Generally, an improvement is considered meritorious simply because it has been proposed/petitioned. Consequently, an adverse analysis has the additional burden of being based on widely accepted information and deduction. The objective of this present paper is to accept this burden and, in so doing, to provide a cost-benefit schedule estimate for the proposed improvement.

In making a cost-benefit analysis several questions need to be addressed:

1. How much land is flooded each year?
2. How much of the flood land will become unflooded?
3. What is the financial benefit?
4. What are the project costs?

MATERIALS AND METHODS

In making this analysis it was decided to resolve all questionable data in favor of the project in order to gain a broad acceptance. The maximum flood occurred in February 1976, when the area of flooded land was about 3,887 ha (9,600 a) (Mekus 1976, 1988). Three remedial plans, named Plan A, Plan B, and Plan C, were suggested in the 1976 report. Each indicated a cost and the area of land it relieved of flooding for maximum flood. Typical values of flood land reduction can be expected to be smaller. In order to favor the project, the maximum figures were used in the present study, as if a maximum flood occurred each year. As a result, construction of the

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proposed project would provide a maximum reduction of flooded area each year. These maximum plan figures were plotted (Fig. 1). A curve was drawn through these points and extended, with artistic license, to show threshold and diminishing returns. An arbitrary 3.6% inflation rate compounded annually for 11 years was used to calculate a multiplier which was used to determine the 1988 cost axis. Thus the 1976 axis cost multiplier is determined as

$$(1+i)^n \qquad (1)$$

where i is the inflation rate at 3.6% and n is the number of years, 11 yr. The construction cost of the recently proposed improvement, nearly $2 million, is less than the threshold. A linear extrapolation based on plan A resolved this dilemma. The extrapolated area was reduced by multiplying by the proportion of the area cropped, 75.87%. The reduction in flood land was determined to be 240.3 ha (593.5 a).

The financial benefit of a drainage project derives from increased income from cropland no longer flooded. Simultaneously, land lying outside the maximum flood land receives no increased sales. Depending on the time that flooding occurs, some crops may be harvested and sold from the flooded land in some years. However, to favor the project, it was decided that the flooded area, prior to project completion, produced no harvestable crops, but that it did incur average watershed planting costs. Additionally, after project completion, the newly unflooded land produces an average harvestable crop each year. Therefore, the financial benefit of the drainage improvement is the annual, gross harvest sale from the newly unflooded land.

Statistically, 75.87% of the land is routinely grain cropped (Ohio Agricultural Statistics 1980 through 1985). The remainder consists of small towns, forest or wasteland, and pasture for animals. Therefore, reduced flooding will increase the amount of cropland almost entirely.

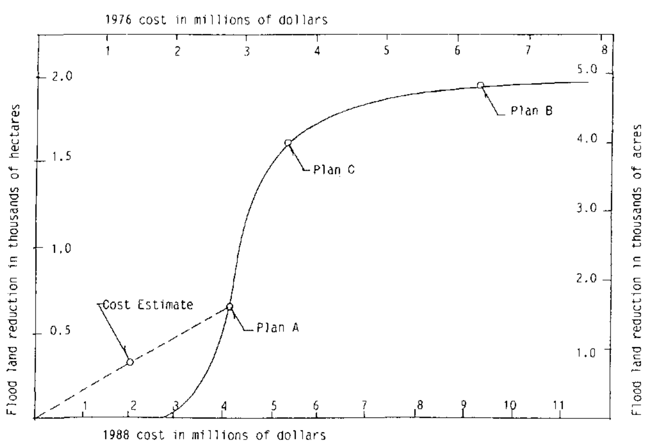

FIGURE 1. Flood Land Reduction as a Function of Cost.

Plans, named Plan A, Plan B, and Plan C, were suggested by the professional engineer (Mekus 1976). An arbitrary 3.6% inflation rate compounded annually for 11 years was used to determine the 1988 cost axis. Because the proposed cost is before the "threshold," an extrapolation from Plan A was used for the Cost Estimate in an effort to make the project look more favorable.

The cropland is devoted almost entirely to growing corn, soybeans, wheat, and oats. The distribution of the cropland among corn, soybeans, wheat, and oats is 35.0, 45.7, 17.2, and 2.1%, respectively (Ohio Agricultural Statistics 1980 thru 1985). The average yields for corn, soybeans, wheat, and oats are 10.3, 3.14, 4.43, and 6.69 m^3 per ha, respectively. In English units these are 115.9, 35.3, 49.8, and 75.3 bu/acre. Average prices at the local market paid over the year for corn, soybeans, wheat, and oats were 42.78, 143.61, 76.11, and 38.33 dollars per m^3, respectively (Stryker Farmers Exchange 1987). In English units these are 1.54, 5.17, 2.74, and 1.38 dollars per bu. The gross average sales per unit area is determined by multiplying the weighted percent planted by yield and by price. This value is $423.51 per ha ($171.52 per a). Finally, the gross, financial benefit is the product of gross sales per unit area times improved land area or $101,800 at the start.

