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Storm Drainage in Indiana Counties

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INTRODUCTION

Because of the relatively recent glaciation, natural drainage systems have not had time to develop adequately in many northern Indiana counties. Some of these counties, as well as many other counties in the state, are experiencing rapidly changing land development from primarily rural to suburban or urban use. These factors, coupled with the recent emphasis on environmental protection and the less than adequate institutional arrangements existing, have led to an increased interest in storm drainage philosophy and design.

Indiana has recognized the problem and attempted to deal with it to some extent with the passage of statutory law, in particular the *Indiana Drainage Code*[1]. Under provisions of the code, the Indiana county surveyors are involved officially in drainage planning, design, and implementation. His duties are outlined as follows (Burns, 27-2009):

1. Be responsible for investigating, evaluating and surveying all legal drains or proposed legal drains, and for the preparation of all reports, plans, profiles and specifications necessary or incident to any proposed improvement. In preparing such plans the surveyor shall include the seeding of all open drain ditch banks where the same is feasible;
2. Prepare, and make public, standards of design, construction, and maintenance that will apply to all legal drains and the appurtenances thereto, and in preparing such standards the surveyor shall give consideration to published recommendations made by Purdue University, the American Society of Agricultural Engineers, the American Society of Civil Engineers, the United States Department of Agriculture, and other reliable sources of information;
3. Superintend all construction, reconstruction, and maintenance work on all improvements; and

[1] See REFERENCES section.

4. Catalog and maintain record of all surveying notes, plans, profiles and specifications of all legal drains in the county, and of all mutual and private drains when available. [Acts 1965, ch. 305, § 109, p. 831.]

In addition, under the code, "The surveyor shall classify all legal drains in the county as: (1) drains in need of reconstruction, (2) drains in need of periodic maintenance, and (3) drains which should be vacated." These duties, if to be done adequately, particularly under conditions of changing land use, will require future land use projections and planning to a degree appropriate for the situation. This is not to say that all areas of the state are lacking in planning. Some counties have prepared comprehensive drainage plans. (As an example, see References 2 and 3)

Within the confines of this paper, the author wishes to discuss some elements of the philosophy and design approach necessary for the planning and execution of well-engineered drainage works. There are important parts of the total drainage picture which will not be considered. This includes a discussion of flood plain studies and associated zoning regulations. Also the institutional arrangements and financing of drainage works will not be covered. It is hoped that this paper might provide some incentive, so that at whatever level a county's present drainage assessment is directed, this activity will be channeled toward long-range comprehensive goals.

PHILOSOPHY OF DRAINAGE DESIGN

Probably the ultimate objective of drainage design is the removal of excess storm runoff (or groundwater) for the protection of property and life in an economically efficient, environmentally sound, and aesthetically pleasing manner. The design of a method for doing this encompasses a broad range of activities from master drainage planning down to the design of individual components in the system. Within the framework of the *Indiana Drainage Code,* the county surveyor should carry out or supervise these activities with this ultimate objective in mind. The county surveyor or drainage engineer is now called upon to advise area plan commissions or zoning agencies in evaluating the impact on drainage of proposed new land uses. Too often, the master drainage planning is lacking or inadequate to allow logical decisions to be made with regard to proposed changes in land use. Blanket arbitrary decisions are made in the absence of this planning. As an example; in at least one county, new permits for subdivision developments are issued only if provisions are made in the drainage design for retention basins so that the *peak* runoff rate is not larger than that existing under prior land use. This is an attempt at regulation, however in this particular case, the regulation is not based on an engineering analysis of the existing drainage system.

The author, realizing the reality of funding and political arrangements within individual counties, is not proposing that every county must have master drainage planning. What is proposed, however, is that the desirability of this goal at some future time be recognized and that current activities be directed with this eventual goal in mind. Thus, a duplication of effort is avoided and component parts are gradually realized.

A good master drainage plan should incorporate projected future land use, should define the future drainage system to service this land use, and should provide the procedures and appropriate criteria to implement this plan.

The planning process might take the following steps. First, survey the existing drainage system. Second, project land use and determine those locations where change and growth are likely to occur within the planning period. Third, evaluate the hydraulic performance of the existing system in these areas. Finally, based on land use and hydraulic performance, arrive at a proposed future system.

