CONSULTANTS

Report

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN ACT 167

Submitted To: County of Allegheny
Department of Economic Development
Pittsburgh, Pennsylvania

Project 91-503-11

July 1998

Project 91-503-10 October 29, 1998

ADDENDUM
REVISIONS TO MODEL ORDINANCE
FLAUGHERTY RUN WATERSHED ACT 167 PLAN
ALLEGHENY AND BEAVER COUNTIES, PENNSYLVANIA

Pages 11-7, 11-9, 11-10, and 11-14 of the Model Ordinance, as bound in the above plan report, have been revised based on comments received from the Pennsylvania Department of Environmental Protection (PaDEP) subsequent to reproduction of the final report. This addendum contains these revised pages, which are to be substituted for the pages bound in the report. For reference, a copy of the PaDEP comments has also been included in this addendum.

Questions may be directed to:

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gai

Mr. French

Pennsylvania Department of Environmental Protection

Rachel Carson State Office Building
P.O. Box 8555
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October 13, 1998

Bureau of Watershed Conservation

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RECEIVED
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GAI CONSULTANTS INC.
PROJ. NO 91-503-10
cc KLFrech

Bud Schubel, Manager
Department of Economic Development
County of Allegheny
Suite 800, 425 Sixth Avenue
Pittsburgh, PA 15219

Re: Flaugherty Run Stormwater Management Plan

Dear Mr. Schubel:

This acknowledges receipt of the final version of the plan and other documents on the public hearing. We look forward to the County adopting the plan so that the municipalities can move ahead with implementation.

The final plan appears to have incorporated most of the comments that we provided earlier. A final reading, however, identified several areas in the model ordinance section that should be addressed prior to distribution of the plan to the municipalities, if it has not been done yet.

1. P. 11-7. The definition of "Municipality" should read "Municipality - _______, County, Pennsylvania. This would be better since this is actually a template for individual municipalities to use and will take care of the Beaver County municipalities using this model.

2. P. 11-9. Section 1.00.07 Stormwater Plan Requirements. Section 1.00.07(b)(2) exempts small development. However, they must control stormwater in accordance with Section 1.00.08(b). There is no Section 1.00.08(b). Subsection (3) then requires the land developer to implement on-site controls. That is requiring someone to do something after they have been exempted. Subsection (4) says that the developer does not have to use an engineer for design work, yet subsection (5) requires the developer to do a hydraulic capacity analysis. We recommend deleting Section 1.00.07 (b)(2) from the fourth sentence on. A period could be placed after the word "runoff" in the third line.

Note that P. 11-14, Section 1.00.11 (b) requires any person engaged in land development to manage stormwater runoff as is reasonably necessary to protect health and property. This would cover the items deleted in 1.00.07 and development that has been exempted from submitting a drainage plan.

3. P. 11-14. Section 1.00.09 requires that if development activities do not start or are suspended for 18 months, the developer must determine if the watershed characteristics have changed and submit a new plan addressing these changes. A land developer is responsible for runoff from their site and not for other development in the watershed that has been approved by the municipality and undertaken by others. Please delete the words "within the watershed" on the 6th line under this section.

Please make these changes prior to adoption and final distribution to the municipalities. I have transmitted a copy of this letter to Kerry Frech of GAI for his records and needed action. Feel free to call me if you have any questions.

Sincerely,

Durla N. Lathia

Durla N. Lathia
Chief
Stormwater Planning
and Management Section
Division of Water Use Planning

bcc: Main File SWMP 114:02
Kerry Frech, GAI
Ritzer
30-Day File
M. Lathia

"Infiltration": The flow or movement of water through the interstices or pores of a soil or other porous medium, or the absorption of liquid by the soil.

"Land Development": The improvement of one lot or two or more contiguous lots, tracts, or parcels of land for any purpose involving a group of two or more residential or nonresidential buildings, whether proposed initially or cumulatively, or a single nonresidential building on a lot, or lots regardless of the number of occupants or tenure, or the division or allocation of land or space between or among two or more existing or prospective occupants by means of or for the purpose of streets, common areas, leaseholds, condominiums, building groups, or other features, or a subdivision of land.

"Land disturbance": Any activity involving grading, tilling, digging, or filling or stripping of vegetation; or any other activity which causes land to be exposed to erosion.

"Maintenance": The upkeep necessary for efficient operation of physical properties.

"Municipality": ______________________, ____________________ County, Pennsylvania.

"NRCS": The National Resources Conservation Service (formerly the Soil Conservation Service), U.S. Department of Agriculture.

"Outfall": The point or location at which stormwater leaves a site, which may include streams, storm sewers, swales or other well defined natural or artificial drainage features, as well as areas of dispersed overland flow.

"Outlet control structure": A structure designed to control the rate of stormwater runoff released from a detention system.

"Peak Discharge": The maximum rate of flow of water at a given point and time resulting from a specified storm event.

"Peak Flow": Maximum flow.

"Performance standard": A standard which establishes an end result or outcome which is to be achieved, but does not prescribe specific means for achieving it.

"Pervious": A surface which permits the passage or entrance of water or other liquid.

"Point of interest": A point of hydraulic concern such as a bridge, culvert, or channel section, for which the rate of runoff is computed or measured.

"Rate of runoff": The instantaneous rate of water flow, usually expressed in cubic feet per second.

"Stormwater runoff volume": The quantity of water resulting from a storm event, usually expressed in cubic feet, acre feet, or inches over acreage of the watershed.

"Stream": A watercourse, whether perennial or intermittent.

"Subbasin": A portion of the watershed that has similar hydrologic characteristics and drains to a common point.

"Swale": A low-lying stretch of land which gathers or carries surface water runoff.

"Time of concentration": The time period necessary from surface runoff to reach the outlet of a subarea from, hydraulically, the most remote point in the tributary drainage area.

"Watercourse": Any channel for conveyance of surface water having a defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

"Watershed": The entire area drained by a river, stream, or other body of water whether natural or manmade. A "designated watershed" is an area delineated by the Pennsylvania Department of Environmental Protection.

"Watershed stormwater management plan": The plan for managing stormwater runoff throughout a designated watershed adopted by Allegheny County as required by the Pennsylvania Stormwater Management Act.

1.00.07 STORMWATER PLAN REQUIREMENTS.

(a) General Requirements. No final subdivision or land development plan shall be approved, no permit authorizing construction issued, or any earth-moving or land disturbance activity initiated until the final stormwater management plan for the development site is approved in accordance with the provisions of this article.

(b) Exceptions for Small Developments.

(1) At the time of application, the Municipality shall determine if the subdivision or land development qualifies as a "small development" and, therefore, is eligible for a simplified stormwater plan submission.

(2) Small developments shall be exempt from the preparation of a detailed stormwater management plan as specified by subsections (c) and (d) hereof. However, such developments shall still provide safe management of stormwater runoff.

(3) Applications for small developments shall include a plan which describes, narratively and graphically, the type and location of proposed on-site stormwater management techniques or the proposed connection to an existing storm sewer system. The plan should show accurately site boundaries; contours at five-foot intervals for areas of greater than twenty-five percent (25%) slope gradient and at two-foot intervals for areas with less than twenty-five percent (25%) slope; location of watershed and/or subarea boundaries on the site (if applicable); and any watercourses, flood plains, or existing drainage facilities or structures located on the site.

(4) Whenever the submission of runoff calculations are required by the Municipal Engineer, they shall be prepared in accordance with Section 1.00.11.

(5) The Municipal Engineer shall review and approve the proposed provisions for stormwater management for a small development. Where the applicant is proposing to connect to an existing storm sewer, the applicant shall demonstrate that sufficient capacity exists in the storm sewer from the point of connection to the point of outlet in the natural drainage system. The Municipal Engineer shall determine if the proposed development site is part of a larger parcel or tract for which a stormwater management plan was approved previously and, therefore, subject to any specific stormwater management control contained in the prior plan.

(6) For a parcel or tract of land held under single ownership, only one application for a small development, as defined above, shall be permitted before requiring a stormwater management plan for the entire parcel.

(c) <u>Stormwater Plan Contents: Preliminary S/LD Plan Submission</u>.

(1) <u>General format</u>. The stormwater plan shall be prepared using the general requirements for plan format contained in the subdivision regulations with the following additions:

A. Watershed location. Provide a key map showing the development site location within the watershed and watershed subbasin(s) (consult Watershed Stormwater Plan for boundaries). On all site drawings, show the boundaries of the watershed(s) and (where applicable) subbasin(s) as they are located on the development site and identify watershed name(s) and subbasin number(s).

B. Flood plain boundaries. Identify 100-year flood plains on the development site (as appropriate), or determine the 100-year flood plain for any watercourse or water body on the development site.

1.00.09 STORMWATER PLAN AFTER FINAL APPROVAL.

Upon recording of the final plat, the applicant may commence to install or implement the approved stormwater management controls, subject to the provisions of Section 1.00.05(b)(6). If site development or building construction does not begin within eighteen months of the date of the final approval of the plan, then before doing so, the applicant shall resubmit the stormwater management plans to verify that no condition has changed that would affect the feasibility or effectiveness of the previously approved stormwater management controls. Furthermore, if for any reason development activities are suspended for eighteen months or more, then the same requirement for resubmission of the stormwater management plan shall apply. The terms of these subsequent reviews shall be subject to the provisions of the subdivision regulations.

1.00.10 STORMWATER PLAN MODIFICATION.

Requests for modifications of the final approved stormwater management controls shall be submitted to the Municipal Engineer as follows:

(a) If the request is initiated before construction begins, the stormwater plan shall be resubmitted and reviewed according to the procedures in Section 1.00.05.

(b) If the request is initiated after construction is underway, the Municipal Engineer shall have the authority to approve or disapprove the modifications, based on field inspection, provided the requested changes in stormwater controls do not result in any modifications to other approved Municipality land use/development requirements (such as required building setbacks, yards, etc.). A plan modification, in accordance with applicable Municipality procedures, shall be necessary if any such requirements are affected. The Municipal Engineer shall submit a record of all approved changes for the stormwater management controls to the Municipality prior to the acceptance of any improvements by the Municipality. Modifications shall not affect the compliance of the plan with the performance standards set forth in Section 1.00.08 and 1.00.09.

1.00.11 STORMWATER MANAGEMENT PERFORMANCE STANDARDS.

(a) Watersheds.

(1) For the purposes of stormwater management, the Municipality is divided into the following watersheds:

A. Flaugherty Run.

(1) The location and boundaries of the watersheds and subbasins are adopted as overlay districts to the Municipality Zoning Map and are shown on the map in the Watershed Stormwater Management Plan for the subject watershed.

COUNTY OF ALLEGHENY
DEPARTMENT OF ECONOMIC DEVELOPMENT
PITTSBURGH, PENNSYLVANIA

FLAUGHERTY RUN WATERSHED
STORMWATER MANAGEMENT PLAN
ACT 167

GAI CONSULTANTS, INC.
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PROJECT 91-503-11

JULY 1998

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1.0 INTRODUCTION

Background

On October 4, 1978, with the passage of the Storm Water Management Act (Act 167) and its companion bill, the Flood Plain Management Act (Act 166), the Commonwealth of Pennsylvania embarked upon a significant new course to reduce flooding and the problems caused by inadequately controlled stormwater runoff. Recognizing the repeated threats to public health and safety, the legislature mandated a comprehensive approach to planning and controlling excess stormwater runoff. The Storm Water Management Act sets up a program for controlling accelerated runoff so that it does not lead to increased flooding. The Flood Plain Act provides for the preservation and restoration of flood plains, which are natural floodwater storage areas.

Since the early 1900s, substantial portions of Pennsylvania's landscape have changed dramatically. With the advent of the automobile, residential, commercial, and industrial development spread across the countryside, transforming it from farms and rural villages to sprawling urban-suburban communities. The alteration of natural surface contours through the construction of buildings, streets, and large parking areas has modified rainfall/runoff patterns to such an extent that local flooding problems now plague communities throughout the Commonwealth.

In some areas, these problems occur on a house-to-house basis. Runoff from one or more lots in a single development may damage walls, or driveways, or end up as a pond on a neighbor's lot. In other areas, runoff from streets and storm sewers in one residential development or from a large commercial development causes flooding of lands and buildings farther downstream. The cumulative effect of development has resulted in the flooding of both small and large streams, with property damage running into the millions of dollars and even causing loss of life.

Storm Water Management Act 167

The statement of legislative findings at the beginning of the Storm Water Management Act sums up the critical interrelationship between development, accelerated runoff, and flood plain management. It says:

> "Inadequate management of accelerated runoff of storm water resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of streams and storm sewers, greatly increases the cost of public facilities to carry and control storm water, undermines flood plain management and flood control efforts in downstream communities, reduces ground-water recharge, and threatens public health and safety.

A comprehensive program of storm water management, including reasonable regulation of development and activities causing accelerated runoff, is fundamental to the public health, safety, and welfare, and the protection of the people of the Commonwealth, their resources, and the environment."

In the past, stormwater management was oriented primarily toward a single site or development. Good stormwater management was getting the water off the site as quickly as possible and into the nearest stream or river. Minimal attention was given to the effects on downstream locations (frequently because they were in another municipality), or to designing stormwater controls within the context of the entire watershed.

Act 167 changes this approach by instituting a comprehensive program of stormwater planning and management. The act requires counties to prepare and adopt watershed stormwater management plans for each "Designated Watershed" located in the county, as identified by the Pennsylvania Department of Environmental Protection (PaDEP). These plans are to be prepared in consultation with the municipalities located in the watershed, working through a Watershed Plan Advisory Committee (WPAC).

The legal analysis of Act 167 assisted in the technical work by clarifying the purposes and intent of the act and the basic standards established by the act for stormwater management. The legal analysis also provided a basis for determining the types and nature of regulatory measures that could and should be applied to implement the Flaugherty Run Stormwater Management Plan. This is an important consideration because Act 167 requires local governments to adopt and enforce necessary land use and development controls to implement the plan.

This management plan includes proposals for ordinance provisions designed to implement the recommended technical measures. These ordinance standards are intended to provide a guide for the municipalities in enacting or amending their existing ordinances. The model ordinance provisions that are provided with this plan can be used as the basis for preparing specific ordinance language for each municipality within the watershed.

A comprehensive watershed stormwater management plan cannot be implemented effectively on a piecemeal basis. A watershed management approach and intergovernmental cooperation is required to provide consistent and effective stormwater management. Therefore, this study identifies several approaches that the municipalities, counties, and state can take to implement a workable stormwater management system. The system should be capable of performing various required functions, including planning, construction, operation and maintenance, regulation, and financing. The management system finally selected for each watershed will vary depending upon the physical, economic, and development characteristics of the watershed. The local officials and residents of each watershed will have to determine the system that will function most effectively and economically in their specific area.

Contents of the Plan

This Flaugherty Run Stormwater Management Plan contains the plan text and describes the background and general characteristics of the study area, the methods used for data collection, the analytical tools used, results of the analysis, and stormwater runoff control alternatives. The content and format of the plan generally follows guidelines recommended by the Pennsylvania Department of Environmental Protection. The Pennsylvania Department of Environmental Resources (PaDER) was reorganized during the preparation of this plan. The Department of Environmental Protection (PaDEP) now administers the Act 167 program for the state. Specific management and regulatory responsibilities are identified as they relate to developers, local and county officials, and state agencies. The location of existing obstructions and identified problem areas, and projected development are presented. The plan also contains a watershed release rate percentage map which presents the proposed stormwater management strategy. Copies of the computer model analyses and calculations are on file with the County of Allegheny, Department of Economic Development.

A separate Executive Summary of this plan is available. The summary highlights the key technical findings and recommendations of the watershed study. It also outlines watershed management alternatives, as well as required additions and changes to municipal land use and development regulations to implement the watershed plan.

2.0 ACT 167 WATERSHED-LEVEL STORMWATER MANAGEMENT PLANNING AND IMPLEMENTATION

General

An analysis of stormwater management would not be complete without some discussion of the law that created the stormwater management program, along with the other laws that relate to its implementation. In addition to the Storm Water Management Act, there are four other laws which collectively provide the legal powers and mandates to implement a comprehensive stormwater management plan. They are the following:

- Dam Safety and Encroachments Act (Act 325-1978)
- Clean Streams Law (specifically, the erosion and sedimentation regulations adopted pursuant to the law)
- Flood Plain Management Act (Act 166-1078)
- Pennsylvania Municipalities Planning Code (Act 247, as amended)

Key provisions of each of the five primary statutes are presented here. Highlighted are the elements that are most pertinent to the watershed stormwater plans and management programs. A brief overview on governmental immunities is included because it is helpful for the municipalities to understand their potential liabilities.

It should be noted that the comments on these acts are not intended to be official legal opinions, nor are they to constitute advice on any specific issue or case. Instead, this chapter is provided to assist in a general understanding of the legal framework for stormwater management.

Storm Water Management Act (Act 167-1978)

There are two key sections of this act: Section 5, which sets up the watershed stormwater planning programs, and Section 13, which establishes the basic standard for managing stormwater runoff to prevent problems resulting from uncontrolled runoff, including flooding, erosion and sedimentation, landslides, and pollution and debris often carried by storm runoff.

Watershed Stormwater Plans. As discussed in the preceding section, one of the act's innovative features is the creation of a public stormwater planning, management, and control system at the watershed level. These plans are to be prepared for each "Designated Watershed" as delineated by PaDEP.

The counties that are responsible for preparing the plans must organize a watershed plan advisory committee (WPAC) composed of representatives from the municipalities in the watershed. The committee is to advise the county during the planning process, and the plans are to be adopted by the county commissioners and approved by PaDEP after public review and comment. The completed plans must be consistent with local land use plans and state plans, such as the regional water quality plan, the state water plan, and flood plain programs.

After the adoption and approval of a watershed stormwater management plan, the location, design, and construction of stormwater management systems, obstructions, flood control projects, subdivisions and major land developments, highways and transportation facilities, facilities for the provision of public utilities, and facilities owned and financed in whole or in part by the Commonwealth (including the Pennsylvania Department of Transportation [PennDOT]) shall be conducted in a manner consistent with the plan. This provision gives the stormwater plan a definite legal status. Unlike municipal comprehensive plans, which are only advisory documents, watershed stormwater plans will be legally binding.

Also, within six months of the approval of the watershed stormwater management plan, each municipality in the watershed must adopt the land use and development ordinances to implement the plan. These regulations must be consistent with the plan as well as with the standards of the Storm Water Management Act. Failure to adopt <u>and</u> implement the necessary ordinances could result in the state's withholding monies from the General Fund for which the municipality might otherwise be eligible.

<u>Basic Standard for Stormwater Management</u>. The basic premise of the act is that those whose activities will generate additional runoff, increase its velocity, or change the direction of its flow, should be responsible for controlling and managing it, so that these changes will not cause harm to other persons or property now or in the future. The policy is that Pennsylvania's legal system will no longer condone those who negligently disregard the impact of runoff from their activities. It will not allow them to shift the burden of runoff management to the public and to downstream property owners.

Section 13 of Act 167 defines the legal duties owed by developers and others engaged in the alteration of land by setting performance standards for runoff management. This section of the act became effective immediately upon its signing (October 4, 1978). These new standards essentially replace prior common law drainage rules. Common law rules, however, will still apply to all developments and land alterations occurring prior to October 4, 1978.

Section 13 provides:

> Any landowner and any person engaged in the alteration or development of land which may affect stormwater runoff characteristics shall implement such measures consistent with the provisions of the applicable

watershed stormwater plan as are reasonably necessary to prevent injury to health, safety, or property. Such measures shall include such actions as are required:

(1) to assure that the maximum rate of stormwater runoff is no greater after development than prior to development activities;

(2) to manage the quantity, velocity, and direction of resulting stormwater runoff in a manner which adequately protects health and property from possible injury.

Act 167 defines persons as individuals, private corporations, municipalities, counties, school districts, public utilities, sewer and water authorities, and state agencies. When, for example, public agencies build storm sewers, roads, buildings, or utility lines, they must implement runoff control measures that comply with Section 13 standards. With this coverage, Section 13 is a truly comprehensive standard for stormwater control.

Section 13's primary measure of sound stormwater management is the taking of reasonable steps to prevent harm or injury to health and property. This general duty is contained in the language which precedes Sections 13(1) and 13(2). Thus, the "bottom line" for stormwater management is: Do not cause harm. The section prescribes two alternatives [Sections 13(1) and 13(2)] for meeting this basic objective.

Further, when Section 13 is read in conjunction with other portions of the act, it becomes apparent that the intent of the act is to apply the standard to protect persons and property not only immediately adjacent to the site but also <u>downstream</u> of the site being altered. In other words, Section 13 is not spatially limited; it applies not only as runoff leaves a site but as far as its impact can be reasonably determined.