Inflation can be expected to increase grain prices. Interestingly, grain prices do not keep pace with inflation (Agricultural Statistics 1985). Improved seed, farming methods, and so forth, increase the gross sales through increased yields. It can be determined that the weighted, average yield grows at a 1.1% rate compounded annually (Agricultural Statistics 1985). The grain price increase was selected to be the inflation rate, as another favor to the project. Therefore, the financial benefit increases at about the sum of the grain price and grain yield rates.

Factors against the financial benefit are: a) project cost including financing costs, b) permanent maintenance costs, and c) loss/cost through depreciation of the project, and its maintenance series. Project construction cost was stated, nearly $2 million, but damages resulting from accesses, easements, and so forth were not included in this cost by the professional engineer (Mekus 1988). Consequently, damage costs were ignored in the cost-benefit determination.

The initial project cost is due at completion and would be paid either through a loan or directly by the assessed landowners. Interest cost is incurred whether a loan is secured or investment income loss occurs. It was decided to distribute the project and interest cost over the life of the project by calculating a constant loan repayment paid annually. The loan period was selected to be 30 years to correspond with one generation of petitioners. The loan interest rate was set at the prevailing bond interest rate, 9%.

Maintenance costs can be expected to increase at the inflation rate. Based on recent experience, the predicted value for inflation was selected to be about 4.4%. Annual maintenance develops into a series of costs which were analyzed as mini-projects.

Depreciation of the improvement, as well as its annual maintenance, results in decreased gross sales. Depreciation of ditch improvement is treated by both the Internal Revenue Service (IRS) (Depreciation 1987, Farmer's Tax Guide 1987) and the U.S. Army Corps of Engineers (Ohio Stream Management Guide 1986). From an example, it can be derived that the Corps of Engineers expects a 9.9% annual maintenance to be required to maintain the level of improvement. The IRS provides a procedure for calculating the depreciation. This procedure is to take a 7.5% per year declining balance for any year that a straight line depreciation is less, followed by a straight line depreciation to zero at 20 years. That is,

$$\text{if } 0.075\,F > (F/(21-x)), \quad (2)$$
$$\text{then } F = 0.925F \quad (3)$$
$$\text{else } F = F-(F-(F/(21-x)), \quad (4)$$

where F is the presently depreciated value, x is the year since project completion, and the right half of (2) is the slope of a line from F to the x axis. Interestingly, the declining balance provides for a natural/exponential depreciation of the improvement. The computer determined that this procedure requires 9.8% annual maintenance to continue the initial level of the improvement after 20 years. The two agencies are nearly in agreement. Interestingly, the consulting engineer has proposed only 3% maintenance the first year, with subsequent years unspecified (Mekus 1988). The IRS depreciation procedure was used for both the initial improvement and the subsequent series of annual maintenances for the cost-benefit determination in the present analysis.

The above information provides answers to the questions asked in the introduction. This information permits computer application to derive a year by year cost-benefit schedule (Table 1). The software program, written in GWBASIC®, updates the cost-benefit each year based on inputs for inflation, crop yield increase, and other factors.

At zero year, the improvement is completed and no payments are due nor benefits received. This line is not shown. At year one, the first project payment is due, the first benefit is received, and the first maintenance completed. At year two and the following years, a benefit is received, and annual project and maintenance payments are due.

RESULTS

The initial finding when cost-benefit data are analyzed is that the annual net benefit is negative each year for a period of at least 30 years (Table 1). That is, a loss is incurred each year after the improvement is completed. With typical projections (Table 2), the loss accumulates to nearly $6 million at 30 years. A second, significant finding is that the computed cost-benefit schedule is an explicit expression which rejects the petitioned improvement according to the Ohio Ditch Law (RC 6131.12).

Additional analyses reveal that the finding of annual loss holds even if:

1) the maintenance were zero (accumulates to nearly $4 million loss),
2) the maintenance were 9.76% of project cost required for level maintenance (accumulates to nearly $9 million loss),
3) the gross sales or financial benefit were 90% higher (accumulates to nearly $3 million loss),
4) the inflation and crop yield increases are each zero (accumulates to nearly $6 million loss at 30 years).

The above examples demonstrate the ease with which a computer cost-benefit study can accommodate a variety of conditions.

TABLE 1

Cost-benefit schedule for the Tiffin River drainage improvement.

