1989-06-01

Water Levels Reference Study. Phase 1. Agriculture Work Group Report

International Joint Commission. Functional Group 3. Work Group 5

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AGRICULTURE
WORK GROUP REPORT

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INTERNATIONAL JOINT COMMISSION
WATER LEVELS REFERENCE STUDY
PHASE I

JUNE 1989

GREAT LAKES FLUCTUATING WATER LEVELS STUDY

FG 3, WG 5

AGRICULTURE INTERESTS

REPORT FOR PHASE 1 A:WG5-2 30/1/89

1. INTRODUCTION/BACKGROUND

On August 1, 1986 a Great Lakes Water Level Reference was forwarded from the governments of Canada and the United States to the International Joint Commission pursuant to Article IX of the Boundary Waters Treaty of 1909. This Reference requests the IJC to examine and report on methods of alleviating the adverse consequences of fluctuating lake levels in the Great Lakes - St. Lawrence River Basin.

This study is being conducted in two phases. Phase I of the study, to be completed in May '89 consists of characterization of fluctuations and consequences, development of a comprehensive inventory of measures and an evaluation framework, and design of a preliminary information program for use by Governments. Phase II consists of refinement of data bases, detailed evaluation of measures, and a design for a final information program for use by governments.

Five Functional Groups have been identified in Phase I of the study, each dealing with different aspects of the fluctuating lake level issues. Functional Group 3 (FG3) has the lead responsibility for analysis and assessment of socio-economic impacts of measures on interest groups including significant impacts on interest groups outside the coastal zone and outside the region. FG3 has identified 9 major interest groups which use and relate to the Great Lakes in a variety of ways: Transportation, Commercial and Industrial, Agriculture, Commercial Fishing, Power, Riparian, Recreation Environmental, and Governments. Each of these interests are represented by separate Working Groups. This paper is the contribution of the Agriculture Work Group of FG3 to the Phase I report.

2. APPROACH OF THE WORK GROUP

The Agricultural Impact Assessment Work Group is tasked to delineate the interest class and describe the ways that it is impacted by fluctuating water levels in the Great Lakes. Direct impacts are erosion of agricultural shore lands, inundation of diked acreage if the dikes are overtopped by extremely high water levels, and the cost of pumping drains which are below lake level. Indirect impacts are agriculture related commerce, especially transport of product or fertilizer by lake navigation.

The Work Group started the study by reviewing several previous Lake Level Studies. The next step was to contact the agricultural departments at the Federal, State and Provincial levels. These agencies, especially at the State and Provincial level, have extensive field programs to work with individual farmers and farm organizations. They understand the perception of the agricultural community on almost all issues. In addition, they were able to indicate the geographical extent of lake-level-sensitive farm land and the nature of potential impacts.

In Ontario there was considerable activity related to diking through the Regional Conservation Authorities. Data on dike heights and acreage protected from these agencies will be used to build the effects model. As described in the Section on Modelling below, this model will use the water level sequences developed by FG 1 to calculate the frequency and extent of flooding due to overtopping associated with the "do nothing" case and each of the "measures" considered in Phase II of the Study. The minor costs of pumping agricultural drains which are below lake level also will be estimated as a function of lake level. Erosion of agricultural shoreline will be estimated by FG 2.

Potential Losses

Thousands of acres of high-value crop are protected by dikes and pumps in the near coastal areas of Lakes Erie and Sinclair and Saginaw Bay. These dikes and pumps are used to drain former marsh lands for agricultural use. A combination of private and public resources have been used to construct and operate these facilities. The rich marsh-bottom soils produce market garden type row crops worth 450 to 1200 dollars per acre. Obviously, it is possible to plant a variety of crops on the same land, so that "current" cropping practice must be assumed to continue or that the farmer is adjusting to fluctuating lake levels by changing to a different crop.. Total, or near total loss of the crop will occur only in the catastrophic case of dike overtopping during the growing season. In all other cases it will be possible to relate the impact of a change in lake level to the changed pumping costs or value of the reduced crop yield. Damage to buildings and other infrastructure must be added to the crop losses.