Section 2 of the act states that the legislature found that inadequate management of runoff has adverse impacts on <u>downstream</u> communities and that reasonable regulation of activities causing runoff is fundamental to the public welfare. Section 3 indicates that the act was intended to manage runoff at the <u>watershed</u> level.

Further, Section 5(c)(1) requires that the watershed plans contain provisions to manage stormwater so that an activity in one municipality does not have adverse effect on persons or property in another municipality in the watershed to which the watershed is a tributary. <u>Therefore, it is clear that the stormwater plans and management activities must consider the impact of land alteration activities on the watershed, and runoff controls must be designed to prevent reasonably foreseeable harm from the boundary of the site downstream to the base of the watershed</u>.

<u>Section 13(1)</u>. Section 13(1) requires that any land alteration not cause an increase in the "maximum rate" of stormwater runoff; that is, the maximum (peak) rate of runoff after development for any level storm may not be higher than the peak rate that would have

been generated from the site before development. By using the terminology of rate rather than volume, Section 13(1) implies that total volume of runoff generated may increase, but any increased volume must be retained and discharged over time, so that the pre-development maximum rate of flow will not be exceeded. This is an important point because it would only be possible to meet a standard that did not permit any increase in volume at sites where additional runoff could be permanently stored or recharged on-site.

In summary, Section 13(1) means that development cannot increase the maximum rate of runoff, or of flow contribution, at any point from the boundary of the site to the outlet of the watershed. Also, development may not cause an increase in maximum rate of flow in any other watershed to which its watershed is a tributary. The downstream cutoff point for purposes of Section 13(1) seems to be the foreseeability of harm. Where it is reasonably possible for the developer to foresee a higher peak rate resulting from the activities, then the duty imposed by Section 13(1) applies.

Section 13(2). One of the purposes of Section 13(2) is to make the statutory drainage standard more flexible. Section 13(2) permits changes in runoff characteristics, including increased runoff rates, provided they do not cause harm. For example, Section 13(2) permits increased rates of runoff to be discharged into storm sewer systems when the storm sewers can handle increased volumes and velocities without, in turn, causing harm.

Prior to the adoption of a watershed plan, the availability of the more flexible Section 13(2) alternative standard will not necessarily result in the implementation of the best runoff management solutions. Neither will it necessarily avoid over-regulation.

Particularly when projects are small, it may not be economically feasible for developers to do the detailed watershed-level hydrological and engineering analysis necessary to determine that increasing the rate of runoff from their development will not cause harm, now or in the future. This usually will require an analysis of the watershed as a whole.

In most instances, it seems that deciding when Section 13(2) permits increased runoff rates can be done only within the context of a watershed plan. The watershed plan should identify those areas where increasing runoff rates will not cause harm or will be beneficial. Thus, the watershed plans will result in a more defined and, therefore, a more usable Section 13(2) standard.

Implementation of a watershed plan may also expand the areas to which the Section 13(2) standard can be applied. For example, increased runoff could be permitted as a result of the installation of regional stormwater retention systems, either upstream or downstream, that reduce existing or potential runoff. The adoption of ordinances that regulate runoff throughout a watershed will limit the maximum possible future runoff. This, in turn, will limit the range of possible future peak rates and allow developers and municipal officials to identify additional areas where increasing the peak rate will not cause harm.

One of the purposes of the watershed stormwater management planning process is to identify when and how the strict Section 13(1) standard can and should be modified. Once this analysis is completed, implementing ordinances can be based on the Section 13(2) standard.

Violations, Penalties, Remedies. Section 15 of the Storm Water Management Act makes any violation of the provisions of the act or of the watershed stormwater plan a public nuisance. Any aggrieved person, county, affected municipality, or PaDEP can institute an action to restrain or abate violations of a watershed plan or of ordinances or regulations adopted under the act. Any person injured by the conduct of a person developing land in violation of the watershed plan and ordinances may recover damages from the responsible party.

Dam Safety and Encroachments Act (Act 325-1978)

Act 325 replaces several older state statutes dealing with dam safety, water obstructions, and encroachments. This act is the primary source of regulation for dams,* existing and new obstructions, encroachments, fill in the flood plains, culverts, bridges, retaining walls, and outfalls (e.g., of storm sewers) in a stream or a (100 year) flood plain. The act requires permits for the construction or alteration or abandonment of dams, obstructions, and encroachments. The owners of existing obstructions or encroachments are also required to obtain permits. Permits are issued by PaDEP pursuant to the act and regulations (15 Pa. Code Chapter 105).

Because it includes new and existing structures, the Dam Safety and Encroachment Act is quite broad in its coverage. It also requires permittees and owners of obstructions to inspect, maintain, and repair the structures. For example, owners of culverts must inspect them annually and remove silt and debris if the carrying capacity is reduced by 10 percent or more (Regulations, Section 105.171). If conditions change so that the design of an obstruction or encroachment no longer conforms to the performance standards in the act or regulations, the permittee or owner has a duty to make such alterations as are necessary to achieve compliance.

PaDEP is the prime agency responsible for administering the act. It must adopt regulations to implement the act and it is the permit issuing agency. The regulations [Section 105.14(b)(9)] require PaDEP, when approving permits, to consider the project's consistency with state and local flood plain and stormwater management programs. Thus, the standards and provisions of the Storm Water Management Act and stormwater plans appear to be applicable to obstructions and encroachments. It is important to note that once the watershed stormwater plan is approved PaDEP must review obstruction permits in light of the plan's standards and criteria. Also, municipalities should not issue local building permits until any necessary obstruction permits are obtained.

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*On some cases, larger retention/detention facilities may qualify as dams under the definition of the act and regulations and, therefore, require a permit from PaDEP.

Clean Streams Law (Erosion/Sedimentation Regulations)

Pennsylvania's Clean Streams Law was enacted in 1937. Its original scope was limited to regulating discharges of sewage and industrial wastes. Since its original enactment, its scope and duties have expanded substantially. In 1972, PaDER determined that sediment constitutes a water pollutant under the provisions of the law and promulgated regulations for the control of erosion and sedimentation caused by earthmoving activities (15 Pa. Code, Chapter 102).

The general requirement of the erosion/sedimentation regulations is that earthmoving activities (including excavations, land development, mineral extraction, or any other activity that disturbs the surface of the land) be conducted in a manner to prevent accelerated erosion and resulting sedimentation of streams and other watercourses, such as culverts. Persons engaged in earthmoving activities must prepare and implement an erosion/sedimentation control plan for the site, regardless of the size of the site.

These plans must be available for inspection at the site at all times. The National Pollutant Discharge Elimination System (NPDES) permit program has been expanded to incorporate stormwater runoff from construction activities. This NPDES program is handled jointly by the PaDEP and the County Soil Conservation Districts. As with obstructions and flood plain permits, local building permits should not be issued prior to receiving the NPDES/Erosion and Sedimentation Plan approval, if required. In Allegheny County and in Beaver County, PaDEP has delegated the administration of the regulations to the Natural Resources Conservation Services District offices, which review plans for permits.

Because the Clean Streams Law antedates the Storm Water Management Act, it does not mention the Storm Water Management Act. However, it can be assumed that erosion/ sedimentation controls should be consistent with the Storm Water Management Act and an approved watershed stormwater plan. Because they could affect stormwater runoff management for a site, they would have to comply with Act 167 standards. Also, the Dam Safety and Encroachments Act requires that obstruction permits comply with the Clean Streams Law, including the erosion regulations, which in turn must be consistent with stormwater management programs.

PaDEP has major administrative and regulatory responsibilities for implementing the Clean Streams Law. PaDEP may also issue enforcement orders. Failure to comply with an order is a nuisance and exposes the violator to abatement actions as well as civil and criminal penalties.

Flood Plain Management Act (Act 166-1978)

The Flood Plain Management Act requires municipalities with flood plain areas to participate in the National Flood Insurance Program and to adopt flood plain management regulations that control new development, at least, in accordance with the minimum requirements established by the Federal Insurance Administration/Federal Emergency Management Agency.

Municipalities participating in the National Flood Insurance Program must require building permits for all construction and development occurring within identified flood plain areas. Such permits are not to be issued until all other required federal and state permits have been received by the applicant. Thus, municipalities should not issue building permits for development within flood plain areas unless the applicant has obtained any necessary encroachment and erosion/sedimentation permits. Of course, building permits should not be issued unless the proposed activity complies with the stormwater management regulations that have been adopted by the municipality.

Through this interrelated permitting process, the Flood Plain Management Act assures control of all activities in a flood plain. It assures compatibility among the actions governed by the different laws.

As noted earlier, preservation of natural flood plains and a comprehensive program of flood plain management are a key part of effective overall stormwater management. Natural flood areas should be maintained as part of a watershed's natural stormwater control system. Similarly, effective future stormwater management will help to preserve flood plain areas and assure that properties not now subject to flooding do not become so in the future.

<u>Pennsylvania Municipalities Planning Code (Act 247, as Amended)</u>

The Pennsylvania Municipalities Planning Code (MPC) is related to stormwater management because of the authorities it grants to municipalities and counties.** The MPC enables communities to prepare comprehensive and land use plans and capital facilities programs. It also empowers them to prepare and adopt zoning (including regional zoning), subdivision and land development, planned residential development, and official map ordinances. The various municipal codes (borough, township, etc.) authorize communities to adopt building/housing codes pursuant to their health, safety, and general welfare powers.

These are the major planning and regulatory mechanisms that municipalities will use to implement the watershed plans. Section 11 of the Storm Water Management Act specifically requires municipalities to adopt "... such ordinances ..., including zoning, subdivision and development, building code, and erosion and sedimentation ordinances ..." to regulate development activity consistent with the watershed plan and Act 167.

**The MPC excludes first and second class cities and counties, including Allegheny County and the City of Pittsburgh; these both draw their land and development powers from their respective municipal codes.

It is necessary to understand that these various ordinances - zoning, subdivision and land development, and building - regulate different and distinct aspects or parts of the land use and development process. It is not possible to adopt one type of ordinance, zoning for example, and simply include the items and controls covered by the other types of regulations. In other words, a community cannot regulate land usage or lot size (a zoning power) in a subdivision and land development ordinance, nor can it establish structural standards for building construction (a building code regulation) in a subdivision and land development ordinance, and so forth. In most cases, a comprehensive development regulation system requires the utilization of all three types of ordinances.

Whenever stormwater is being regulated for a land use or development activity that falls within the scope of one of the enabling authorities contained in the planning code (i.e., zoning, subdivision/land development, planned residential development) or under the building codes' power in the municipal codes, then the applicable stormwater controls should be included in the proper ordinance. For example, if the activity being regulated is a subdivision, then the relative stormwater provisions belong in the subdivision ordinance. If a community utilizes a separate, single-purpose stormwater ordinance, the ordinance should be clearly referenced into the appropriate sections of the municipality's zoning, subdivision/land development, and building codes. Also, the preamble of a separate stormwater ordinance should indicate that it is being adopted pursuant to the Pennsylvania Municipalities Planning Code, the Storm Water Management Act, and applicable sections of the municipal code.

With either approach, when a development activity is within the scope of the MPC, the municipality should be sure to follow the various plan review processes and other administrative procedures prescribed in the MPC, including procedures for enacting and amending zoning and development regulations. The inclusion of specific procedural requirements in the MPC clearly demonstrates the legislature's concern that all development applications be given a fair and timely review. Since most stormwater management activities will relate to zoning, subdivision/land development, or building applications, the stormwater reviews should adhere to the procedures required in the respective ordinances.

In this study, a Municipal Questionnaire was completed which identified and compiled the existing municipal ordinances and agencies. The questionnaires are presented in Appendix A of this plan. More specific information is provided in Section 8.

Governmental Tort Immunity

Municipal immunity is becoming a concern to local communities and officials who will be adopting and implementing stormwater management regulations. Also, Pennsylvania and municipal immunity statutes have been subject to recent changes and litigation, including the relationship of the new (1979) Political Subdivision Tort Claims Act to stormwater management issues in local municipalities. Municipal officials, of course, will have to be guided by the advice of their solicitors on potential liabilities as specific cases or situations arise.

Federal and State Immunity. At common law there were three distinct levels of governmental tort immunity: sovereign immunity, political subdivision immunity, and public official immunity. Sovereign immunity was part of the common law from its very beginnings and became part of the law of this country and Commonwealth when the common law of England was adopted after independence. The concept behind the doctrine was that the king was sovereign and could be sued only if he consented.

Congress, by statute, has dramatically limited the doctrine of sovereign immunity as applied to the federal government. The Federal Tort Claims Act (Title 28 U.S.C 1346, 2671 et. seq.) provides (subject to certain enumerated exceptions) that the federal government can be held liable to the same extent as a private individual for the negligent acts or omissions of its employees.

With respect to the state sovereign immunity, the trend among states is to abolish or severely limit the doctrine by statute or case law. The belief is that the doctrine is unfair and not suited to the times. The Pennsylvania courts grudgingly applied the sovereign immunity doctrine, while pointing out its unjust results and strongly suggesting the need for legislation to reform the law. The Pennsylvania Supreme Court abolished the doctrine in Maybe v. Pennsylvania Department of Highways, 479 Pa. 384 (1978), but before the end of September of that year, the legislature had recreated sovereign immunity by statute (42 Pa. C.S.A. 58521 et. seq.). This statute provides for some very limited specifically enumerated exceptions, most of which go to negligent failure to adequately enforce state statutes and regulations. The statute also limits the amounts that can be recovered in suits brought under the exceptions. It is important to note that state immunity extends to state agencies, such as PennDOT and PaDEP.

Municipal Immunity. The second level of government tort immunity which developed as common law was applied to political subdivisions (i.e., municipalities, counties, municipal authorities, municipal agencies, commissions, and departments, including planning commissions and zoning hearing boards). The historical basis of the doctrine was that local governments were the agents of the king.

A substantial number of states have abolished municipal immunity by statute or judicial decision. The Pennsylvania Supreme Court first limited the doctrine by holding that it applied only to torts arising out of governmental functions (i.e., those activities which are typically performed by government, e.g., police, fire, regulatory, etc.) and not to torts arising out of a municipality's proprietary activities (i.e., activities that could be carried on by private corporations, such as owning and operating utilities).

Finally, in 1973, the court abolished the municipal immunity doctrine in Ayala v. Philadelphia Board of Public Education, 453 Pa. 584.

This was the situation until 1978 when the Pennsylvania legislature enacted the Political Subdivision Tort Claims Act. The result of this legislation is that since its effective date (January 24, 1979), the doctrine of municipal immunity, with certain statutory exceptions, has been resurrected in Pennsylvania. (The provisions of this act have been amended and recodified at 42 Pa. C.S. 38501 et. seq.)

The Political Subdivision Tort Claims Act applies to municipalities, municipal authorities (e.g., sewer and stormwater authorities), and counties. The purpose of the statute is to limit the liability of political subdivisions for the torts of their agencies, appointed and elected officials, and their employees. Under the act, a municipality is not liable for damages caused by the negligence of an officer, employee, or agent unless specific preconditions are met (see Section 8542).

The Political Subdivision Tort Claims Act only protects municipalities and their officials from private suits. It does not protect them from enforcement orders issued by a state agency or from any criminal penalties provided by a state statute. Both the Encroachments Act and the Clean Streams Law provide for PaDEP enforcement orders and criminal penalties for violations of the statutes.

Official Immunity. The final area of tort immunity is that immunity given to public officials, employees, and agents themselves. Sections 8545 and 8546 of Title 42 Pa. C.S. generally codify the common law rule with respect to official immunity. These sections provide that an elected and appointed officer, employee, and agent when carrying out official duties (i.e., when acting within the scope of his or her employment) is liable for damages caused by his or her negligence only to the same extent as is the governmental unit (i.e., provisions of Paragraph 8542 of the Political Subdivision Tort Claims Act are applied to public officials). This coverage does not extend to independent contractors under contract with the governmental unit where the unit has no right to control.

3.0 DESCRIPTION OF THE FLAUGHERTY RUN WATERSHED

Location

The Flaugherty Run Watershed, illustrated on Figure 3-1, the Watershed Location Map, is located north of the Pittsburgh International Airport, in western Allegheny County and eastern Beaver County. The watershed is situated in Pennsylvania Congressional Districts 42nd and 47th (Senatorial), and 28th and 15th (Representative), encompassing portions of Crescent, Moon and Findlay Townships, in Allegheny County, and Hopewell Township in Beaver County (see the map, Figure 3-2). A summary of the land area associated with each township is presented in Table 3.1.

Table 3.1

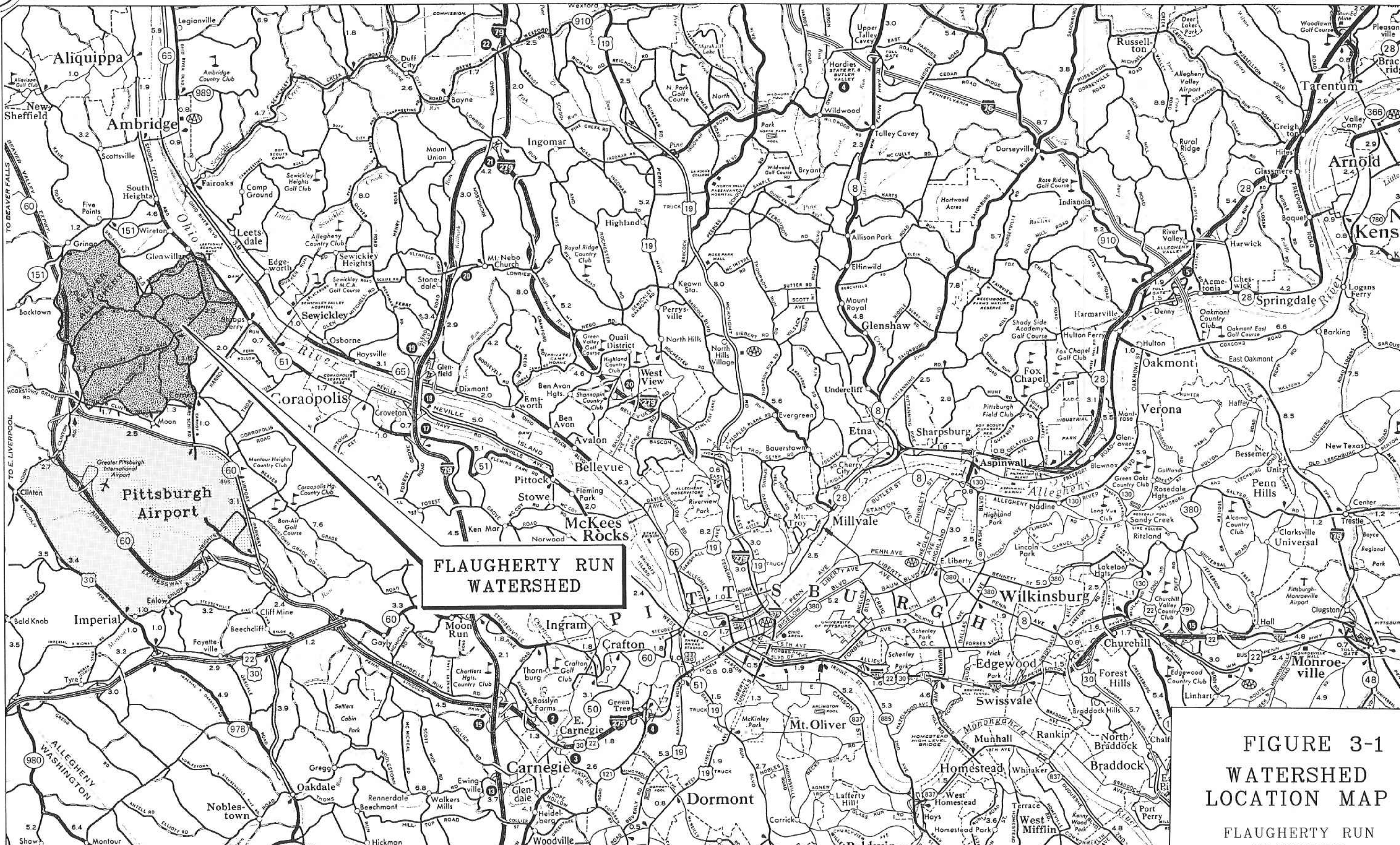
SUMMARY OF TOWNSHIP AREAS IN FLAUGHERTY RUN WATERSHED

Township	County	Area (square miles)
Moon	Allegheny	6.52
Crescent	Allegheny	0.84
Findlay	Allegheny	0.30
Hopewell	Beaver	1.20
	TOTAL	8.86

Flaugherty Run is a tributary of the Ohio River, draining approximately 8.86 square miles. Figure 3-3, the Watershed Map, shows Flaugherty Run and its major tributaries, including Boggs Run (3.15 square miles) and Spring Run (0.45 square mile). The headwaters of Flaugherty Run lie in Moon and Findlay Townships. Flaugherty Run flows east-northeast to its confluence with Boggs Run, then turns northward to enter the Ohio River at Glenwillard, in Crescent Township. Boggs Run arises in Hopewell and Findlay Townships, and flows east-southeast to Flaugherty Run. Spring Run arises in Moon and Crescent Townships and merges with Flaugherty Run at Glenwillard. The watershed has a relatively compact drainage system, with Flaugherty Run and Boggs Run each contributing approximately 40 percent of the total watershed area at their confluence.