Surveys of the existing drainage system is an ongoing process and is done in many localities as problems arise. For future hydraulic studies, the following information should be obtained. For open ditches, an adequate survey would include plan and profile drawings, cross-sections of the ditch where changes in size or shape occur, a notation as to type and growth of the vegetation lining the banks, and finally the bank soil type. Closed drains should be surveyed for plan, profile, pipe size, pipe type, and pipe condition. In addition all structures affecting open ditches should be noted. For bridges and culverts, this would include waterway cross-sectional area (or culvert diameter), length of the structure, inlet and outlet elevations, alignment with respect to the ditch, and inlet construction (i.e. wingwalls, flared entrance, etc.).

Too often, present surveys do not include all of the above information. However, much of this information, not presently being obtained, can be secured at little additional expenses as the survey is conducted.

With the survey information at hand, a hydraulic investigation can be conducted at the time when it becomes necessary to analyze components of the system. This type of investigation may be quite comprehensive (see reference 2 for example) or it may be of a much simpler form. This investigation will provide knowledge of the present system capacity, will show the location of any "bottlenecks" in the system for possible reconstruction, and will provide a rational basis for decision making when changing land use requests are considered by planning or zoning agencies.

In formulating the master drainage plans, decisions should be made as to how the system necessary for future drainage will evolve. Since changes in land use from rural to suburban and finally to urban involve greater peak rates of runoff, decisions should be made as to whether the capacity of the drains will be increased or whether storm water storage will be provided. Temporary storage can be provided in retention or detention basins, on roofs, in parking lots or in greenway areas. The drains themselves can be either open channels or closed conduits. In making these decisions, economics, institutional arrangements, safety, environmental factors, and aesthetics should be considered.

Keep in mind that there is currently discussion on the advisability of treating storm discharge in the urban region to control water quality. In the environmental area, what is today discussion is tomorrow practice. Under these conditions, the temporary storage of storm flow is advantageous. Suspended sediment is allowed to settle, and peak rates of runoff are reduced, thus requiring smaller treatment facilities.

Consideration should also be given for the provision of two drainage systems in urban and suburban areas. These have been designated the "initial" and "major" systems. (See reference 4) The initial, which is designed for a storm return period of from two to ten years, provides the drainage necessary to protect against regularly recurring damage and is the usual storm sewer system. The major system, with a design return period of once in perhaps 100 years, is designed to obviate major property damage and loss of life. This system consists of provisions for surface water courses which normally would be dry but would be available if needed. Roads and streets can also be used if water escape routes are provided.

DESIGN OF DRAINAGE FACILITIES

Even though storm drainage systems have been designed for many years, there still is inadequate knowledge of design procedures, particularly in the urban setting. The federal government is presently funding many research activities in this area. (See for example, the American Society of Civil Engineers, Urban Water Resources Research Program, as outlined in *Civil Engineering* magazine, May 1968.) It might be expected that results of this research will reach the practitioner in the next decade. Until this time, the designer must rely on available procedures.

This simplest approach to channel or culvert design in the rural setting is a relationship between drainage area and waterway cross-sectional area. Talbot's formula is one often used method of this type. Its use however, is to be discouraged since the hydraulics of the system and a decision based on storm return period, hence degree of flood protection offered, are ignored. Better methods are available which can lead to a more economically efficient and safer design, particularly in areas which are changing in land use. These other methods, which typically involve two steps—runoff calculation and hydraulic design—are adequately outlined in many available publications. The author has assembled a list of readily available, low-cost references of this nature along with some notation as to their applicability.

Calculation of the Magnitude of Storm Runoff

1. Rational Method
   Ref. 5, pages 5-7; Ref. 7, pages 139-144; Ref. 8, pages 122-126; Ref. 9, pages 29-52; Ref. 12, pages 6-11.
   Used for areas of less than approximately 200 acres and for *urban* storm sewer design.
2. U. S. Bureau of Public Roads Method. Ref. 10
   Used for *rural* areas from 100 to 10,000 acres. For 68 percent of the ungaged watersheds for which estimates of discharge may be desired, the difference between the actual and the estimated discharge may be assumed to be ±20 percent of the estimated value. Likewise, for 95 percent of the ungaged watersheds, this difference may be assumed to be less than ±40 percent.
3. Wu-Delleur-Diskin Method. Ref. 15
   Nomographs are presented for the estimation of peak discharges from *rural* watersheds in Indiana, varying from 5 to 250 square miles, with return periods of 10, 25, 50 and 100 years. Charts are also included to facilitate the computation of design hydrographs for rural basins varying from 3 to 100 square miles.
4. Soil Conservation Service Method. Ref. 16
   Primarily designed for *rural* areas, but can be applied to *suburban* areas as well.