Modelling

Quantitative impact assessment will require a mathematical model capable of predicting the effect of various measures on agriculture, particularly those which would change the regime of water levels. The model will make use of a substantial amount of information developed by other Functional Groups. An effort underway during Phase 1 by the Terrestrial Subgroup of FG 2 will ultimately provide the foundation for quantitative analysis. FG 2 is developing a land use / land cover data base for the flood and erosion prone shoreline areas through the

interpretation of color infrared aerial photography. Once complete, the data base will provide up-to-date information on the extent and nature of agricultural practices in the shoreline regions, identify the areas most susceptable to the effects of lake level fluctuations and measures which would affect levels, and would enable the estimation of the rate at which land is converted to other uses.

As noted above, there are potentially significant agricultural benefits from any change which limits the extreme high levels that would result in over-topping existing protective dikes. Some agriculture benefits would result from a lowering of the mean water level because this would result in lower average pumping costs associated with agricultural drainage compared to the "do nothing" case. A reduction in both the high and low extremes would reduce pumping costs even if the mean water level was unchanged because most pumping is needed only for the higher water levels.

The model must be able to incorporate both of these modes of benefit. The benefits or losses will be measured relative to the "do nothing" condition. It will operate with the hydrologic predictions from FG 1. and calculate the cost to agriculture (pumping + inundation) for each monthly mean water level. There will be an agricultural losses vs water surface elevation relationship for each of Lakes Michigan/Huron, St Clair, Erie, Ontario and Ste Pierre.

3. DESCRIPTION OF THE INTEREST CLASS

The Great Lakes region of North America, taken as a whole, is of major significance in agricultural production. Yet, despite the overall importance and large scale of agriculture in the region, the specific effects of Great Lakes water level fluctuations on agriculture are quite limited. The impact on agriculture is minor for several reasons. On the U.S. side, particularly, the majority of the Great Lakes shoreline is given to non-agricultural uses. In Canada, erosion of agricultural shoreline, while equally extensive as urbanized shoreline, is much less costly and there usually is little structural damage.

Inundation due to dike overtopping is catastrophic to the affected farmer but is small in comparison to other effects of fluctuating water levels because it is limited to only a few low lying areas. The total acreage is relatively small. In addition, there is a very low probability of dike overtopping.

The agriculture interest includes any facet of agriculture that could be impacted by the various measures under consideration to address the problem of fluctuating water levels. This includes loss of land due to erosion, inundation of land due to high water levels, restriction of land use by zoning or other regulations and the use of tax and other incentives to adapt to fluctuating water levels. Irrigation of agricultural crops is very limited in the basin and largely unaffected

by fluctuating water levels. The indirect impact of crop or fertilizer transport by lake navigation is included under the navigation interest.

The interest class can be subdivided by the mode of physical impact, ie. either erosion or inundation. In some cases erosion leads to inundation, ie. protective dikes may fail due to erosion, exposing agricultural acreage to inundation.

The kind of crop also provides the basis for subdivision. Some crops are much more valuable per acre, for example pasture land vs row crops such as tomatoes. Some crops are more resilient to temporary inundation. For example, well established corn may survive several days of inundation whereas field tomatoes would be destroyed immediately.

Previous Studies

Earlier studies of the impact of Great Lakes Water Levels on the Coastal Zone have not treated agricultural property separately. The Regulation of Great Lakes Water Levels Report of 1973 listed "Economic Effects on Shore Property" under five sub headings, but lumped agricultural land in the sub-heading "Erosion and Inundation". It was noted that 80% of the damage under this category was "Urban". It can be assumed that the other 20% was either agriculture or undeveloped, such as park land or forested.

The Lake Erie Water Level Study of 1981 described a major category of interest as the "Coastal Zone". Land use in the coastal zone of each lake was quantified and tabulated, but in this study agriculture was grouped with forested land. Only in Quebec was agricultural use identified separately.

On the U.S. side, the 1971 National Shoreline Study used the land classification "Agriculture and Open Spaces" in its shoreline land use survey. It was estimated that approximately 17 % of the U.S. shoreline was in this category in 1970.