Topography

The Flaugherty Run watershed is characterized by narrow, steep-sided valleys and broad, rounded ridges. The valleys are generally less than 500 feet in width, whereas the ridges typically reach 1000 feet in width. The valley side slopes range upwards to 30-70 percent; consequently, developed and developable land is restricted to the valleys



2 MILES 0 2 MILES

SCALE: 1" = 2 MILES

REFERENCE: AAA - 1995
PITTSBURGH AND VICINITY MAP

FIGURE 3-1
WATERSHED LOCATION MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

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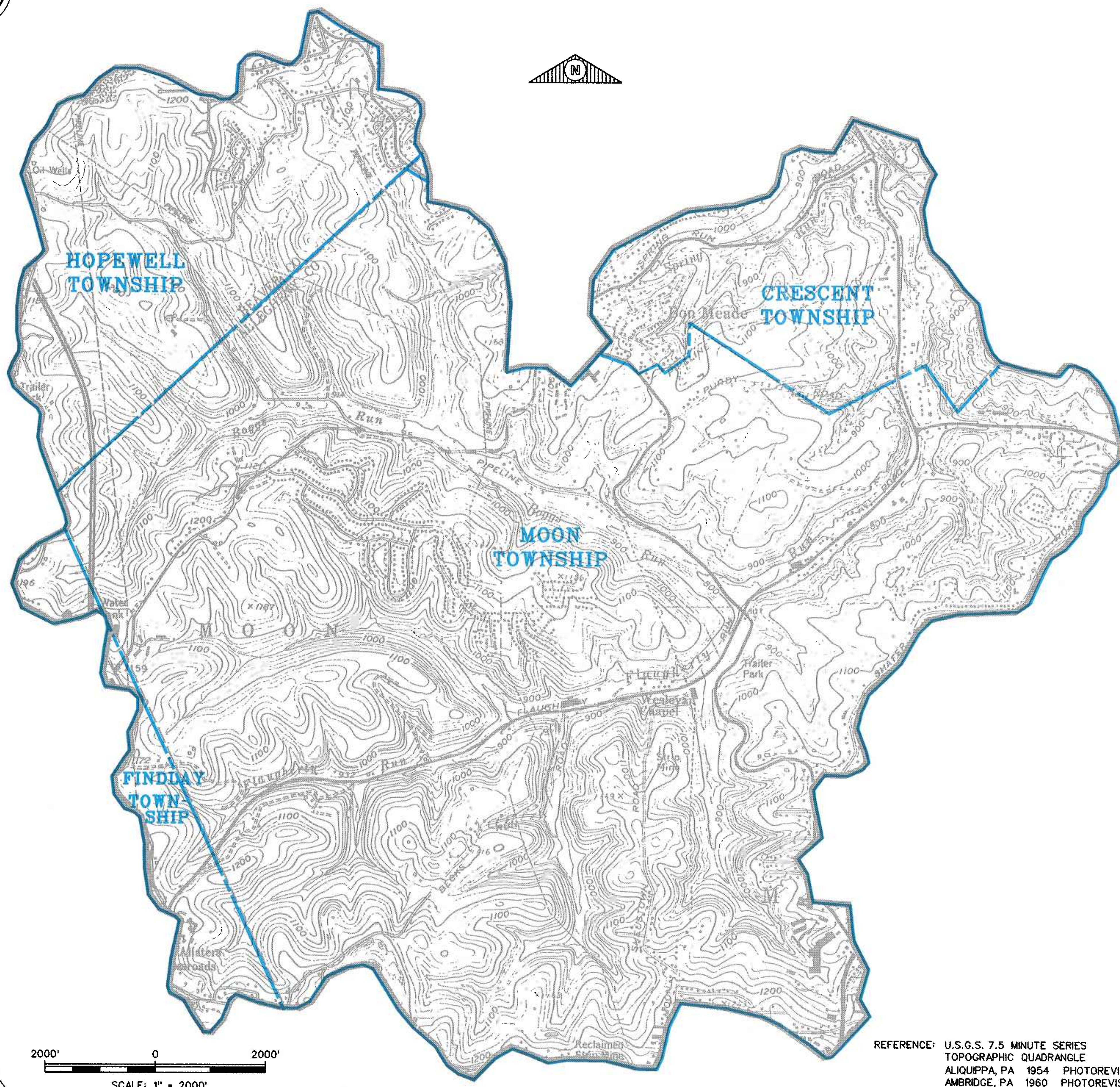
GAI DRAWING NO. 95038002.DGN



REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

FIGURE 3-2
MUNICIPAL BOUNDARIES MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

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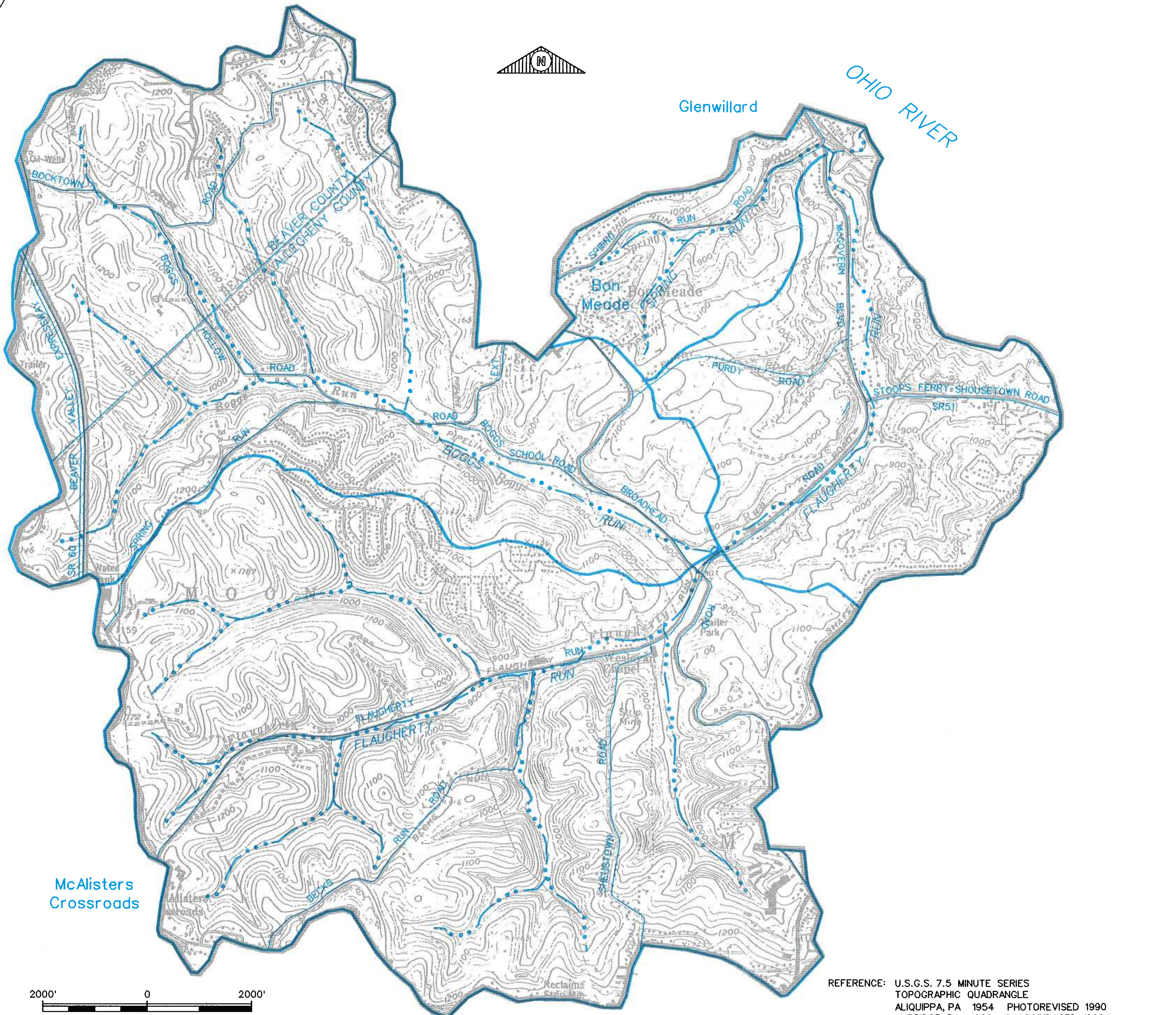


REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

GAI DRAWING NO. 1503B004.DGN

FIGURE 3-3
WATERSHED MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

GAI CONSULTANTS
570 Beatty Road, Monroeville, PA 15146 412/856-6400

and the ridges. The Slope Map, shown on Figure 3-4, is based on slope ranges given by the Allegheny County and the Beaver County Soil Surveys (References 1 and 2).

The runoff conditions can be significantly affected by development on the ridges. Where the basin is undeveloped, runoff flows generally become concentrated into defined channels in the valleys and lower portions of the hillsides. As the ridges become developed, however, runoff flows become concentrated at the ridges. These concentrated flows may significantly increase the flood peaks in downstream areas, and may also increase the erosion potential in the receiving channels. Planned development and appropriate stormwater management controls can mitigate many of the adverse effects.

Wetlands

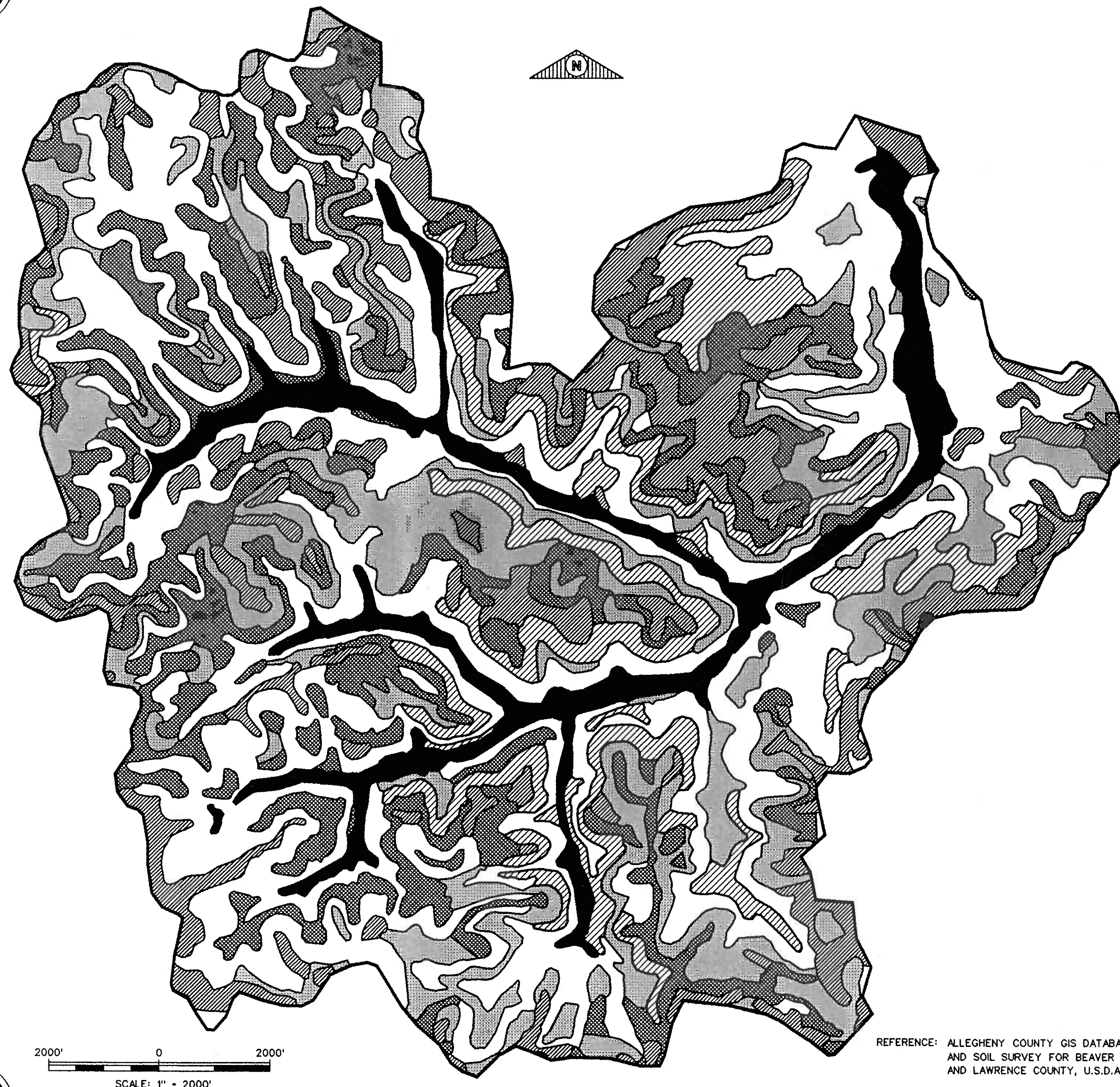
The National Wetland Inventory Maps (NWI, References 3 and 4) for the Ambridge and Aliquippi quadrangles show five (5) isolated areas of wetlands within the Flaugherty Run watershed. The wetland types shown correspond to palustrine unconsolidated bottom and palustrine forested wetlands. These areas are shown on Figure 3-5, the Wetland Inventory Map. The total area of the wetlands shown is approximately 5 acres. Additional wetlands may be present in the watershed, and a site investigation would be required to identify the presence of wetlands at any specific site.

The general absence of widespread wetland areas would indicate that wetlands play a relatively insignificant role in flood reduction in the Flaugherty Run basin.

Geology

Rock strata encountered in the Flaugherty Run watershed are the relative flat-lying Casselman and Glenshaw Groups of the Conemaugh Formation. These rock strata generally consist of cyclic sequences of sandstone, shale, redbeds, and thin limestone and coal seams. Several fossiliferous limestones occur in the Glenshaw Group, including the Ames Limestone, which is the uppermost unit in the group. The general dip of the rock is less than one (1) percent to the northwest, and is controlled by two structural features that parallel the valley: The West Middletown Syncline to the north and the Crows Run Anticline to the south.

There has been no activity associated with coal mining in the valley. The Pittsburgh Coal, which marks the bottom of the Monongahela Group and separates it from the Conemaugh Formation, has been eroded over the extent of the valley. The Upper Freeport Coal, which is the uppermost unit of the Allegheny Formation immediately below the Conemaugh Formation, is not of sufficient thickness to make it economically feasible for mining in this part of western Pennsylvania.



LEGEND

(solid black)	0 TO 3 PERCENT SLOPE
(pattern)	3 TO 8 PERCENT SLOPE
(pattern)	8 TO 15 PERCENT SLOPE
(pattern)	15 TO 25 PERCENT SLOPE
(pattern)	25 TO 35 PERCENT SLOPE
(white)	GREATER THAN 35 PERCENT SLOPE

NOTE: SLOPE RANGES ARE BASED ON THE SOIL CLASSIFICATIONS PRESENTED IN THE SOIL SURVEYS FOR ALLEGHENY AND BEAVER COUNTIES.

REFERENCE: ALLEGHENY COUNTY GIS DATABASE AND SOIL SURVEY FOR BEAVER COUNTY AND LAWRENCE COUNTY, U.S.D.A., SCS, 1982.

FIGURE 3-4
SLOPE MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

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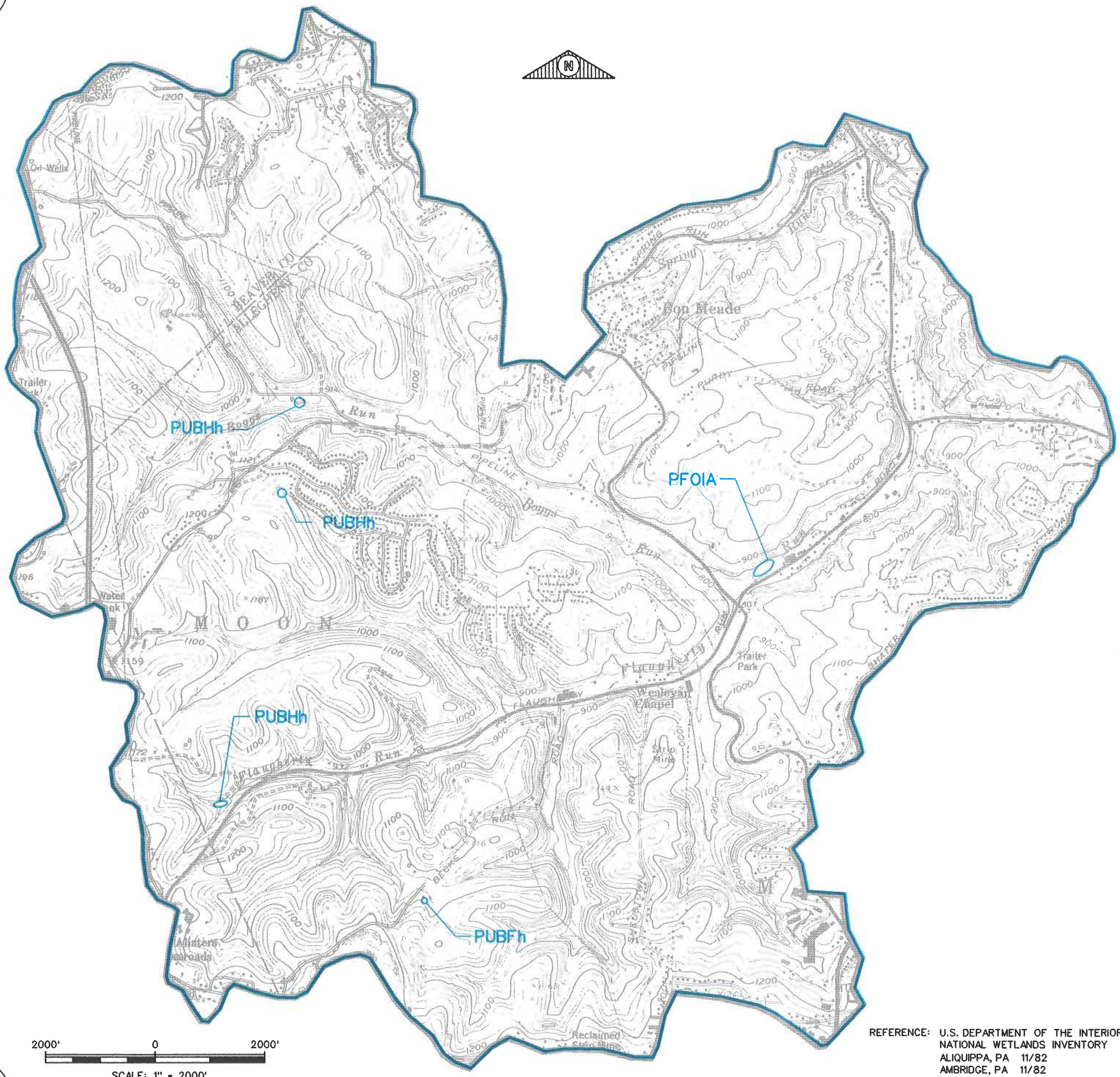

LEGEND

PFOIA	PALUSTRINE-FORESTED-BROAD-LEAVED DECIDUOUS-TEMPORARILY FLOODED WETLAND
PUBHh	PALUSTRINE-UNCONSOLIDATED BOTTOM-PERMANENTLY FLOODED-DIKED/IMPOUNDED WETLAND
PUBFh	PALUSTRINE-UNCONSOLIDATED BOTTOM-SEMI-PERMANENTLY FLOODED-DIKED/IMPOUNDED WETLAND