Year	Gross Annual Benefit[1]	Annual Cost[2]	Net Annual Benefit[3]	Accumulated Benefit
1	102	194	–93	–93
2	103	257	–154	–247
3	104	259	–156	–402
4	105	262	–157	–559
5	107	265	–159	–718
6	108	268	–160	–878
7	110	272	–162	–1,040
8	112	275	–163	–1,203
9	117	279	–162	–1,364
10	119	282	–163	–1,528
11	120	286	–166	–1,694
12	121	290	–169	–1,862
13	122	294	–173	–2,035
14	122	299	–177	–2,212
15	121	303	–182	–2,395
16	119	308	–189	–2,583
17	117	313	–196	–2,780
18	113	318	–205	–2,985
19	109	324	–215	–3,200
20	103	330	–227	–3,427
21	96	336	–240	–3,666
22	101	342	–241	–3,907
23	107	348	–242	–4,148
24	113	355	–242	–4,391
25	119	362	–243	–4,634
26	125	369	–244	–4,878
27	132	377	–245	–5,123
28	140	385	–245	–5,368
29	148	394	–246	–5,614
30	156	402	–247	–5,861

Amounts expressed in thousands ($)

Footnotes:

1. The gross, financial benefit values are calculated by:
   a) depreciating the initial benefit—7.5% during the early years,
   b) appreciating the initial benefit by the inflation, 4.4%,
   c) appreciating the initial benefit by the annual yield increase, 1.1%,
   d) appreciating the benefit in proportion to the fraction of the maintenance to the initial, about 62/200, each year—thereby forming a series of maintenance terms, with a limit of 20, and
   e) depreciating each term of the maintenance series appropriately by the depreciation procedure per (a) above.
2. The annual cost is the sum of the annual constant payment ($194,000), the annual maintenance cost ($62,000), and the appreciation of the annual maintenance appreciation at the inflation rate (4.4%).
3. The net annual benefit is the difference of the first two columns. Occasional unitary, subtraction differences occur in the schedule because the computer uses the exact numbers before rounding.

DISCUSSION

A cost-benefit statement is made in the 1988 report of the professional engineer (Mekus 1988). In part it states,

> "If the watershed cropland experienced a $1.80 per acre [$4.44 per ha] savings for 5 years, the project would be paid for. In other words, the savings could be an increase in productivity or stopping a decrease in productivity of $1.80 per acre. . . .$1.80 per acre amounts to approximately 0.5 bushel per

TABLE 2

Values used to calculate Tiffin River cost-benefit schedule.

PARAMETER	at start	at 30 years
Initial cost ($)	1996954	---
Financing interest (%)	9	9
Annual payment ($)	194376.2	˜194376.2
Annual maintenance ($)	62300	208018.5
Inflation (%)	4.4	4.4
Crop price growth (%)	4.4	4.4
Crop yield growth (%)	1.1	1.1
Gross sales per hectare ($)	423.65	2111.48
or sales per acre ($)	171.52	854.85

acre [0.044 m^3 per ha] of a combination crop of corn, wheat, and soybeans. . . .Based on the above summation of benefits, we are of the opinion that. . . .the benefits exceed the costs."

The report states further that there are 249,984 cropland acres [101,168 ha] in the watershed. In five years this calculates to a $2,249,856 benefit. Against this, it states that the project cost is $2,240,954 with a maintenance cost at $1,000 per mi [$621.50 per km]. This calculates to a net benefit of $8,902 at five years. The cost-benefit schedule (Table 1), provided as an objective of this study, indicates a loss at five years of $718,000, with losses continuing to accumulate.

The cost-benefit statement in the engineer's report is not generally acceptable because it assumes that each unit area of cropland of the entire watershed will experience an equal profit increase. Much of the watershed area is some distance from the river. Since more than 97% of the watershed is not flood land, it seems most unlikely that this large remainder would experience any increase in profit. Moreover, the $1.80 per acre seems to be a contrived value without reasoned basis. The report's cost-benefit statement seems typical of those used to promote ditch improvements. The present study uses reasoned but favorable values, derived from reliable sources (Table 2), to show that the project would not be cost effective (Table 1).

The Ohio Department of Natural Resources (ODNR) provides a guide for those seeking ditch improvements (Ohio Stream Management Guide 1986). This guide states,

"Larger streams cost more per mile to modify and maintain. Streams which are enlarged too much will tend to fill with sediment, thereby increasing the costs of maintaining the modified channel. For this reason, modification of large rivers is rarely cost-effective, except in urban areas where valuable property is located in the floodplain."

The statement by ODNR is a generality which fails to provide a procedure to determine the cost-benefit merit. Trapped by its own statement, ODNR encouraged the project's construction (Mekus 1988) so long as it could provide a "mitigating" team to oversee the improvement. No attempt was made by ODNR to demonstrate how the Tiffin River ditch improvement would be cost-effective. The present study suggests that the proposed improvement, even when analyzed in the most favorable light, would not be cost-effective (Table 1).

The petitioned Tiffin River ditch improvement was rejected by a Joint County Board of Commissioners on 13 June 1988, at a meeting in Wauseon, OH (Archbold Buckeye 1988). That the rejection was, in part, attributable to the analysis described in this paper was admitted privately to the author by at least one commissioner.

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