4. SENSITIVITY OF AGRICULTURE TO FLUCTUATING WATER LEVELS

This study is concerned primarily with the problems associated with water level fluctuations and the assessment of the likely impacts of potential measures for dealing with water level changes. The direct causes of problems associated with water levels are erosion and inundation, both of which are at their worst when storms coincide with high water levels.

Changing water levels have occurred throughout the development of the agricultural areas of the Great Lakes. The agricultural areas now at risk are actually encroachments into the natural regime of the lakes. Natural wetland marshes and low lying land subject to periodic flooding

was converted to agricultural purposes. As development occurred, adjustments to water level fluctuations were made, such as diking, drainage works, and the installation of control structures and pumps. These adjustments over time served to lessen the impacts of high water levels. However, damage susceptibility remains, particularly in low lying and diked areas, since higher than previously observed water levels are possible and dikes can fail for a variety of reasons.

The Nature of Agricultural Losses

The agricultural interest group is affected by fluctuating levels and by most possible measures in much the same way as most other riparian land owners and the process at work can be similar in both urban and rural settings.

Agricultural land at the shoreline is subject to erosion at the same rate as urban development. The vast difference in dollar losses, however, leaves agriculture losses due to erosion as a relatively small portion of the total erosion loss. Erosion of the protective dikes, however, will lead to very significant inundation losses. Once breached by localized erosion, the dike will erode further due to the rush of water through the breach.

The areas most subject to problems with runoff and lake related flooding are those areas that have been converted from marshes and wetland to farming. Two such notable areas are the lower Saginaw River basin in Michigan and the southwest part of Ontario in Kent and Essex counties. Such areas tend to be extremely flat so that a small difference in flood stage creates very large differences in the area flooded. Thousands of acres in the Ontario counties are protected from flooding during high lake levels by extensive diking. A small area (650 hectares) in the Province of Quebec, along the shore of Lac Ste Pierre, has similar problems.

Some low-lying agricultural lands are undiked and occasionally are inundated during periods of high water level. Loss of production from these lands, now and again, is accepted because the loss is less than the cost of building dikes.

The very flat fields must be under drained and many "Municipal" drains have been constructed to carry this drainage to the lake. At low lake levels these drains operate under gravity flow. As the lake level rises it becomes necessary to pump many of these drains to lift the drainage water to lake level. Indeed, some of this agricultural land is below lake level even when the lake levels are in their "normal" range. The cost of this pumping is directly proportional to the water level in the lake.

Crop damage can occur even before it becomes necessary to pump the drains. If the water level in the main drains is too high, the soil in the field becomes water logged and the crop will suffer. If this condition occurs only infrequently and for short periods, the farmer simply accepts the lower yield rather than install an expensive pumping system. Thus, even at relatively low water levels in the lake, agricultural losses are evident.

Dike Overtopping

The most severe and catastrophic agricultural losses result when the water level in the lake rises above the top of the protective dike. Inundation in this case will rapidly cover thousands of acres. Overtopping of the unconsolidated dike will cause local erosion of the dike and the breach will be enlarged so that water will continue to flow through the breach until the flood water over the fields is at the same level as the lake.

This local high water often will be associated with a temporary rise in local water levels above the static lake level due to wind related "set up". In this case, it may be possible to repair the breach after the local water level recedes and prevent a continuation of the flooding. Even with the dike repaired, the water inside the dike must be pumped out. This process could take some considerable time.

Pumping Cost vs Lake Level

Field drainage water must be discharged to the lake. When lake levels are low this discharge will occur naturally as the water in the municipal drains flows down to the lake. As lake levels rise the available slope from the fields to the lake is decreased. This decreases the amount of water flowing in the drains.

When the drains cannot carry the water away fast enough to protect the crop, it is necessary to install pumps at various places to lift the water and thus increase the discharge. As the lake level increases further it is necessary to pump against a higher head to keep the water flowing to the lake. This requires more power at the pump so that there is a direct relationship between pumping costs and the water level in the lake.