REFERENCE: U.S. DEPARTMENT OF THE INTERIOR
NATIONAL WETLANDS INVENTORY
ALIQUIPPA, PA 11/82
AMBRIDGE, PA 11/82

FIGURE 3-5

WETLAND INVENTORY MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

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Soils

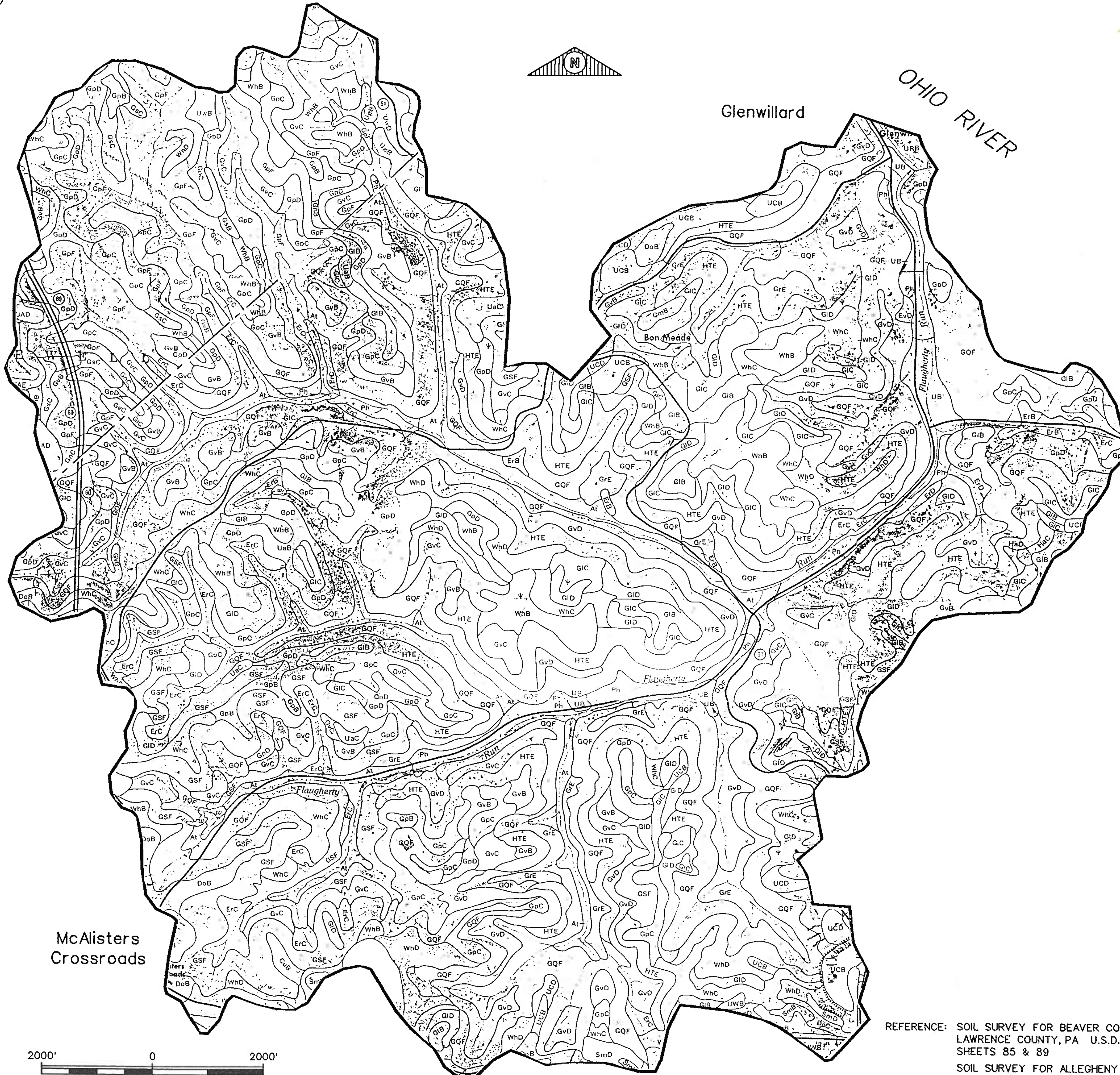
The soils in the Flaugherty Run watershed are typically residual soils, from the in-place weathering of bedrock. Alluvial soils are found in the base of the valley, and residual soils are found on the valley walls. Soils in the base of the upper valleys are characteristic stream deposits, whereas soils in the lower valley areas are a result of the ponding of the area's major rivers by glaciers. The residual soils on the valley walls above approximate elevation 920 feet, mean sea level, are derived from claystone strata of the Lower Grafton and Upper Saltsburg segments of the Conemaugh Formation. Residual soils below this elevation are primarily from sandstones and shales of the Lower Saltsburg, Buffalo, and Mahoning sections. Soil complexes commonly found in the watershed are the Gilpin-Upshur-Atkins associations in the valleys and lower slopes, and the Gilpin-Wharton-Upshur associations along the ridges. These associations are characterized by moderately deep and deep, well-drained and moderately well-drained soils, overlying shales in the uplands and poorly-drained soils in the flood plains (References 1 and 2). Figure 3-6 presents the Soils Map, based on the Allegheny County and the Beaver County Soil Surveys (References 1 and 2) and the Allegheny County GIS (Reference 5).

The Gilpin, Atkins, and Wharton soils are silt loams, and the Upshur soils are silty clay loams. The erosion potential of these soils is largely dependent on the topography (Reference 1, p. 38-42), with the greater potential occurring on the steeper slopes. The erosion potential caused by runoff flows being concentrated in the upper areas of the hillsides because of ridge development is therefore increased.

Climate

Southwestern Pennsylvania has a humid continental climate, with the weather primarily dictated by continental air masses (Reference 6). Large storms may also occur due to air masses originating in the Gulf of Mexico or in the Atlantic Ocean, typically during the months of June-November. Summers are relatively mild, with average monthly temperatures in the low 70s and relative humidities in the 70 percent to 80 percent range. Precipitation averages 36.4 inches per year. The greatest seasonal precipitation occurs in the spring and summer months, March-August, when the monthly averages range from 3.1 to 4.0 inches. The fall and winter months experience less precipitation, ranging from 2.4 to 2.9 inches. A summary of monthly climatic data for the National Weather Service station at the Pittsburgh International Airport (Reference 7) is presented in Table 3.2.

In the spring, the combination of high precipitation and saturated and/or frozen soil conditions can exacerbate flooding conditions. In the summer and fall, flooding may be caused by short, intense thunderstorms or tropical storm systems. The small size and compact shape of the Flaugherty Run watershed can accentuate the flooding. The watershed is small enough that all or a significant portion may be affected by a thunderstorm, and the relatively rapid response time (drainage time) and compact drainage network can quickly concentrate flows.



SOILS

AgB	Allegheny	HaC	Hazleton
AgC	Allegheny	HaD	Hazleton
At	Atkins	HTE	Hazleton
BrB	Brinkerton	Hu	Huntington
CaB	Cavode	Oth	Other
CaC	Cavode	Ph	Philo
CmB	Clymer	RaA	Rainsboro
CmC	Clymer	RaB	Rainsboro
CmD	Clymer	RaC	Rainsboro
CuB	Culleoka	RyB	Rayne
CuC	Culleoka	RyC	Rayne
CuD	Culleoka	SmB	Strip Mines
DoB	Dormont	SmD	Strip Mines
DoC	Dormont	SmF	Strip Mines
DoD	Dormont	UaB	Upshur
Du	Dumps	UaC	Upshur
Dw	Dumps	UB	Urban Land
ErB	Ernest	UCB	Urban Land - Culleoka
ErC	Ernest	UCD	Urban Land - Culleoka
ErD	Ernest	UCE	Urban Land - Culleoka
EvB	Ernest-Vandergrift	UGB	Urban Land - Guernsey
EvC	Ernest-Vandergrift	UGD	Urban Land - Guernsey
EvD	Ernest-Vandergrift	URB	Urban Land - Rainsboro
GIB	Gilpin	URC	Urban Land - Rainsboro
GIC	Gilpin	UWB	Urban Land - Wharton
GID	Gilpin	UWD	Urban Land - Wharton
GpB	Gilpin-Upshur	W	Water
GpC	Gilpin-Upshur	WhB	Wharton
GpD	Gilpin-Upshur	WhC	Wharton
GQF	Gilpin-Upshur	WhD	Wharton
GrE	Gilpin-Vandergrift		
GSF	Gilpin, Weikert, & Culleoka		
GuC	Guernsey		
GvB	Guernsey-Vandergrift		
GvC	Guernsey-Vandergrift		
GvD	Guernsey-Vandergrift		

FIGURE 3-6
SOILS MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

REFERENCE: SOIL SURVEY FOR BEAVER COUNTY AND LAWRENCE COUNTY, PA U.S.D.A, SCS. 1982. SHEETS 85 & 89
SOIL SURVEY FOR ALLEGHENY COUNTY, PA U.S.D.A., SCS. 1981. SHEETS 22, 23, 31, & 32

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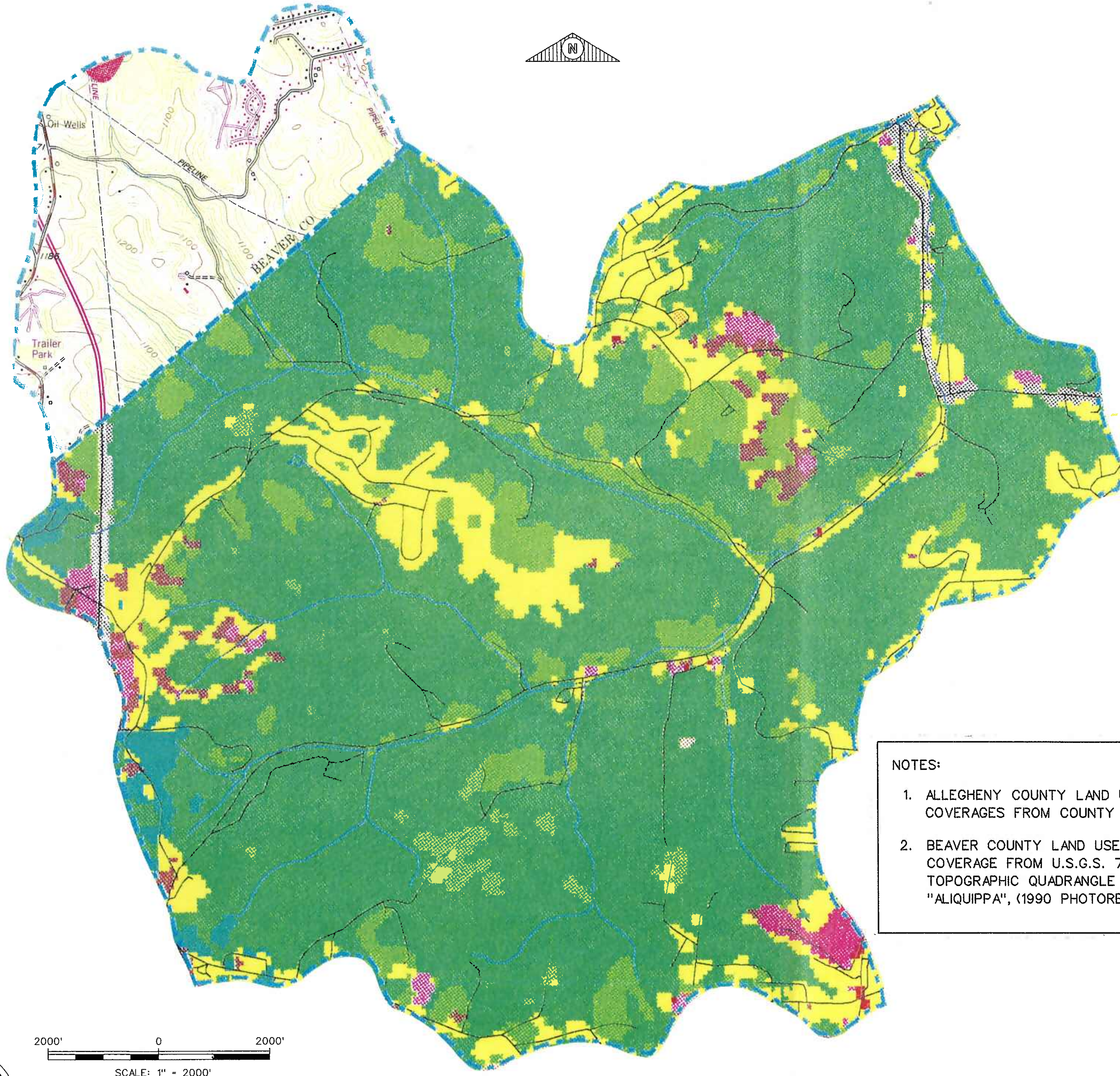

NOTES:

1. ALLEGHENY COUNTY LAND USE COVERAGES FROM COUNTY GIS.
2. BEAVER COUNTY LAND USE COVERAGE FROM U.S.G.S. 7.5 MINUTE TOPOGRAPHIC QUADRANGLE "ALIQUIPPA", (1990 PHOTOREVISED).

Landcover Legend

- Water
- Transportation
- Forest
- Grassland/Open Space
- Agricultural/Pasture
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Identified Malls
- Commercial
- Industrial
- Heavy Industrial
- Strip Mine
- Non-vegetated

Line Legend

- Roads - USGS
- Hydrography
- Watershed Boundaries

FIGURE 3-7
LAND USE MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

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Table 3.2

SUMMARY OF CLIMATIC DATA

Month	Average Monthly Temperature (°F)	Average Monthly Precipitation (inches)	Average Mean Number of Days With Snow	Precipitation	Thunderstorms
January	29.9	2.85	3.6	16.4	0.2
February	31.1	2.46	2.8	13.9	0.4
March	39.9	3.28	2.4	15.7	1.7
April	51.0	3.08	0.5	13.5	3.3
May	61.7	3.38	0.1	12.6	5.2
June	70.1	3.74	0	11.5	6.8
July	74.3	3.99	0	10.8	6.9
August	72.5	3.25	0	9.7	5.6
September	66.2	2.70	0	9.5	3.2
October	54.7	2.44	0.1	10.4	1.2
November	43.1	2.48	0.9	13.0	0.6
December	33.3	2.77	2.5	16.3	0.3
Year	52.3	36.43	12.9	153.3	35.4

SOURCE: "Local Climatological Data. 1994, Annual Summary with Comparative Data, Pittsburgh, Greater Pittsburgh Airport," National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, North Carolina.

Land Use

Development in the Flaugherty Run watershed has followed the traditional pattern of concentrating first at the mouth and in the downstream valleys, then spreading to the more upland and upstream areas. Major transportation routes are State Route (SR) 51 in the northeast portion of the watershed; SR 60 along the southern and western boundaries; and Flaugherty Run Road, which runs northeast-southwest across the watershed, and connects SR 51 and SR 60 (see Figure 3-1). Pittsburgh International Airport is located south of the watershed, and is the major developmental force in western Allegheny

County. Developmental pressures may be anticipated to increase as a result of the airport and the availability of lands for development. Due to the steep hillsides within the Flaugherty Run watershed, these pressures will concentrate development along the remaining valleys and ridges. The steepness of the valley walls and compactness of the drainage system will make stormwater management a critical factor in minimizing potential adverse effects.

Existing Land Use. The Allegheny County GIS database (Reference 5) indicates that approximately 62 percent of the watershed was still wooded in the early 1990s. Residential areas at roughly 15 percent and grassland/open space at roughly 14 percent constituted the next largest land uses. Recent development has resulted in a decrease in wooded acreage, and increases in residential and open space acreage. Commercial, industrial and public areas comprise a total of about 4 percent of the watershed. Table 3.3 and the Land Use Map, Figure 3-7 present a summary of the existing land uses in the Flaugherty Run watershed, based on 1992 data in the Allegheny County Department of Planning GIS (Reference 5), U.S. Geological Survey (USGS) mapping (Beaver County, References 8 and 9), and field estimates. A summary of land use by municipality is presented in Table 3.4. The Zoning Map, Figure 3-8, summarizes the current municipal zoning in the watershed, based on the Allegheny County GIS database (Reference 5) and available information from Hopewell Township. The bulk of the watershed is zoned as residential, with commercial/industrial zoning concentrated along the major transportation routes.

Table 3.3

SUMMARY OF LAND USE BY AREA

	Percent of Watershed	Acres
Forest	62.4	3,540
Grassland/Open Space	14.3	810
Low Density Residential	15.1	860
Medium Density Residential	0.9	50
Non-Vegetated	2.5	140
Commercial	1.6	90
Malls	0.9	50
Transportation	0.9	50
Agricultural/Pasture	0.9	50
Industrial	0.5	30
TOTAL	100.0	5,670

Table 3.4

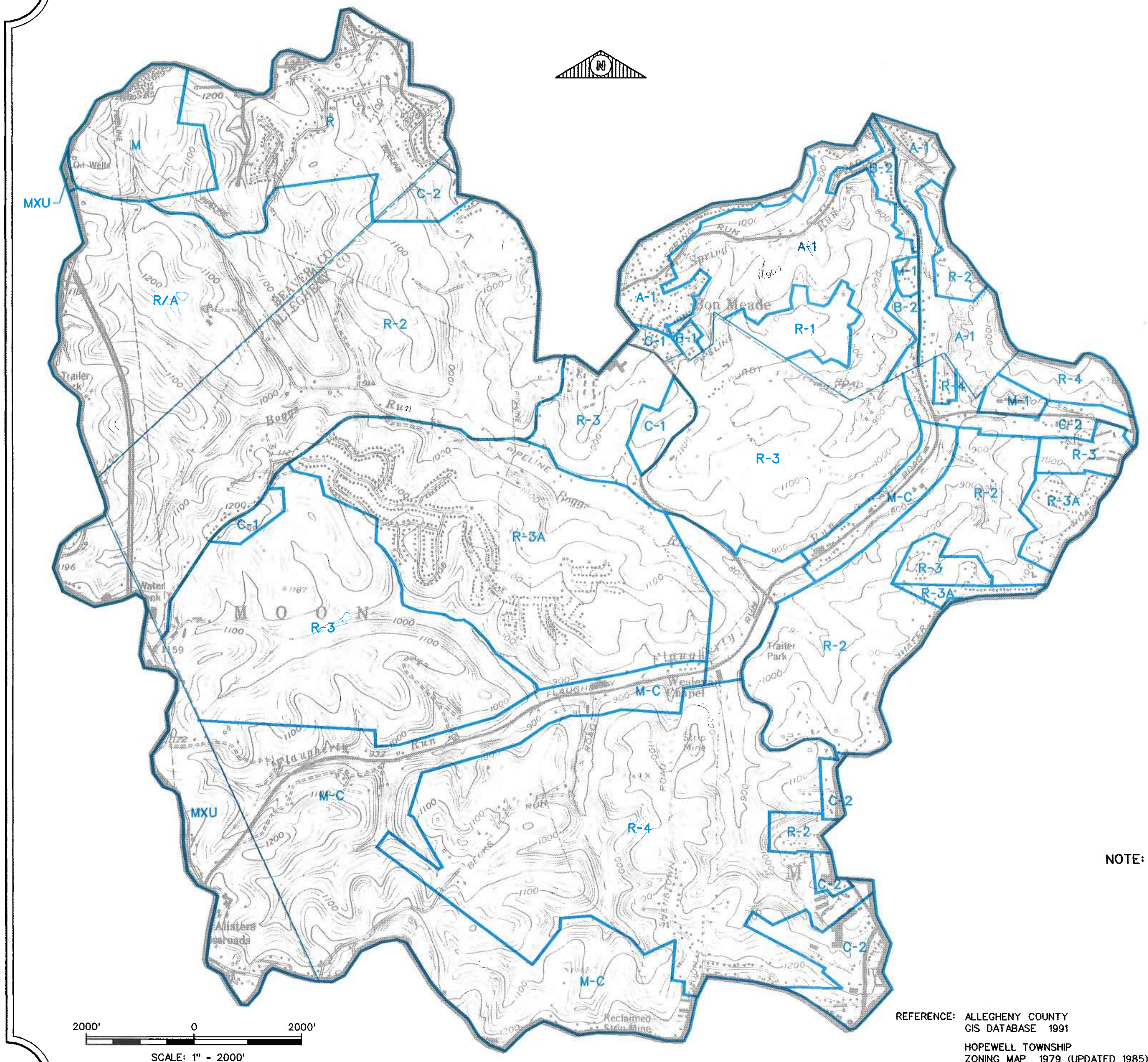
SUMMARY OF LAND USE BY MUNICIPALITY

	Crescent %	Moon %	Hopewell %	Findlay %
Forest	60	62	60	26
Grassland/Open Space	5	13	24	10
Low-Density Residential	20	15	10	25
Medium-Density Residential	5	1	0	0
Non-Vegetated	2	3	2	2
Commercial	2	2	1	2
Malls	0	1	0	10
Transportation	5	1	1	5
Agricultural/Pasture	0	1	0	20
Industrial	1	1	2	0

NOTE: Percentages have been rounded to the nearest integer.

SOURCE: Allegheny County GIS and USGS Topographic Quadrangle, "Aliquippa," 1954, Photorevised 1990.