Design of Watercourses

In all cases, Manning's equation is used. Applicable references are 7, 11 and 12. Reference 12 discusses the philosophy of design including alignment, protection from erosion, hydraulic principles, and methods of design. Reference 11 contains design charts for rectangular, trapezoidal, triangular, grassed, and pipe channels. Also included are many example problems illustrating the use of the charts.

Reference 7, pages 145-151, discusses in brief detail the principles of design and refers to references 11 and 12 for details and charts.

Design of Culverts

The hydraulic principles of culvert flow and design charts and nomographs are adequately treated in references 5, 6, 7, 9, 13 and 14.

CONCLUSIONS

The following conclusions, it is hoped, will be made by the reader:

1. The Indiana county surveyor, under statute law has a responsibility for some aspects of county drainage planning.
2. Changing land use and interaction with regulatory agencies governing this land use, is complicating the county surveyor's duties in the drainage area and has led to the need for long-range drainage planning.
3. While comprehensive drainage planning is not necessary at the present time in all counties, the surveyor should be aware of the type of information required for this planning and should endeavor to obtain *all* this information when drainage surveys are currently made. The county thus will be in a better position for planning in the future.
4. There are available a number of excellent, low-cost publications, designed for the practitioner which can assist those surveyors wishing to provide more economical and safer designs for drainage works within their realm of responsibility.

REFERENCES

1. *Burns Annotated Indiana Statutes,* Title 27, Chapters 20-26, latest published replacement or supplement.
2. Fisher, John E., "Comprehensive Master Drainage Plans," *Proceedings of the 57th Annual Road School,* Engineering Extension Series No. 138, Purdue University, 1971.
3. The Three Rivers Coordinating Council, *Master Plan for Storm Drainage, Fort Wayne-New Haven-Allen County Metropolitan Area,* 1972.
4. Denver Regional Council of Governments, *Urban Storm Drainage Manual,* in 2 volumes, 1969.
5. American Concrete Pipe Association, *Concrete Pipe Design Manual,* First Edition, 1970.
   Concrete Pipe Association of Indiana, Inc.
   P. O. Box 21007
   Indianapolis, Indiana
6. American Concrete Pipe Association, *Design Data.*
   Same address as reference 5

7. American Iron and Steel Institute, *Handbook of Steel Drainage and Highway Construction Products,* Second Edition, 1971.
Armco Steel Corporation
Metal Products Division
1839 N. Meridian St.
Indianapolis, Indiana 46202

8. National Clay Pipe Institute, *Clay Pipe Engineering Manual,* 1968.
National Clay Pipe Institute
69 N. Wren Drive
Pittsburgh, Pa. 15243
Thurman Busz, District Engineer
4244 Cold Spring Road
Indianapolis, Indiana 46208

9. Portland Cement Association, *Handbook of Concrete Culvert Pipe Hydraulics,* 1964.
Portland Cement Association
33 West Grand Avenue
Chicago, Illinois 60610

10. U.S. Bureau of Public Roads, *Peak Rates of Runoff From Small Watersheds,* Hydraulic Design Series No. 2, 1961 (Price $.30)

11. U.S. Bureau of Public Roads, *Design Charts for Open-Channel Flow,* Hydraulic Design Series No. 3, 1961 (Price $.70)

12. U.S. Bureau of Public Roads, *Design of Roadside Drainage Channels,* Hydraulic Design Series No. 4, 1965 (Price $.40)

13. U.S. Bureau of Public Roads, *Hydraulic Charts for the Selection of Highway Culverts,* Hydraulic Engineering Circular No. 5, 1965. (Price $.?)

14. U.S. Bureau of Public Roads, *Capacity Charts for the Hydraulic Design of Highway Culverts,* Hydraulic Engineering Circular No. 10, 1965. (Price $?)

Note: References 10 through 14 are available from:
Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

15. Wu, I. P., J. W. Delleur, and M. H. Diskin, *Determination of Peak Discharge and Design Hydrographs for Small Watersheds in Indiana,* 1964. (Price $1.00 + sales tax unless exempt)
Joint Highway Research Project
Purdue University
Lafayette, Indiana 47907

16. Rainfall Intensity-Frequency-Duration Data for particular areas of the state will be provided by the state climatologist upon request. Write to:

    Laurence A. Schaal, State Climatologist
    National Weather Service
    Agronomy Department, Poultry Bldg., Room 201
    Purdue University
    Lafayette, Indiana 47907

17. "Hydrology Guide for Use in Watershed Planning," *National Engineering* Handbook, Section 4, U.S. Department of Agriculture, Soil Conservation Service.