Some fields are below lake level even at long term mean lake levels. In these cases it is necessary to pump continuously in order to farm the land. The cost of keeping these fields in production simply increases as the lake levels increase. Obviously, these fields have been "reclaimed" from the lake at some time in the past. As with many former marsh lands, the value per acre of the crops grown may be very high.

Reduced Crop Yields

Effective under drainage is essential to produce maximum crop yields. If the ground water level rises close to the surface, a water logging condition interferes with plant growth. If this condition occurs only occasionally, and if it persists for only a short time, it may be better for the farmer to accept a lower yield, or even loose a years crop, now and then, rather than to bear the cost of constructing a pumping system. Thus, even in areas where there are no pumps there can be a loss to agriculture because of increased lake levels.

Position of the Interest Group

The farmers who are protected from fluctuating water levels by dikes see any possibility of dike failure as catastrophic. They invest in the farming enterprise on the assumption that their land will not be flooded. Any threat to the dike system or even occasional overtopping is viewed as a disaster and government assistance and compensation is expected. The farmers are prepared to pay the cost of pumping drainage water as an ordinary cost of operation.

Farmers are accustomed to dealing with the uncertainties of nature. The occasional flooding of undiked land would be seen as similar to drought or hail damage. This situation is not unlike the farming of the flood plain of a large river.

5. IMPACT OF MEASURES

Type I Measures

Proposed Type I measures involve the investment of public funds in control and diversion works. These are the measures designed to change the regime of water levels in the Great Lakes.

One such measure would be "Interbasin Diversions", that is, existing interbasin diversions would be increased or decreased in such a way as to reduce the range of the water levels in some of the lakes. This could have large agricultural benefits if it prevented overtopping of protective dikes. Even a decrease in the frequency of overtopping water levels would be beneficial.

The model would estimate the agricultural losses associated with a particular regime of water levels. This would be compared to the losses associated with the "do nothing" regime of levels. The difference in losses would be the benefit or disbenefit to agriculture. The input to the model is the series of levels resulting from the manipulation of

interbasin diversions. The output is the losses to agriculture in dollars/year.

A second proposed Type I measure would be the construction of a control dam at the head of the Niagara River along with increased channel capacity so as to control the water level of Lakes Erie, Huron and Michigan. This would be done at the expense of a greater range of water levels on Lake Ontario or a greater range of flows and levels in the St. Lawrence River. This measure would have agricultural benefits for the Ontario farmers because they would be protected against dike overtopping. The farmers in Quebec, however, would be worse off because of an increase in the range of water levels and flows in the St. Lawrence River, leading to an increase in the range of water levels on Lac Ste. Pierre.

Once again, the model would estimate the agricultural losses associated with a controlled regime of water levels. In this case, however, the benefit on Lake Erie will be offset somewhat by the loss on Lac Ste Pierre. While it is possible to calculate a "net" benefit for all agriculture, it would be politically expedient to report these two counteracting effects separately.

Type II Measures

Proposed Type II measures use public investment to direct land and water use to adapt to shore fluctuating levels. This type of measure has only two possible scenarios for agriculture. Either raise the dikes to protect against the highest possible water level or buy out the farmers and return the land to natural marshes. Shore protection to prevent erosion is not cost effective for agricultural land because of its relatively low value compared to residential or commercially developed land. Neither of the proposed Type II measures, ie. off shore barrier islands or structural flood proofing would be of any benefit to agriculture.

Type III Measures

Proposed Type III measures require direct public regulation of land and water use. This could place restrictions on how erosion and inundation prone lands could be used.

One important factor in agricultural inundation is the ability of a crop to survive short periods of inundation. In some cases a crop will survive several days of inundation, while even a few hours will destroy other crops. Thus, it might be appropriate to restrict the type of crop. If the land is flooded frequently, it might be appropriate to prohibit farming altogether.

The first proposed measure from Type III calls for adaptive design for fluctuating levels. The agricultural dikes are an example of this kind of action. Unfortunately, they give a false sense of security. This increases the value of the land and encourages investment even though it is impractical to build the dikes high enough to protect against any possible water level. We have no guarantee that the highest possible water level is contained in the short historic record available.