Projected Land Use. Residential development, and to a lesser extent commercial development, is anticipated to continue in the Flaugherty Run watershed. Based on information obtained from Moon and Crescent Townships, several residential and commercial projects are in various stages of planning and/or expansion. All but one of these projects are located along the ridges (see the Projected Future Development Map, Figure 3-9). Table 3.5 presents a summary of the projected development, based on information provided by the townships, the Greater Pittsburgh International Airport Impact Area Study (Reference 11), and the Southwest Pennsylvania Regional Planning Commission (Reference 12). Available developable land within the watershed lies mainly along the ridges, and in the remaining undeveloped stream valleys. It is estimated that approximately 25 percent of the watershed is potentially developable, with the major portion situated in the upland areas to the south and west. These areas are in close proximity to the major transportation routes and to the airport. The Zoning Map, Figure 3-8, shows where the residential and commercial development is currently planned to occur. The watershed is zoned for various densities of residential development, with the higher density residential zones situated in the upstream areas and ridges of the watershed. The commercial and industrial development zones are located along the major transportation routes.



LEGEND

A-1 — CONSERVATION

B-1 — BUSINESS
B-2 — RESIDENTIAL

C — COMMERCIAL
C-1 — COMMERCIAL I
GENERAL COMMERCIAL
LIMITED COMMERCIAL
C-2 — COMMERCIAL II
CENTRAL BUSINESS
MIXED RESIDENTIAL/COMMERCIAL

M — INDUSTRIAL
M-1 — LIGHT INDUSTRIAL
M-C — INDUSTRIAL/COMMERCIAL
MXU — MIXED USE DISTRICT

R — RESIDENTIAL
R-1 — ONE FAMILY DWELLING
RESIDENTIAL, 3 DWEL/15,000 SQ/FT
SINGLE FAMILY RESIDENTIAL
SINGLE FAMILY RESIDENTIAL DISTRICT
ONE FAMILY DWELLING
R-2 — RESIDENTIAL, 6 DWEL/7,500 SQ/FT
SINGLE FAMILY
SINGLE FAMILY RESIDENTIAL
SINGLE FAMILY RESIDENTIAL DISTRICT
R-3 — MULTI FAMILY RESIDENTIAL
RESIDENTIAL, 18 DWEL/2,500 SQ/FT
SINGLE FAMILY RESIDENTIAL
SPECIAL RESIDENTIAL DISTRICT
TWO FAMILY DWELLING
R-3A— RESIDENTIAL
R-4 — RESIDENTIAL
RESIDENTIAL, 7.5 DWEL/6,000 SQ/FT
SPECIAL RESIDENTIAL
TWO FAMILY DWELLING

NOTE: ZONING BOUNDARIES HAVE BEEN MODIFIED TO BE CONSISTENT WITH MUNICIPAL BOUNDRIES.

REFERENCE: ALLEGHENY COUNTY GIS DATABASE 1991
HOPEWELL TOWNSHIP ZONING MAP 1979 (UPDATED 1985)

FIGURE 3-8

ZONING MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

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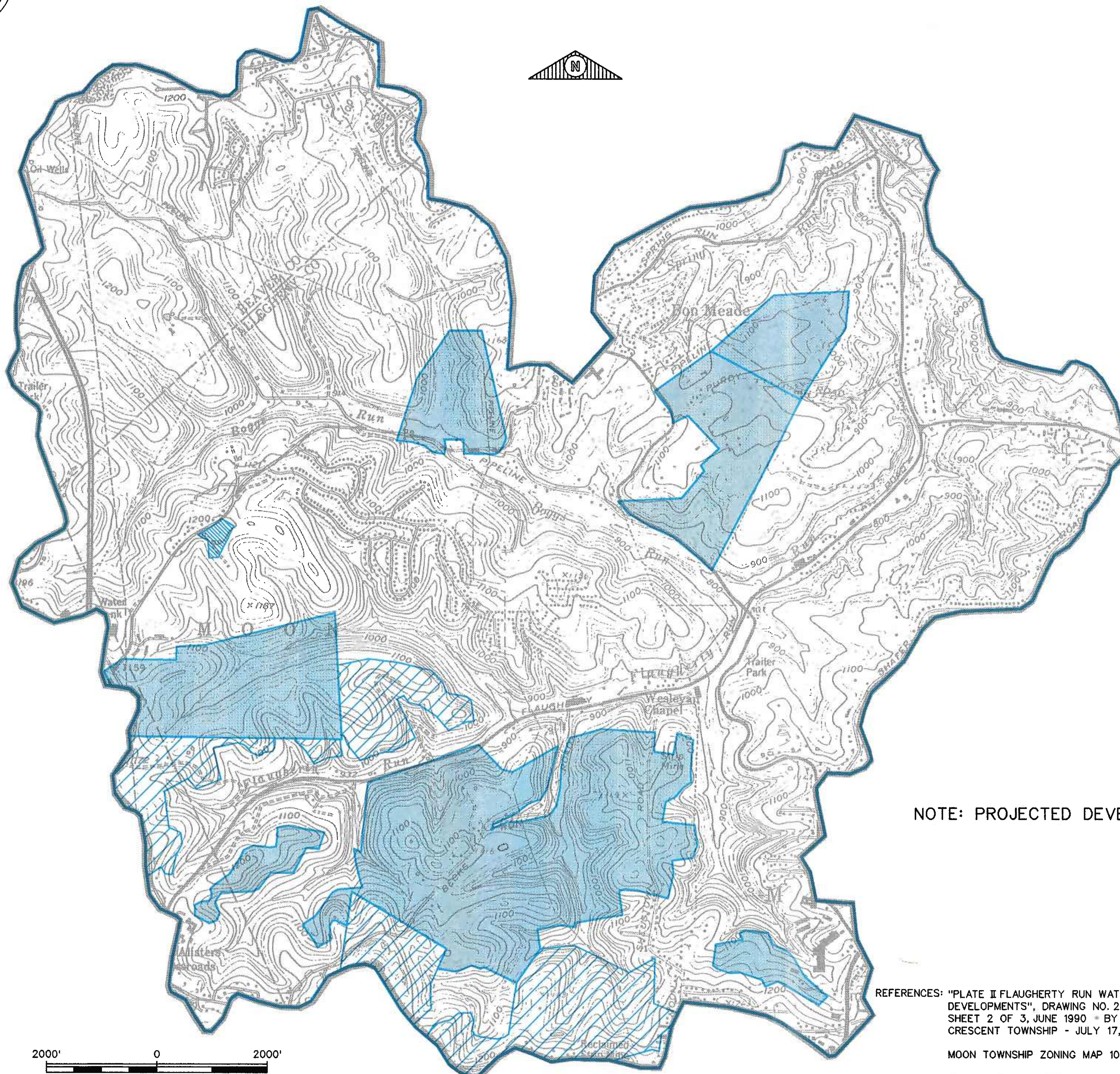
GAI DRAWING NO. 1503B009.DGN



LEGEND

RESIDENTIAL

INDUSTRIAL / COMMERCIAL

LIMITED COMMERCIAL

- NO PROJECTIONS FOR UNSHADED AREAS
- PROJECTIONS ASSUME SOME REZONING MAY OCCUR

NOTE: PROJECTED DEVELOPMENT TO YEAR 2005.

REFERENCES: "PLATE II FLAUGHERTY RUN WATERSHED PROPOSED DEVELOPMENTS", DRAWING NO. 28-3117-97-2 SHEET 2 OF 3, JUNE 1990 BY BCM
CRESCENT TOWNSHIP - JULY 17,1996

MOON TOWNSHIP ZONING MAP 10/17/90

"IMPACT AREA PLAN", ALLEGHENY COUNTY, JULY 1988

FIGURE 3-9

PROJECTED FUTURE DEVELOPMENT MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

GAI DRAWING NO. 1503B011.DGN

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Table 3.5

SUMMARY OF PROJECTED DEVELOPMENT 1995-2005
FLAUGHERTY RUN WATERSHED

Township	Residential (acres)	Commercial and Industrial (acres)	Sewered Total (acres)
Moon	408	166	574
Crescent	100	0	0
Findlay	3	32	35
Hopewell	39	77	116
TOTAL	450	275	725

SOURCES: "Moon Township Municipal Authority Feasibility Study for the Flaugherty Run Waste Water Treatment Plant Expansion," (Reference 10), "Greater Pittsburgh International Airport Impact Area Plan," (Reference 11), and data from the Southwestern Pennsylvania Regional Planning Commission" (Reference 12).

Personal Communication, Crescent Township Commissioners (Mr. Roy Weatherbee), July 17, 1996 at WPAC meeting.

91503-s3.klf/cwi9

4.0 WATERSHED HYDROLOGY

General

The hydrologic description of a watershed consists of those factors which affect how precipitation/rainfall occurs, how the rainfall is converted to runoff, and how the runoff drains through the watershed. These factors include the types of precipitation events, the runoff characteristics of the ground (soil conditions, land cover, imperviousness); and the hydraulic characteristics of the stream and its tributaries (drainage network, channel and flood plain flow capacities, and obstructions such as culverts, dams, and bridges).

Rainfall

As discussed in a previous paragraph, flooding in the watershed can occur any time, and especially due to summer thunderstorms, spring rains, and/or snowmelt. The small, compact shape of the watershed results in a rapid runoff response, and in a greater susceptibility to basin-wide storms than a larger basin would have. The rainfall distribution and intensity of a storm can, therefore, be of equal or greater significance as the total rainfall amount.

The Flaugherty Run watershed is sufficiently small (8.86 square miles) that all or a significant portion of the watershed could experience a short, intense thunderstorm as well as a regional or frontal system storm. Therefore, the potential exists for sudden floods with little or no warning. Planning for floodplain development and stormwater management should keep this potential in mind.

Runoff Characteristics

The major runoff characteristics are land cover (or land use), soil type and conditions, and imperviousness. These characteristics influence how the rainfall is converted to runoff, surface storage, evaporation/transpiration, and infiltration. Land use is typically divided into two groups, "developed" and "undeveloped". "Developed" areas are generally associated with man-made alterations to the land, and typically include impervious surfaces (paving, buildings) and/or large scale earth disturbance. Examples include residential, commercial, and industrial lands, strip mines, airports, and urban parks. "Undeveloped" areas are areas in which vegetation predominates the land surface, and includes woods and meadows. The "quality" or degree of vegetation is also considered. Agricultural lands may generally be considered to be undeveloped, in that their function is typically oriented toward vegetation, and there is little or no impervious surface. However, some types and practices of agriculture may result in little or no vegetal cover at various times of the year. Imperviousness is associated with pavement and buildings, and is a measurement of the land surface on which negligible infiltration would occur. Soil conditions which affect runoff include the infiltration capability and the soil moisture conditions. The "Hydrologic Soil Group" (HSG) is an indication of a soil's minimum infiltration rate, and is commonly used with land cover characteristics to obtain a measure of the runoff characteristic of a soil. Soil moisture conditions take into account both the surface permeability (moisture in the soil before the storm) and the physical state of the moisture (frozen or unfrozen). Saturated soils and frozen soils typically produce higher runoff rates than drier, unfrozen soils. By incorporation of these factors, a single measure of the runoff characteristic of a land surface, commonly in the form of the Soil Conservation Service (SCS) "curve number", can be determined.

Hydraulic Characteristics

Once runoff has formed, the hydraulic characteristics dictate how the runoff collects and merges with runoff from other areas, and flows through the watershed. The geology and topography dictate many of the hydraulic characteristics of a basin. The presence or absence of highly-erodible or non-erodible rock, limestone, coal (and coal mining), the dip of rock strata, and the basin rock strata soils are examples of geologic conditions which can establish hydraulic characteristics. Similarly, the steepness of the valley walls, the presence or absence of ridges or plateau areas, and the valley floor topography are examples of topographic conditions affecting a basin's hydraulic characteristics.

Hydraulic characteristics commonly include the drainage network, flow capacities of the streams, flood plains, and obstructions, and travel times for the passage of flow through the basin.

- The drainage network is the collection and connection of the swales, gullies, streams, and valleys which drain the land. The finer the network, the faster the runoff enters a stream, and the more rapid the collection and conveyance of water.

- Flow capacities affect the passage of flow through the watershed. Streams are usually more efficient at passing flow (i.e., flow at high velocities) but their capacity is limited due to the size of the channel. Excessive flows or velocities in the channel may also cause accelerated erosion. At high flows, the flood plains must pass a portion of the flow, and flood damages frequently result. Flood plains, although generally much greater than channels in size, are less efficient in passing flow, in that velocities are much slower. Obstructions such as bridges and culverts may restrict the flow capacity of a channel, or of a flood plain. An example of this is a road embankment, which elevates the road above the surrounding ground in the vicinity of a bridge or culvert. In this situation, the flood plain flow may be forced back into the channel so as to pass through the bridge or culvert. The typical results are higher velocities, raised flood levels, and greater potential for scour and accelerated erosion at the bridge.

- Travel times are a measure of the ability of channels and flood plains to convey flow. Short travel times imply short distances, or large or more efficient channels and flood plains. Efficiency is not always beneficial in preventing or reducing flood damages, however. The greater velocities present in more efficient channels and flood plains may also present a greater risk of erosion, property damage, and possible loss of life. In addition, making a channel more efficient may only serve to exacerbate flooding conditions in more downstream areas.

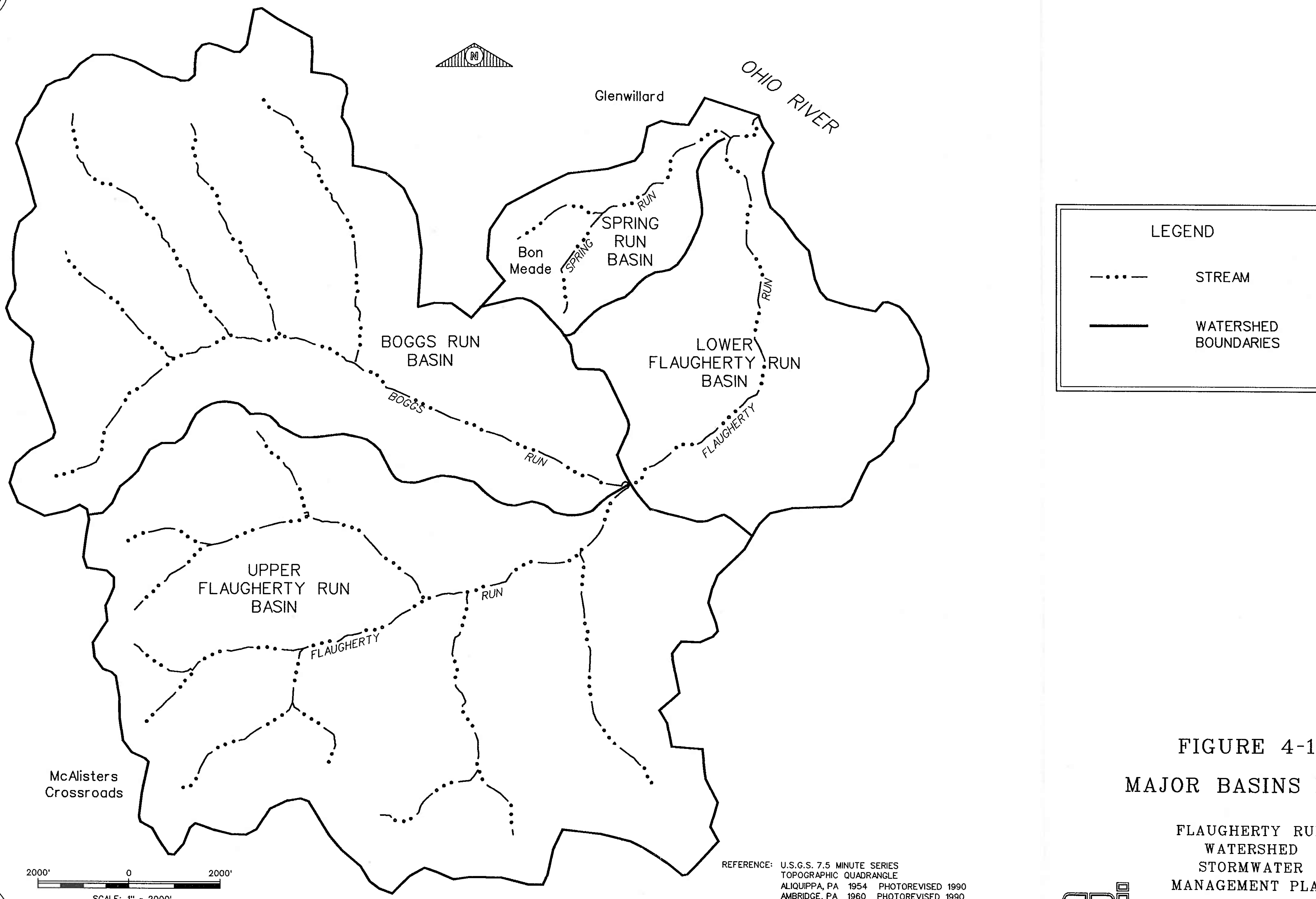
The combination of the basin's hydraulic characteristics can be expressed as the response time of the basin. The shorter the response time of a basin, the greater is the number of storms which affect the entire basin. The greater the number of storms which affect the entire basin, the more frequent and greater is the susceptibility to flooding in the basin. One of the usual results of development is a decrease in the response time. And, while a single development may have a seemingly insignificant impact on the response time, or runoff flows, or other hydrologic results, the cumulative impact of several developments may be dramatic.

Hydrologic Description

The Flaugherty Run watershed can be divided into four (4) relatively distinct parts:

- upper Flaugherty Run basin (upstream of confluence with Boggs Run);
- Boggs Run;
- Spring Run; and
- lower Flaugherty Run basin.

These areas are shown on Figure 4-1, the Major Basins Map. The Boggs Run basin (3.15 square miles) is approximately the same size as, and is hydrologically and hydraulically similar to, the upper Flaugherty Run basin (3.88 square miles). These two streams funnel flows into the lower Flaugherty Run basin. The lack of stormwater controls or the use of inappropriate controls in these upper basins may significantly impact the areas downstream of their confluence. As will be described later, runoff flows from the upper Flaugherty Run and Boggs Run basins peak at about the same time under a basin-wide, uniform storm event, a not uncommon occurrence due to the relatively small size of the entire watershed. This occurrence can be seen on the Runoff Impact Map, Figure 4-2, which shows how runoff hydrographs combine at selected locations in the watershed. Flaugherty Run downstream of the confluence becomes a bottleneck for the upstream flows, and therefore may dictate the level of controls necessary in the upper basins to prevent increased flooding downstream.



REFERENCE: U.S.G.S. 7.5 MINUTE SERIES TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

FIGURE 4-1
MAJOR BASINS MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

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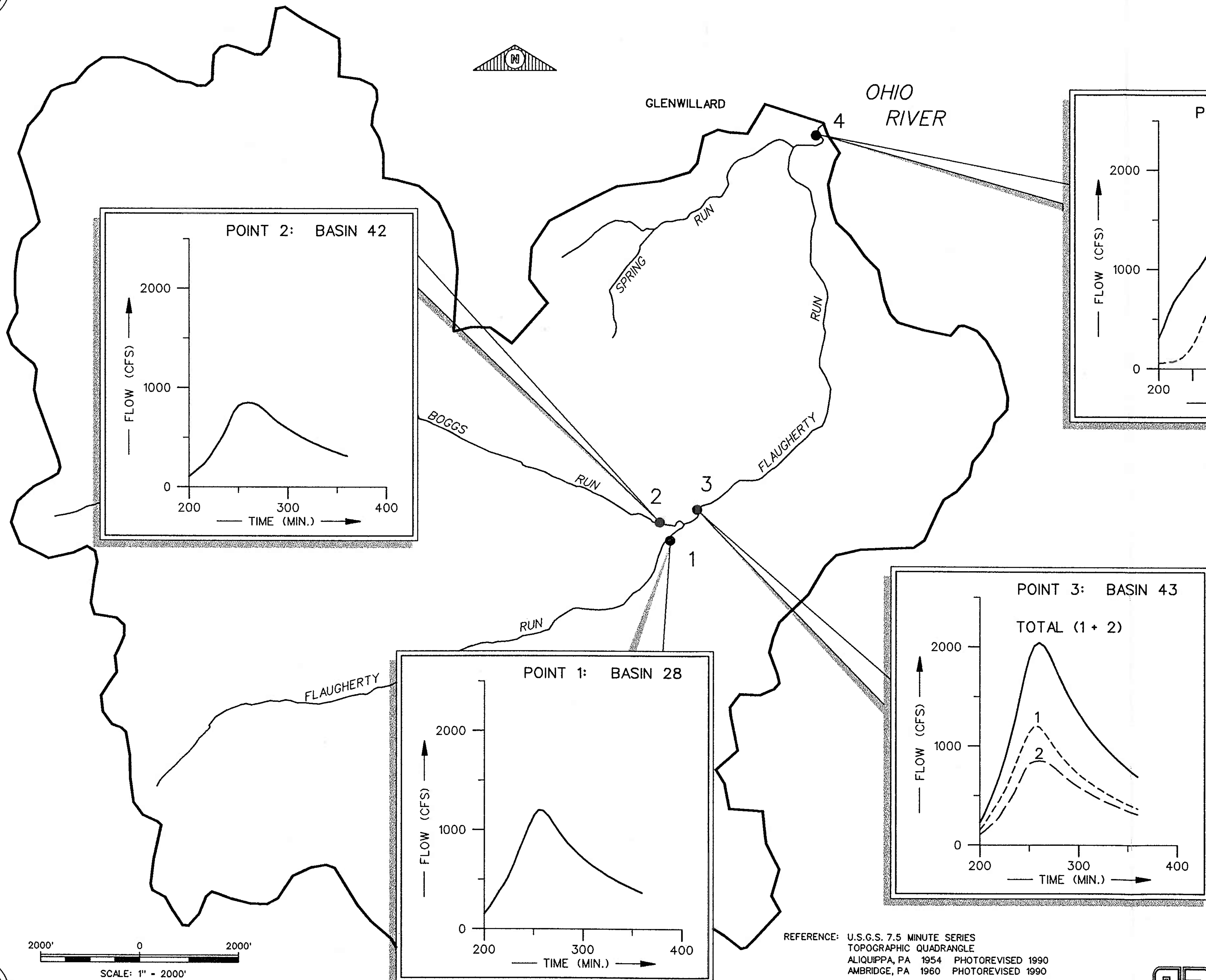
GAI DRAWING NO. 15038022.DGN



REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

FIGURE 4-2
RUNOFF IMPACT MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

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GAI DRAWING NO. 1503B005.DGN

Flood History

Flaugherty Run does not have a stream flow gage which would aid in identifying past floods. Consequently, precipitation records at the National Weather Service Station at the Pittsburgh International Airport were used to identify large storms. A summary of the available storm information is presented in Table 4.1. Additional information is provided in the following paragraphs.

Table 4.1

MAJOR RECENT STORMS IN THE FLAUGHERTY RUN WATERSHED

Year	Date(s)			Rainfall (inches)
1972	June 20	-	June 24	4.14*
	September 12	-	September 13	2.50
1973	May 24			2.31
	October 28	-	October 29	2.18
1974	May 11	-	May 12	2.13
1975	February 23	-	February 24	2.75
	July 8	-	July 9	2.40
	September 23	-	September 24	2.26
1978	December 8	-	December 9	2.00
1980	May 12	-	May 13	2.38
	July 8			2.27
	May 1	-	May 2	1.95
	November 3	-	November 4	3.30
	November 15	-	November 16	1.97
1986	June 5	-	June 6	2.83
	July 8	-	July 9	2.55
1987	June 20			2.96
	August 4	-	August 5	2.88
1989	June 20	-	June 21	1.99
1990	December 30			2.76
1991	June 30			2.18
1992	August 27	-	August 28	2.31
1993	April 25	-	April 26	1.89
1993	November 13	-	November 14	1.98
1994	August 2			2.12
1995	July 17			2.12

* Tropical Storm "Agnes" - measured at the NWS raingage at the Federal Building, Pittsburgh.

SOURCE: NWS Raingage, Greater Pittsburgh International Airport, Local Climatological Data, NOAA, except as noted.

Flood Hazard and Stormwater Problem Areas

The areas of past flooding, due to high stream flows or runoff flows, are shown on the Areas of Past Flooding Map, Figure 4-3. These areas were identified by municipal officials and residents during the field reconnaissance. Table 4.2 presents pertinent information on the history of past floods at these areas. Flooding caused by high stream flows has occurred at sporadic locations in the watershed. Stream bank erosion has occurred at several sites along Flaugherty Run and Spring Run, and may constitute the most common problem caused by flood flows. Evidence of past attempts to remedy stream bank erosion using concrete rubble and/or rock were observed at several locations. These attempts appear to be largely ineffective, due in part to the absence of an engineered filter for the large rubble.

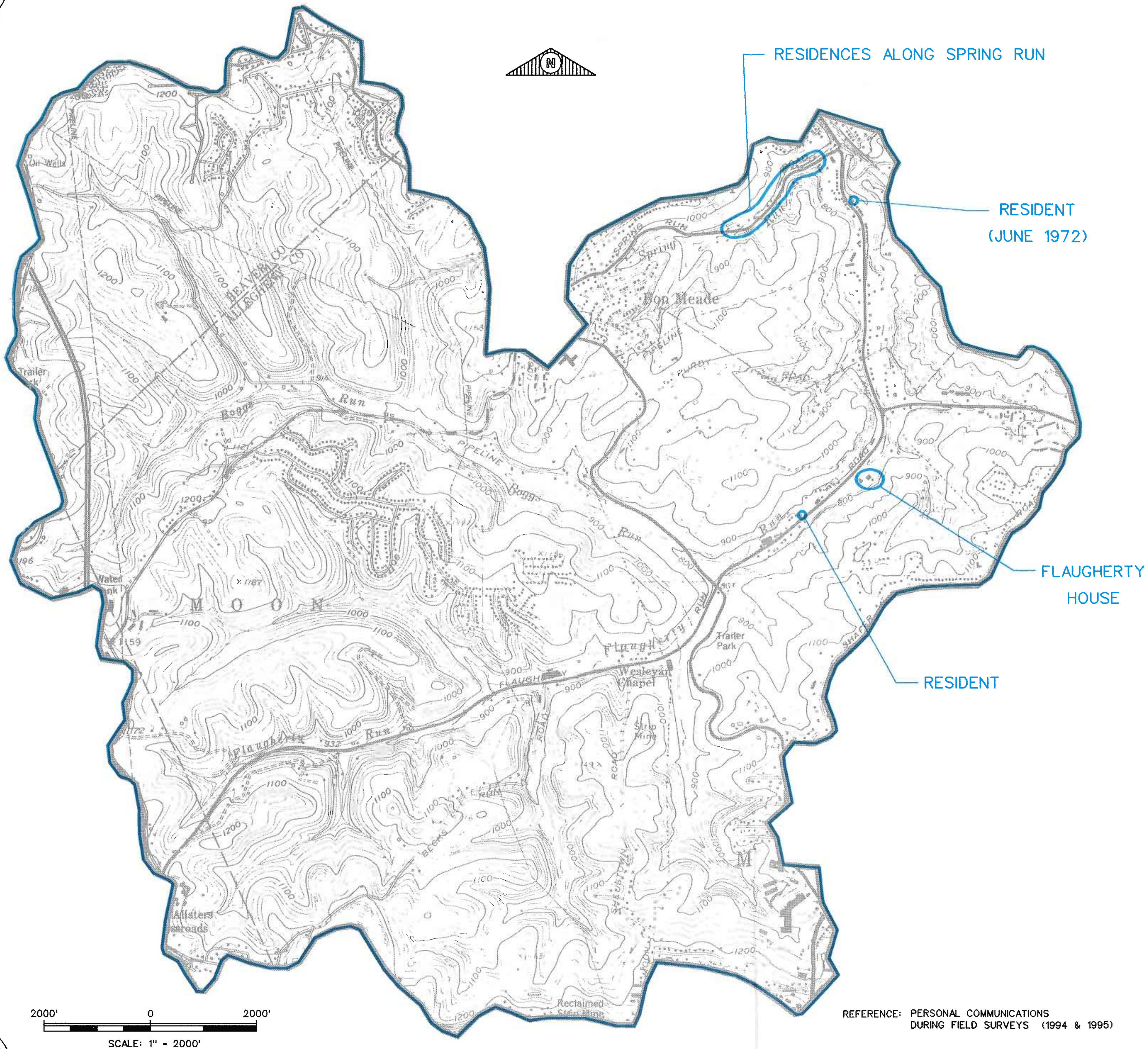
Table 4.2

SUMMARY OF PAST FLOODING

Location	Flooding Source	Date or Frequency of Occurrence	Extent of Flooding
The Flaugherty House	Flaugherty Run	Frequent	Lawn flooding
Residences Along Spring Run Road	Spring Run	Annually	Stream bank erosion, clogging of culverts
Residence	Flaugherty Run	Once (June 1972)	Basement flooding
Residence	Flaugherty Run	Frequent	Lawn flooding

Flood Insurance Mapping. Flood insurance studies have been prepared for the Townships of Crescent, Moon, Findlay, and Hopewell (References 13, 14, 15, and 16). Flaugherty Run was not studied in detail for any of these townships. The Ohio River produces significant backwater effects on Flaugherty Run, as shown on Figure 4-4, the Flood Boundary and Floodway Map for Crescent Township. The absence of Flaugherty Run in these studies indicates that, at the time of their preparation (late 1970's), flooding along the stream was considered not to be of significance.

Flood-Prone Mapping. The flood-prone maps for the Ambridge and Aliquippa quadrangles (References 17 and 18) show only minor areas of flooding in the Flaugherty Run watershed for the 100-year event. The Flood-Prone Area Map, Figure 4-5, presents the flood-prone areas in the Flaugherty Run watershed, based on the flood-prone maps.



REFERENCE: PERSONAL COMMUNICATIONS DURING FIELD SURVEYS (1994 & 1995)

LEGEND

AREAS OF PAST FLOODING

FIGURE 4-3

AREAS OF PAST FLOODING MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

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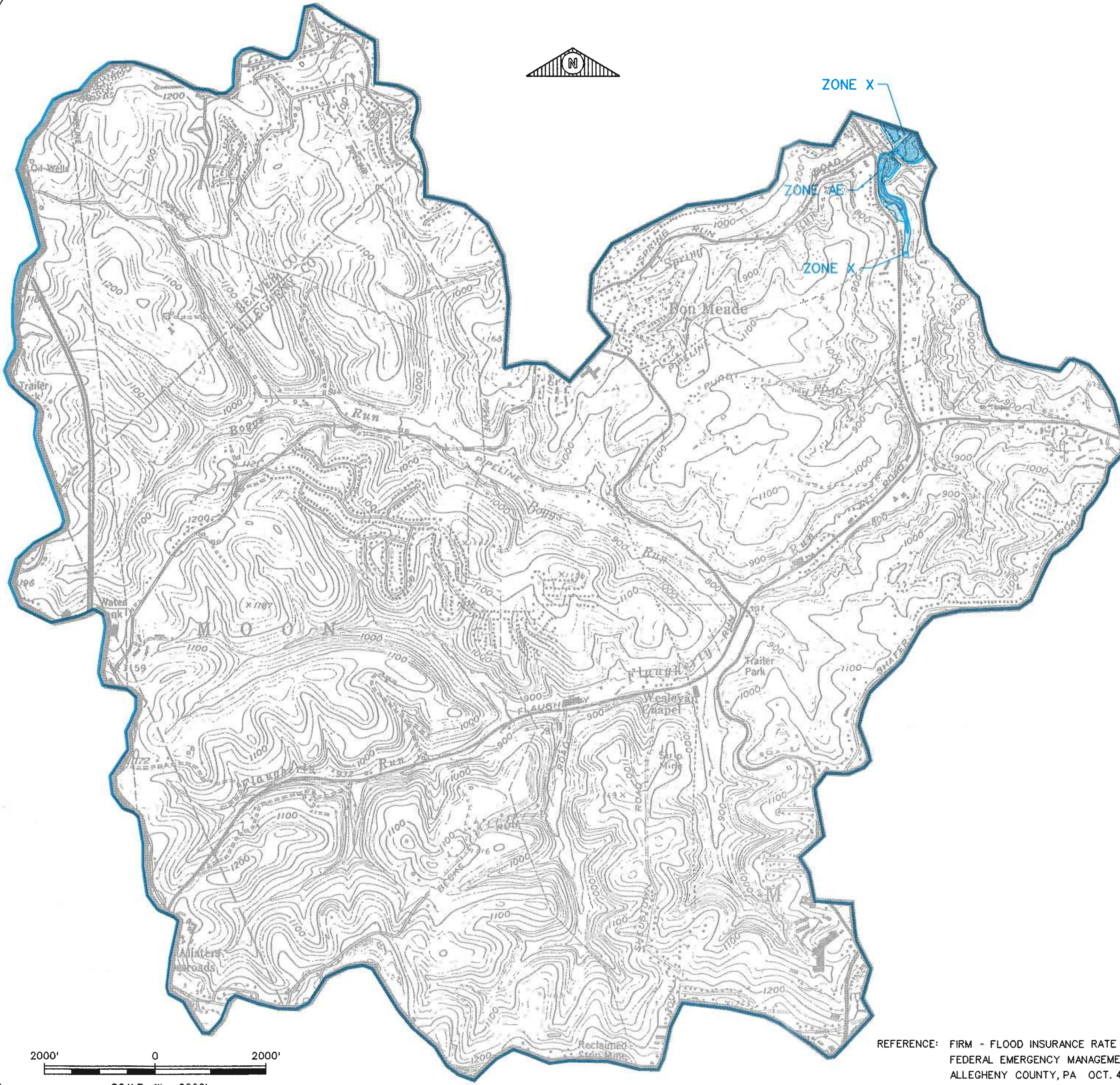
GAI DRAWING NO. 1503B020.DGN



LEGEND

ZONE AE - 100 YEAR FLOOD
BASE FLOOD ELEVATIONS DETERMINED.

ZONE X - 500 YEAR FLOOD
AREAS OF A 100-YEAR FLOOD WITH AVERAGE DEPTHS OF LESS THAN 1 FOOT OR WITH DRAINAGE AREAS LESS THAN 1 SQUARE MILE, AND AREAS PROTECTED BY LEVEES FROM 100-YEAR FLOOD.

REFERENCE: FIRM - FLOOD INSURANCE RATE MAP
FEDERAL EMERGENCY MANAGEMENT AGENCY
ALLEGHENY COUNTY, PA OCT. 4, 1995
PANELS 161 AND 162 OF 558

FIGURE 4-4

FLOOD BOUNDARY AND FLOODWAY MAP CRESCENT TOWNSHIP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

GAI DRAWING NO. 1503B023.DGN

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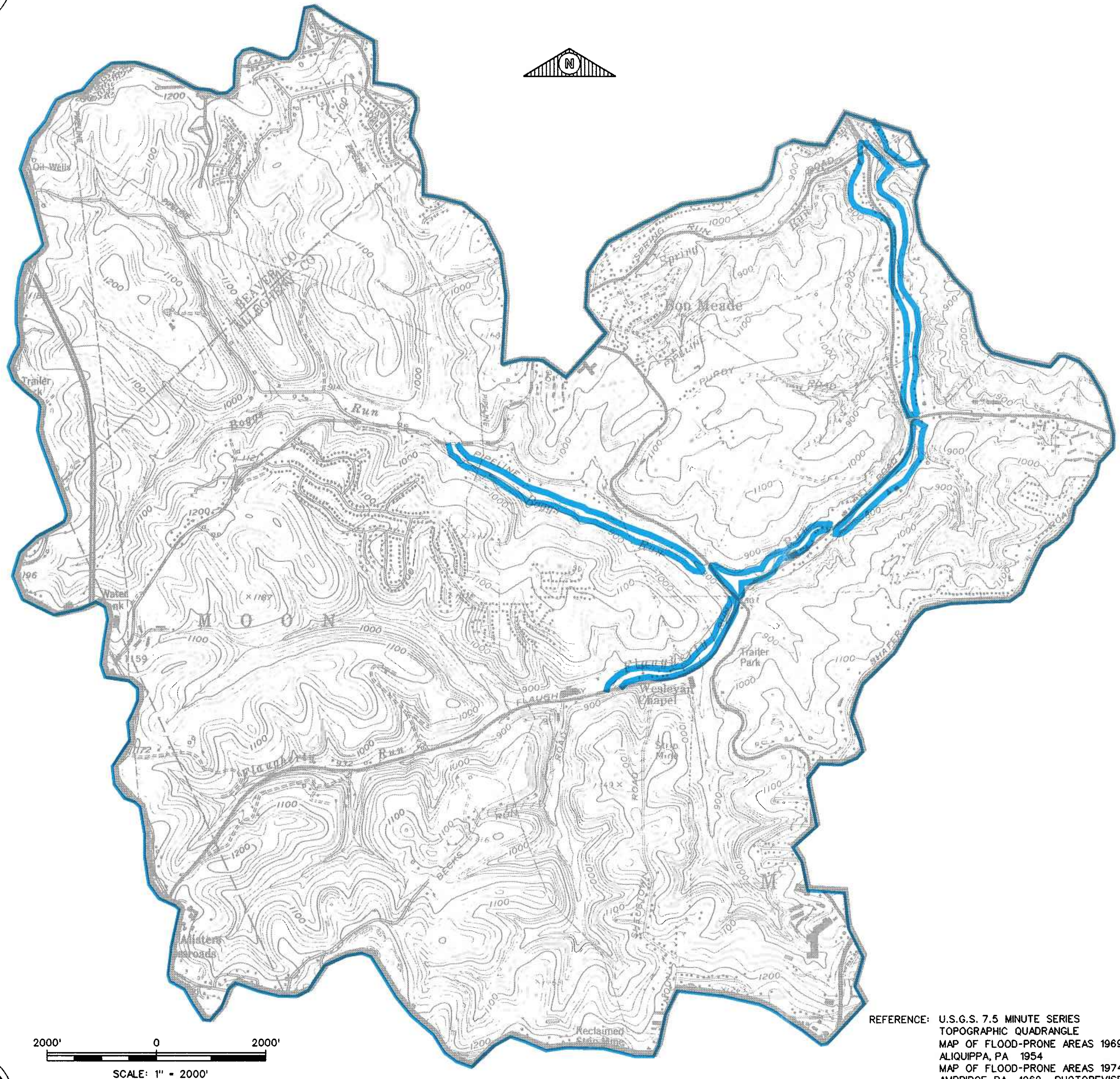

REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
MAP OF FLOOD-PRONE AREAS 1969
ALIQUIPPA, PA 1954
MAP OF FLOOD-PRONE AREAS 1974
AMBRIDGE, PA 1960 PHOTOREVISED 1969

FIGURE 4-5
FLOOD-PRONE AREAS MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

GAI DRAWING NO. 1503B015.DGN

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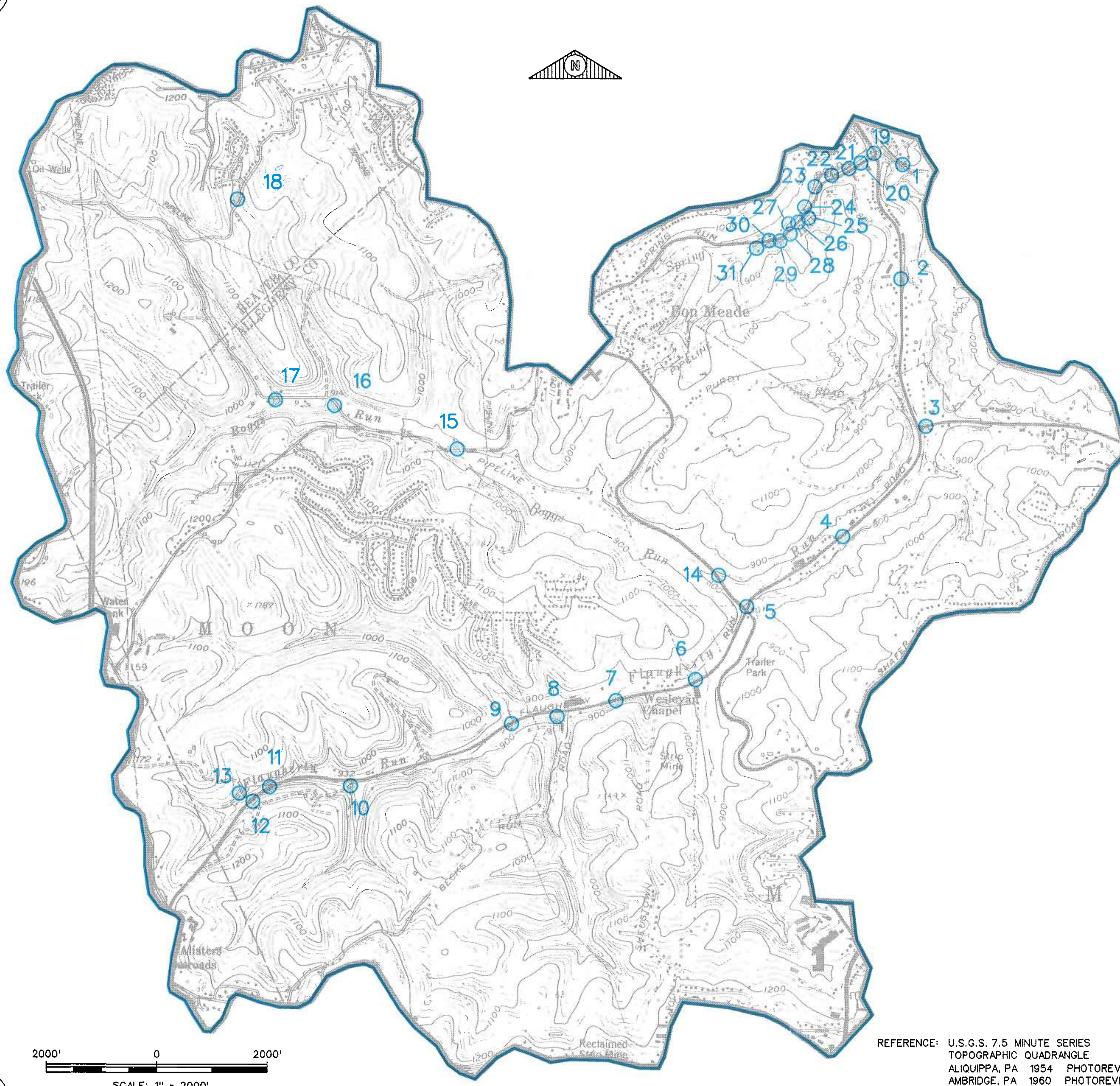
Summary. As late as the mid-to-late 1970's, flooding was apparently considered to be not significant in the Flaugherty Run watershed. Flood hazard and stormwater problem areas identified by local authorities and residents in this study are scattered along the main stems of Flaugherty Run and Boggs Run, in general agreement with the areas shown on the flood-prone area mapping. Consequently, flooding problems in the basin are still relatively minor. Recent development in the watershed, spurred in part by the Pittsburgh International Airport, is currently managed by restricting post-development peak flows to be no greater than pre-development peak flows. As will be described in a subsequent section, this approach may actually exacerbate downstream flooding conditions. The implementation of a watershed-wide stormwater management plan is, therefore, of significance to the prevention of increased flood damages.