The second proposed Type III measure is erosion setback zoning. This has no application to agricultural interests because,as noted earlier, erosion along undiked reaches is of only minor interest to agriculture.

Type IV Measures

Proposed Type IV measures are public programs to indirectly influence land and water or the effects of fluctuating levels. The first proposed Type IV measure is Interest Rate Subsidy Loans. These loans would be made to individual property owners to partially fund protective works. In terms of the agricultural interest, this could include building or improving the protective dikes and the installation of additional pumps. The dollar limits on the program are too low for most farm situations.

The second proposed Type IV measure is Real Estate Disclosure. This provision to protect future land owners applies equally to urban and rural property. The prospective purchaser of hazard lands must be protected from the unscrupulous property owner who would not inform the buyer of the erosion or inundation history. Unlike an urban purchaser, a farmer might knowingly complete the purchase, and be prepared to take his chances just as he does against drought or hail storms.

Type V Measures

Proposed Type V measures are the emergency response capability. One of the proposed Type V measures is the creation of an Information Centre which would be manned on an emergency, 24 hour, basis during critical periods to provide real time information on water level and wind velocity. This information would assist the property owner, along with government support, to defend his property or avoid loss of life. This measure applies equally to urban and rural property.

The second proposed Type V measure is sand bag and diking assistance. This measure is especially appropriate to the agricultural interest. Sometimes even a few inches of additional dike height can avoid serious overtopping and the consequent flooding of hundreds of acres of farmland. It usually is uneconomic to design the dike height to withstand very improbable water levels.

6. PRINCIPLES (CRITERIA)

The agricultural interest group is unaffected and disinterested in lake levels until there is a threat to their protective dikes. Damage due to dike overtopping depends on the type of crop flooded, the duration of flooding and the season in the crop year. Some farm land is unprotected by dikes and experiences some inundation during periods of high lake levels. In these cases, the farmer has decided to accept the occasional flooding rather than pay for dike protection.

Erosion of farm land is identical in process to the erosion of any other shore property, but the relatively low value per acre rules out most forms of erosion protection.

The appropriate evaluation criteria for quanitative assessment of the impacts of measures are changes in average annual losses due to inundation and changes in land values (net income factors). The first addresses the principal problem associated with high water and the measures which might affect the incidence of flooding. The second addresses erosion and measures which might affect its incidence. Changes in land values also applies to measures which would affect future land use or land use changes, such as Types II and III.

7. NEEDS FOR ASSESSING IMPACTS

Assessing the impacts of various measures on the agricultural interests requires the development of a stage/damage relationship for each region which is at risk. For dike protected acreage this will be a step function with very little impact until the dike is overtopped. For unprotected acreage the damage function will be continuous and must be modified for season of the year, duration of inundation and kind of crop. Economic analyses performed for the economic justification of the diking project are available to assist in developing the damage portion of the analysis of impact.

In Ontario, there is good data on the height of the protective dikes which will permit the determination of the number of times there would be overtopping under the base case conditions and with any particular measure. As with shore erosion, the effect of wind set-up, and the probability of a storm coinciding with high water levels must be factored into the analysis.

Dike protected agricultural acreage on the shore of Lac Ste Pierre, down river from Montreal, must be included in the determination of the total impact of any measure which includes regulation of the outflow from Lake Erie. Top of dike information for this region should be readily available since the dikes currently are under construction.

8. SUMMARY AND CONCLUSIONS

Agricultural land is at risk in several regions of the United States and Canada. The primary concern is for catastrophic flooding of low lying acreage which is protected by dikes. Dike overtopping could inundate thousands of acres of valuable cash crop. Such areas are located in Essex and Kent Counties of Southwestern Ontario, on the north shore of Lac Ste. Pierre in Quebec, and in the lower Saginaw River Basin in Michigan.

A secondary consideration is the direct erosion of agricultural acreage. Losses of this kind will be much lower than erosion losses in urban areas because of the relatively low value of agricultural land.

Agriculture will be unaffected by many of the proposed measures. There will be a significant benefit from any measure which reduces the number of occurrences of dike overtopping water levels but the net benefit determination must take into account the likely disbenefits to Lac Ste. Pierre farmers.

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