Stream Obstructions

Obstructions to flow are commonly created by bridges, culverts, excessive flood plain development, and accumulation of sediments and debris. Stormwater management facilities may also be obstructions if they are inadequate to control flows. In the Flaugherty Run watershed, bridges and culverts make up the bulk of the obstructions (see the Obstruction Map, Figure 4-6). There is also one small dam situated on Flaugherty Run, near its headwaters (obstruction #13). The dam appears to be privately-owned, and may be used for general recreational purposes, as there is no development in the area. A listing of the obstructions in the watershed is given in Appendix B. A listing of the more significant obstructions is provided in Table 4.3. It is noted that there are numerous private, residential driveway bridges and culverts in the watershed, especially along Spring Run, and the lower reaches of Flaugherty Run also contain several significant obstructions (see Figure 4-6). These latter obstructions are of particular significance as they occur below the confluence of Boggs Run with upper Flaugherty Run, the hydrologic importance of which has been discussed in previous sections. In general, any structure or embankment which reduces either the flow area or the efficiency of the channel or flood plain can cause increased flooding. Stormwater planning, therefore, must take into account the presence of existing obstructions, and proposed obstructions must take into account stormwater management to minimize their impact. Current PaDEP permitting requirements ("Dams and Encroachments Act") mandate consistency with stormwater management plans. An on-going maintenance plan, consistent with PennDOT and PaDEP regulations and procedures, would reduce the effect of sediment and debris at the obstruction sites.

Description. The list of obstructions given in Appendix B consist primarily of bridges and culverts. No significant obstructions due solely to sediments or debris were identified during the site visits. These materials were, however, observed at several bridges and culverts. In addition, incidental and/or deliberate accumulations of trash and other debris were also observed.



REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

LEGEND

○ 2 OBSTRUCTION

NOTE: SEE APPENDIX B FOR DETAILED INFORMATION ON THE OBSTRUCTIONS

FIGURE 4-6
OBSTRUCTIONS MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

GAI DRAWING NO. 1503B010.DGN

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Table 4.3

LISTING OF SIGNIFICANT OBSTRUCTIONS

Obstruction Number	Description	Municipality
3, 4	Flaugherty Run Road on Flaugherty Run	Moon
5	Broadhead Road on Flaugherty Run	Moon
26, 27, 28	Spring Run Road on Spring Run	Crescent
20-25, 29-30	Private Residence Driveways on Spring Run	Crescent

Obstruction Numbers are keyed to Figure 4-6, the Obstruction Map.

Most of the recent development has occurred on the ridges, where flows are being concentrated sooner and prior to reaching Flaugherty Run, Boggs Run or Spring Run. The hillsides are steep and wooded, with soils classified as moderately erodible (References 1 and 2). The potential for the occurrence of debris and sediments at obstructions in the watershed is therefore considered to be high.

Evaluation and Analysis. Measurements were taken of each obstruction listed in Appendix B, and hydraulic analyses were performed to estimate the approximate flow capacity of the obstruction, and the maximum flow capacity prior to overtopping of the road or obstruction. This information is presented in Appendix B.

A significant number of the obstructions were found to have flow capacities on the order of the 10-year event, based on the hydrologic modelling performed. The effects of sediments or debris were not specifically analyzed where these deposits were present at the structures, unless it appeared that maintenance was minimal or absent. Critical obstructions or areas of obstructions are noted in Table 4.3. These obstructions present inordinate flow constrictions or restrictions, and may be appropriate for further study to lessen their effects.

Stormwater Management Facilities

The effects of existing and proposed stormwater management facilities were investigated with the assistance of township officials. Where appropriate, these facilities were incorporated into the technical analyses of this plan.

Existing Stormwater Management Facilities. Stormwater management for recent developments in the Flaugherty Run watershed has generally followed the "no increase above existing conditions peak flows" philosophy. The 25-year storm is currently being used in the watershed as the upper limit for storm events to be evaluated under this management philosophy. As will be discussed in subsequent sections, this philosophy can lead to increased flood flows and increased flood damages in downstream areas.

There are seven existing or proposed and approved developments with stormwater management (SWM) facilities in the watershed; five are located in Moon Township, and one each is located in Crescent and Hopewell Townships. The locations are shown on the Stormwater Management Facilities Map, Figure 4-7. The SWM facilities typically consist of ponds, although rock sumps and underground pipes are also being used at some locations. Specific information on the SWM facilities is presented in Table 4.4. The SWM facilities considered to have a significant impact on stormwater flows were included in the hydrologic models. The developments in Moon Township are low-density residential. The Shelbourne Plan is a proposed development which has an initial phase that has been approved by Moon Township, and, therefore, this development's initial phase was included in the existing conditions. The Sunrise Hill Estate Plan is currently under review by Crescent Township, and has not been included in this plan.

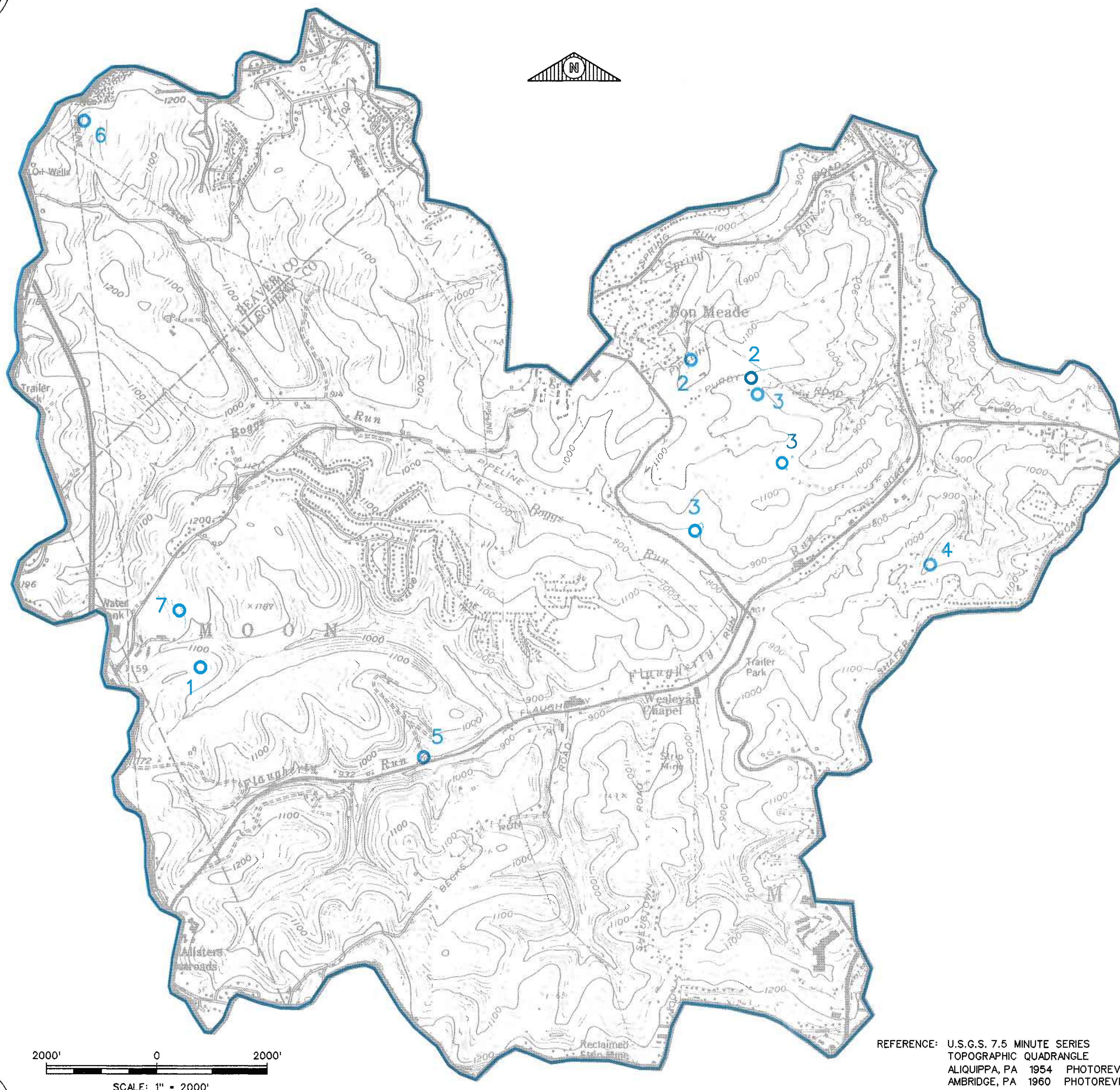
Proposed Stormwater Management Facilities. Residential and commercial/industrial developments were identified in a Moon Township Municipal Authority planning document (Reference 10) as proposed for construction in the next 10 years. Each development will be subject to the existing stormwater management regulations or those proposed herein, and will, therefore, require stormwater management facilities.

Existing and Proposed Flood Control Facilities. There are no existing flood control facilities (exclusive of the site stormwater management facilities) in the Flaugherty Run watershed. The PaDER completed the construction of a channel improvement and stabilization project on Flaugherty Run in 1985. The purposes of the project were to increase the channel's flow capacity and to stabilize an eroded bank to alleviate flood damages to adjacent residences. Additional information is provided in Appendix C. This project provides only localized flood control. No other flood projects in the watershed are known to exist or are known to be planned by either the U.S. Army Corps of Engineers (Pittsburgh District), the PaDEP, or the Soil Conservation Districts.

Storm Sewer Systems

Storm sewer systems are required improvements for developments within the Flaugherty Run watershed as stipulated in the ordinances for all townships.

Existing Storm Sewers. Storm sewers exist for each development in the watershed, including those listed in Table 4.4, and for road drainage. Approximately 10 percent of the watershed is currently drained by storm sewers. The design storm for storm sewers is the 25-year in Moon Township. Crescent Township does not establish a minimum design storm.



LEGEND

1 WHISPERING WOODS
2 BROADHILL FARMS COURTS
3 BROADHILL FARMS
4 HELDON ESTATES
5 SHELBOURNE
6 HOPEWELL BUSINESS AND INDUSTRIAL PARK
7 HERITAGE HILLS

REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

FIGURE 4-7
EXISTING & PROPOSED SWM FACILITIES MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

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570 Beatty Road, Monroeville, PA 15146 412/856-6400

GAI DRAWING NO. 1503B016.DGN

Table 4.4

SUMMARY OF STORMWATER MANAGEMENT FACILITIES

Name of Development	Location	Type of Development	Area Controlled (acres)	Number of Facilities	Type of Facilities	Management Procedure	Operational Maintenance Responsibility
Whispering Woods	Moon	low-density residential	51	1 14	pond rock sumps	match pre-existing flows to 25-year	
Broad Hill Farms and Broad Hill Farm Courts	Moon	low-density residential	102	5	ponds	match pre-existing flows to 25-year	
Heldon Estates	Moon	low-density residential	24	1	pond	match pre-existing flows to 25-year	
Shelbourne Plan*	Moon	low-density residential	4.4	1	pond	match pre-existing flows to 25-year	
Hopewell Business and Industrial Park	Hopewell	industrial	3.9	1	pond	match pre-existing flows to 25-year	
Heritage Hills	Moon	low-density residential	--	1	pond	match pre-existing flows to 25-year	
Sunrise Hill Estates**	Crescent	low-density residential	32±	3	ponds	match pre-existing flows to 25-year	

* Proposed and approved -- included under existing conditions.

** Proposed only -- not included under existing conditions.

Projected Future Storm Sewers. Proposed development will be required to construct storm sewers. It is projected that approximately an additional 13 percent of the watershed will be drained by storm sewers within the next 10 years.

Financing Construction. New storm sewer systems and stormwater management facilities would be constructed by and paid for by the developer/owner. Most of the projected development is private, and therefore private developers would finance the construction with minimal or no capital costs incurred by municipalities.

Operation and Maintenance. The operation and maintenance responsibilities for storm sewer systems and stormwater management are currently split between the municipalities and the owners. Currently, the municipalities generally accept responsibility once the construction is complete, and is accepted/or approved by the municipality. Crescent Township generally accepts storm sewers, but to date has never accepted a stormwater retention facility, and currently does not plan to do so. The ability of an owner, homeowner's association, or other private entity to assume operation and maintenance responsibilities should be evaluated carefully, in light of changes in ownership or membership of the entity. The advantages of a municipality assuming responsibility include continuity of ownership and a trained work force. The municipality also has a vested interest in the areas downstream of a SWM facility, whereas a private entity's interests typically end at the property line.

5.0 WATERSHED TECHNICAL ANALYSES AND MODELLING

Introduction

To evaluate the need for managing stormwater from future developments, it was necessary to create a hydrologic model of the watershed. The hydrologic model predicted flood flows and volumes for specified storms, which were used to evaluate the existing runoff conditions, and the potential impacts of projected development. Determinations were then made of the adverse impacts due to uncontrolled or inappropriately controlled development, and of the need and benefits of a coordinated, watershed-wide stormwater management system. Given the need and benefits of a watershed-wide stormwater management system, an evaluation of recommended strategies to achieve effective and practical management can be made.

This section describes the hydrologic model selection, the data collection and preparation, and the technical analyses performed. The modelling results are presented in Section 6. Discussion of the proposed stormwater management procedure can be found in Section 7.

Model Selection

The purpose of the hydrologic model is to assist in the development of a practical and effective stormwater management plan for the Flaugherty Run watershed. The Penn State Runoff Model (PSRM) was selected for use in the Flaugherty Run study for the following reasons:

- The PSRM can perform standard hydrologic modelling, and can be used to track and analyze the peak flows, runoff volumes, and the timing of various runoff flows as they travel through the watershed. This capability can determine not only the effects of upstream basins on downstream areas, but can also be used to identify appropriate management policies and to evaluate specific management strategies.

- The PSRM has been used in the preparation of several Act 167 stormwater management plans in Allegheny County and in Pennsylvania, including the plan for the adjacent Montour Run watershed. The model is, therefore, familiar to the County of Allegheny, Department of Economic Development and to some of the involved municipalities.

- Data collection, preparation, and model set-up for the PSRM are relatively straight-forward, and the procedures in the PSRM are also similar to the Soil Conservation Service (SCS) methods currently used in standard engineering design for stormwater management.

The 1993 version of the PSRM software program was used in this study.

Modelling Methodology

The PSRM software was used to develop hydrologic models of "Existing Conditions" and of "Projected Future Conditions." The models were used to simulate six design storms, ranging from the 2-year storm to the 100-year storm.

Existing Conditions. The existing conditions model served as the baseline for the technical development of the watershed-wide stormwater management plan. The flow contributions of individual basins within the watershed were computed, and used to evaluate various management policies. The existing conditions model was based on information provided by Allegheny County and the municipalities, and from several site visits conducted during the summer of 1994. Spot checking of the GIS land use data was performed in July-August 1994. Obstructions were identified and described, and computations were performed to predict the hydraulic capacities (see Appendix B). Existing stormwater management facilities and facilities under construction, using design and as-built information obtained from the townships, were included as appropriate in the existing conditions model.

Future Projected Conditions. The projected future conditions model served to simulate potential hydrologic conditions in 2005 (10 years ahead). The projected future development was estimated from discussions with township and county officials, available zoning, water, and sewerage information, published planning documents, and information provided by the Southwest Pennsylvania Regional Planning Commission (SPRPC). The resulting model represents "reasonably-expected development," and is not a "worst-case" condition. The projected future conditions model incorporates the current stormwater management philosophy in the watershed of "no increase in peak flows from the site." The results of the projected future conditions model were then compared to those of the existing conditions model to better quantify the impacts of development and to permit an evaluation of the need for stormwater management.

General Model Development. Development of the PSRM models generally followed the steps listed below.

- Initial meetings with county and township officials, to obtain information on existing policies, facilities, flooding problems;
- A series of site visits, to analyze information obtained from the officials, conduct the obstruction survey, spot-check data, and collect additional data;
- Data analyses and evaluation, to prepare the information in a form for use in the PSRM;
- Selection of design storms for use in the hydrologic analyses, and for subsequent use in developing the proposed stormwater management procedure;

- Running the preliminary existing conditions model for each of the design storms;

- Calibrating the existing conditions model to available flood history information;

- Finalizing the existing conditions models;

- Obtaining projected future development data and running the projected future conditions model; and

- Comparing the results of the existing conditions and projected future conditions modelling.

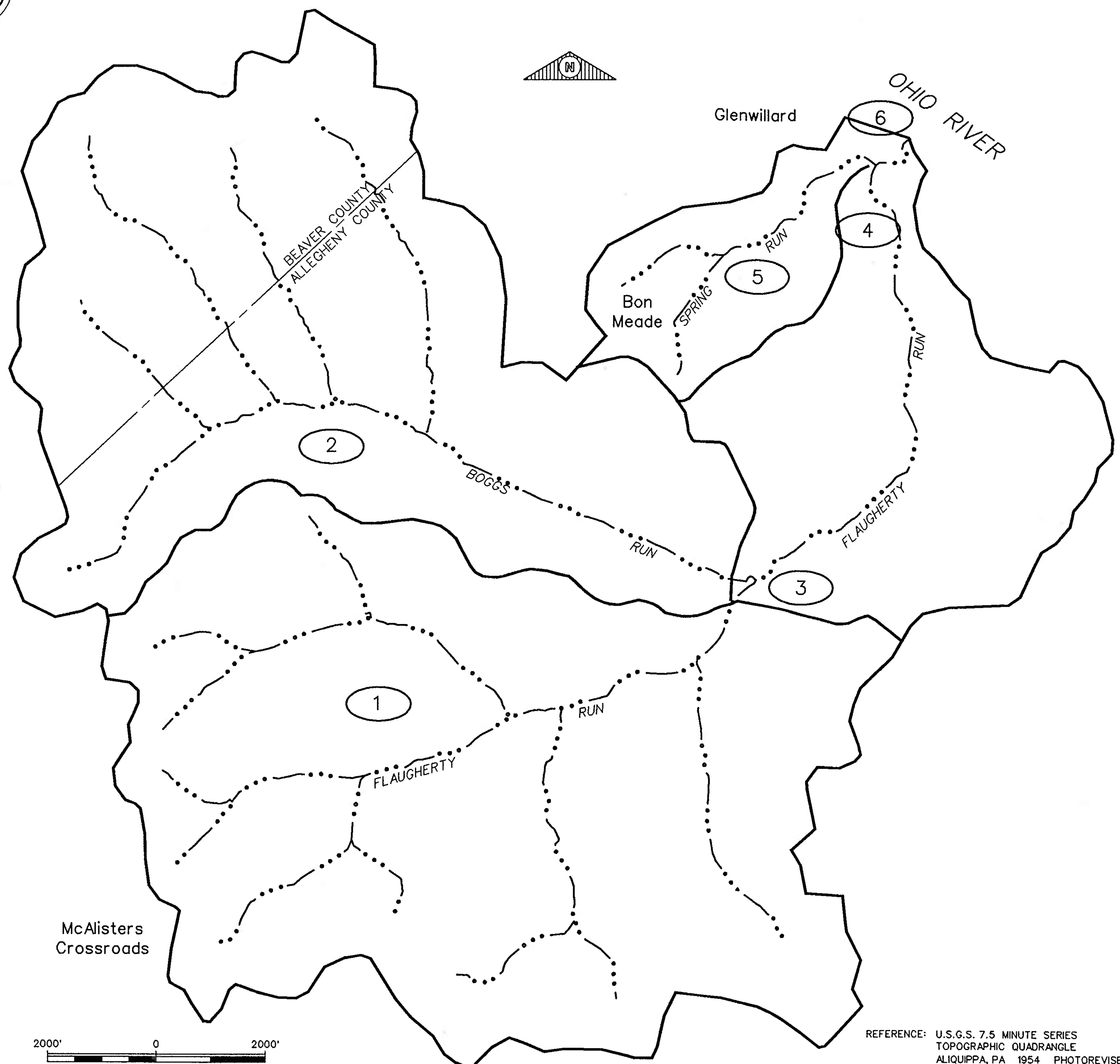
Detailed descriptions are provided in the following sections.

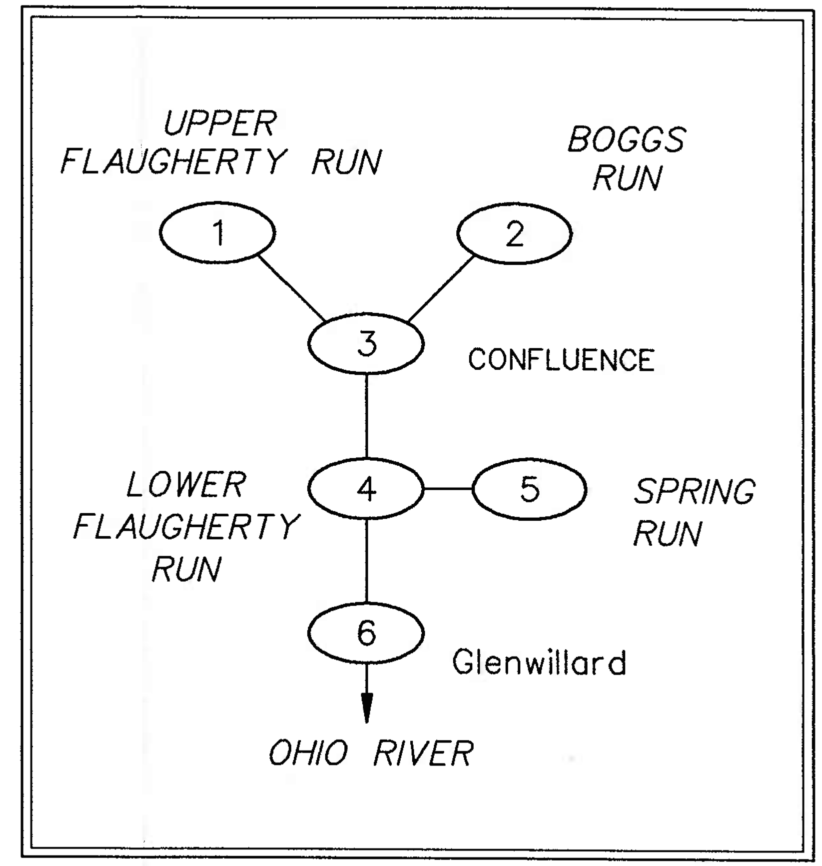
Basic Data Requirements

The PSRM requires data which characterizes the hydrologic conditions of the watershed. The data is used not only to develop the model, but also to calibrate the model to predict past flood flows and conditions. This data includes physical characteristics (drainage network, drainage areas, land use, soils, slopes, and lengths); storm characteristics (amount, duration, and distribution of the rainfall); hydraulic information (channel capacities, obstruction capacities, travel times, channel and flood plain conveyance parameters); existing SWM facilities (type, area controlled, control procedure and philosophy); and flood history (flows, flood levels, and damage).

Physical Characteristics. Physical watershed characteristics describe the watershed in terms that the PSRM computer model can interpret. Each characteristic describes a specific aspect of the watershed, and affects the formation, collection, and movement of runoff through the watershed.

- Drainage Network. The drainage network is a representation of how drainage occurs in the watershed. A watershed is composed of a series of channels or streams, each draining a specific area or basin. How the basins are connected is defined by the network, in a form that the model can interpret. A simplified version of the Flaugherty Run watershed drainage network is shown on the Simplified Watershed Network, Figure 5-1, which is based on the Major Basins Map, Figure 4-1. Figure 5-1 shows the upper Flaugherty Run basin ("1") and the Boggs Run basin ("2") meeting at basin "3", where the flows are added. The combined flows are then passed through the lower Flaugherty Run basin ("4"). The Spring Run basin ("5") combines with the lower Flaugherty Run basin at basin "6", which discharges to the Ohio River.





REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

GAI DRAWING NO. 1503B017.DGN

FIGURE 5-1

SIMPLIFIED WATERSHED NETWORK

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

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An initial drainage network was formulated following the municipal start-up meetings, based on the stream drainage. Revisions were subsequently made to the network to reflect the information collected, including the existing and the proposed and approved SWM facilities, flood damage areas, and obstructions.

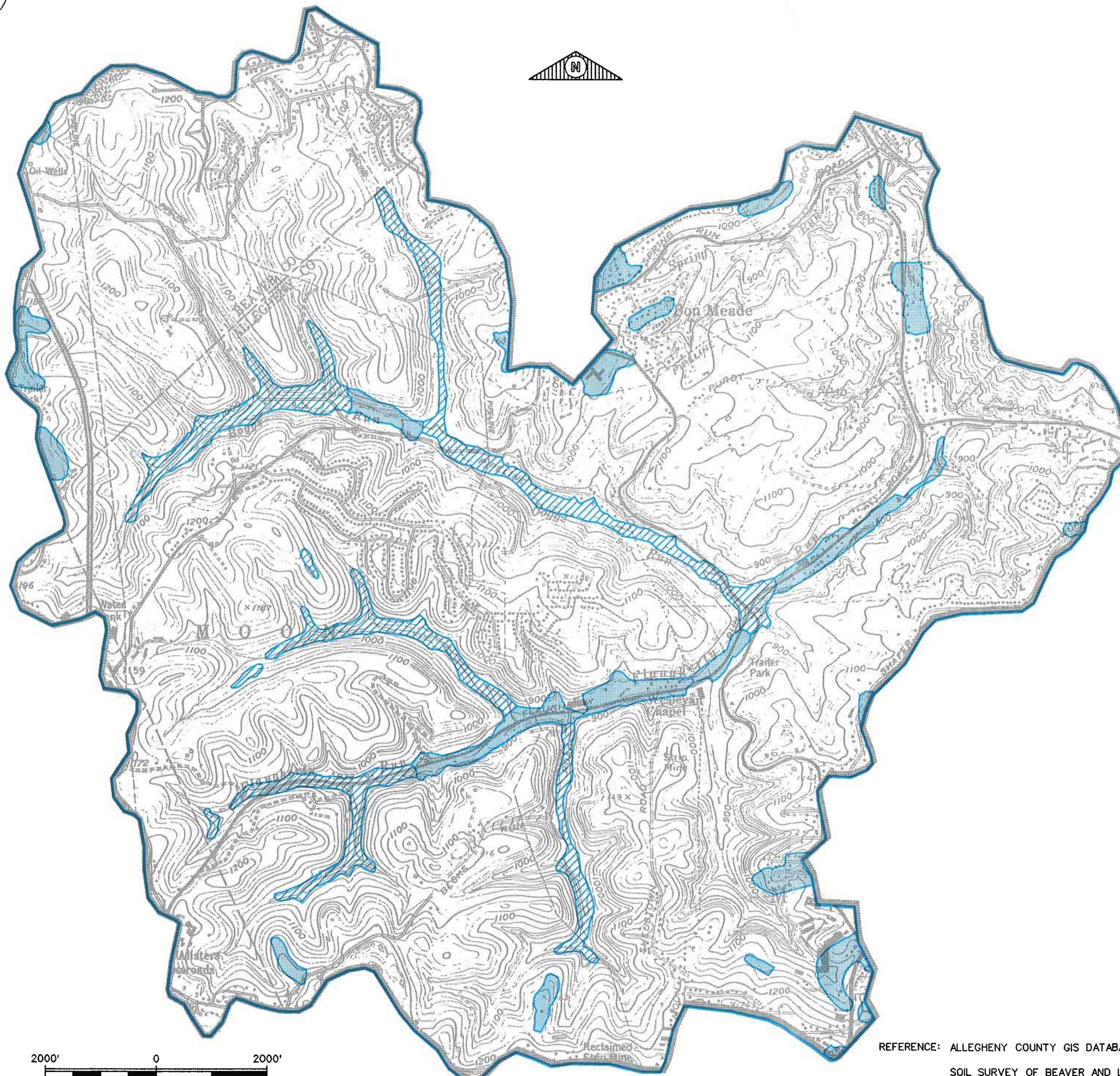
Land Use Data. The Allegheny County GIS database was accessed to obtain recent (1992) land use data. This data was classified to one of 14 land use categories for each basin in the drainage network. The USGS topographic quadrangles were used to determine land uses in the Beaver County portion of the watershed. This data was used with information on the soils and the impervious surface fraction to determine the runoff characteristics of the land.

Soils and Hydrologic Soil Groups. Soils information was obtained from the Allegheny County GIS and the Soil Surveys for Allegheny County and Beaver County (References 1 and 2). The soil types were correlated with the Hydrologic Soil Group (HSG, Reference 19), which describes the minimum infiltration capacity of the soil. The majority (greater than 60 percent) of the watershed is comprised of soils classified as HSG "C", which have low infiltration rates and a moderately high runoff potential when thoroughly wetted (see the Hydrologic Soil Groups Map, Figure 5-2). The remainder of the watershed is characterized by HSG "B" soils on the ridges (10 percent), and HSG "D" soils in the stream valleys (30 percent).

Impervious Fraction. The impervious fraction refers to that portion of the "developed" watershed that is covered by impervious surface (paving, buildings, ...). The "developed" portion of the watershed is defined here as all land uses which contain impervious surfaces. Developed areas, therefore, include residential, commercial, and industrial areas, transportation corridors, and water bodies. The percent impervious fraction typically associated with these land uses, and shown in Table 5.1, was obtained from the SCS TR-55 (Reference 19). The importance of the impervious fraction lies in the modelling procedures used in the PSRM, in which runoff from "pervious" and "impervious" areas is computed separately (Reference 20).

Antecedent Moisture Condition. This parameter describes the moisture conditions of the soils prior to the storm event. Antecedent Moisture Condition (AMC) II was adopted for use in this study. AMC II is correlated to an average value for annual floods, and has soil moisture conditions reflective of between 0.5-1.1 inches of rainfall occurring in a 5-day period preceding the storm during the dormant season, and 1.4-2.1 inches of rainfall for the same period during the growing season (Reference 21, Schwab, et al., p. 106).

Hydrologic Condition. The hydrologic condition is an indication of the quality of the land cover, and is usually associated with vegetative land covers. Good hydrologic conditions imply dense, well-established stands of vegetation and ground cover, including vegetative litter. Poor hydrologic conditions would be characterized by scattered patches of vegetation and/or no vegetative litter. Factors used to estimate the hydrologic condition are canopy density, density and quality of vegetative ground cover, amount of vegetative litter, seasonality of the vegetation, vegetative layers (presence of trees, brush, grasses), and surface roughness. The hydrologic conditions were evaluated during the site visits for



LEGEND

HYDROLOGIC SOIL GROUPS (HSG)

- HSG "A"
- HSG "B"
- HSG "C"
- HSG "D"

2000' 0 2000'

SCALE: 1" = 2000'

REFERENCE: ALLEGHENY COUNTY GIS DATABASE

SOIL SURVEY OF BEAVER AND LAWRENCE COUNTIES, PENNSYLVANIA-APRIL 1982, SHEETS 85 & 89

FIGURE 5-2

HYDROLOGIC SOIL GROUPS MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

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Table 5.1

IMPERVIOUS FRACTION AND HYDROLOGIC CONDITION BY LAND USE

Land Use	Impervious Fraction (%)	Hydrologic Condition
Water	100	N/A
Transportation	85	N/A
Forest	0	Good
Grassland/Open Space	0	Good
Agricultural/Pasture	0	Good
Low Density Residential	20	N/A
Medium Density Residential	30	N/A
High Density Residential	65	N/A
Malls	85	N/A
Commercial	85	N/A
Industrial	72	N/A
Heavy Industrial	72	N/A
Strip Mine	0	N/A
Non-Vegetated	0	N/A

N/A - Not Applicable

the major stream basins. For the purposes of this study, good hydrologic conditions were determined to exist throughout the watershed, although lower levels may be found at specific locations.

SCS Curve Number. The Curve Number (CN) is a quantitative description of the average runoff condition of an area, given the land use, hydrologic condition or quality of the land use, hydrologic soil group, antecedent moisture condition, and the impervious fraction. The CN can vary from a value of 0 (no runoff, all infiltration) to 100 (all runoff, no infiltration), but the usual range is 60 to 98. The PSRM computes runoff from pervious areas and from impervious areas separately. Therefore, a CN applicable to each condition was estimated. A curve number of 95 is assigned to all impervious areas in both the existing and the projected future conditions modelling. For the Flaugherty Run watershed, the CN varied from 70 for wooded areas in good hydrologic conditions to 98 for completely paved areas. A summary of the CNs by land use is given in Table 5.2.

Table 5.2

CURVE NUMBER BY LAND USE

Land Use	Curve Number
Water	100
Transportation	98
Forest	70
Grassland/Open Space	73
Agricultural/Pasture	78
Low Density Residential	79
Medium Density Residential	81
High Density Residential	90
Malls	96
Commercial	94
Industrial	91
Heavy Industrial	91
Strip Mine	91
Non-Vegetated	91

A decrease in the curve number occasionally occurs under projected future conditions compared to the existing conditions. This decrease is due to the projected development occurring in the more natural (woods and meadows) areas of the basins. The impervious fraction of these basins may also increase significantly.

Design Storm Parameters. Six design storms were selected to evaluate the range of floods for the stormwater modelling. The storms analyzed were the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year. These storms cover a wide range of potential flood conditions, ranging from an approximate "channel flowing-full" condition (2-year storm) to the regulatory flood plain management criterion (100-year storm). Design storm conditions for these events have been established by the Soil Conservation Service (SCS, now the Natural Resources Conservation Service), with the SCS Type II, 24-hour storm applicable to southwestern Pennsylvania. This storm type is commonly used in engineering practice for stormwater analyses and design, and the 24-hour duration is the standard for most of the hydrologic software packages in use. The precipitation amounts associated with these storms are presented in Table 5.3. These precipitation values are also consistent with those contained in the current Moon Township and Findlay Township

Table 5.3

DESIGN STORM PRECIPITATION

Return Period	24-Hour Rainfall (inches)
2-Year	2.6
5-Year	3.3
10-Year	3.8
25-Year	4.4
50-Year	4.7
100-Year	5.0

stormwater ordinances. More recent precipitation data has been developed by the PaDEP (Reference 22) with values differing slightly from the values presented in Table 5.3. For consistency with existing township stormwater management plans, however, the values in Table 5.3 were used in performing the stormwater management analyses in this plan.

Hydraulic Data and Analyses. The capacities of the various stream channels, culverts, and bridges to convey storm flows were estimated using representative stream cross sections obtained during the obstruction surveys. Manning's equation was used to estimate flow capacities of the channels. The Federal Highway Administration's "Hydraulic Design of Highway Culverts" (Reference 23) was used to estimate the hydraulic capacities of the obstructions, which are presented in Appendix B. In general, the flow capacities of the obstructions were significantly less than the flow capacities of the stream channels. Table 5.4 presents a summary of the representative flow capabilities at selected locations in the watershed.

Table 5.4

STREAM CHANNEL CAPACITIES

Channel Description	Bank Full Capacity cubic feet per second (cfs)
Flaugherty Run - Downstream of Boggs Run	950
Flaugherty Run - Upstream of Becks Run	800
Becks Run - Near Confluence with Flaugherty Run	350
Boggs Run - Near Confluence with Flaugherty Run	800
Boggs Run - 8000 Feet Upstream of Flaugherty Run	250
Spring Run - Near Confluence with Flaugherty Run	500

6.0 PSRM MODELLING

Introduction

The PSRM hydrologic models for the Flaugherty Run watershed under existing conditions and under projected future conditions were developed incorporating the foregoing data and analyses, and the six design storm events were modelled. For each basin, the models predicted the generation and the movement of the runoff flows downstream.

Existing Condition PSRM

Table 6.1 presents the results of the PSRM calculations under existing conditions. The peak runoff flows from the individual basins are presented in Table 6.1 under the heading "Basin." This heading allows for the comparison of the relative flows occurring in the basins. From the tables, it can be seen that basins "25", "33", "39", "41", and "54" produce the greatest runoff flows. In general, due to the relative homogeneity of the watershed, the flows are fairly proportional to basin drainage area. The computed ranges of runoff flows/drainage area for the six design storm events are shown in Table 6.2 for selected basins. The effects of urbanization on runoff flows can be seen in basin 60, which contains the village of Glenwillard. The values of peak flow/area in basin 60 are several times greater than the values for the other basins.

Table 6.1 also presents the cumulative peak flows at the outlet of selected basins (column heading "Total"). For example, the total peak flow shown for Basin "2" is computed as the greatest sum of the runoff flow from Basin "2" plus the upstream flow from Basin "1". As one moves downstream in the watershed, the runoff hydrographs of more basins would contribute to the cumulative flow. Thus, at Basin "60", the most downstream basin, all 59 upstream basins plus Basin "60" contribute to the total flow. The amount of flow that an upstream basin would actually contribute to the peak flow of a downstream basin's total flow hydrograph is dependent upon the timing of the individual basin and total flow hydrographs and the travel time between the basins. Flow from an upstream basin takes a certain period of time to travel to the downstream basin. Depending upon the length of this travel time, the flow from an upstream basin may occur at the beginning, the middle, or at the end of the total flow hydrograph at the downstream basin. This is shown pictorially on Figure 6-1 for a hypothetical watershed. Basins "A" and "D" in Figure 6-1 contribute very little to the total peak flow: Basin "A" because its peak flow occurs well before the time of the total peak flow, and Basin "D" because its peak flow arrives well past the total peak flow. Only Basins "B" and "C" would contribute significantly to the total peak flow. In the Flaugherty Run watershed, the individual runoff hydrographs for most of the basins, especially in the upper Flaugherty Run and Boggs Run watersheds, were determined to have significant overlap; i.e., to most closely resemble Basins "B" and "C". This finding is attributed primarily to the small size and compact shape of the watershed. The Spring Run watershed, on the other hand, would correspond to Basin "A". This can be seen on Figure 4-2, the Runoff Impact Map.

Table 6.1

EXISTING CONDITIONS - PEAK RUNOFF FLOWS
AND TOTAL FLOWS FROM THE INDIVIDUAL BASINS
(cubic feet per second)

	Storm											
	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
Basin	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total
1	13	13	28	28	42	42	60	60	70	70	80	80
2	33	44	77	101	119	156	178	233	211	275	245	319
3	34	34	75	75	114	114	170	170	200	200	232	232
4	7	7	18	18	28	28	42	42	50	50	58	58
5	0	41	1	93	1	142	1	211	2	250	2	290
6	5	45	11	101	18	152	26	228	31	269	37	309
7	0	88	1	199	1	297	1	425	2	496	2	566
8	27	14	46	19	62	28	83	45	93	53	104	60
9	15	114	37	247	59	368	92	527	110	609	129	690
10	26	19	46	27	64	38	87	55	100	75	113	95
11	38	38	71	71	100	100	141	141	162	162	185	185
12	0	55	1	95	1	130	1	186	2	219	2	267
13	21	72	45	133	68	182	100	254	118	291	138	343
14	26	26	51	51	76	76	110	110	129	129	148	148
15	0	96	1	182	1	244	1	324	2	367	2	421
16	27	115	56	224	84	304	124	395	146	446	170	498
17	0	226	1	467	1	666	1	919	2	1048	2	1179
18	17	235	32	488	46	688	67	944	79	1082	91	1215
19	48	48	87	87	122	122	173	173	200	200	230	230
20	18	18	43	43	67	67	101	101	120	120	140	140
21	0	63	1	124	1	183	1	268	2	314	2	363
22	29	89	73	184	117	264	181	368	217	427	255	481
23	0	317	1	663	1	942	1	1311	2	1499	2	1677
24	39	334	67	669	94	987	134	1364	156	1562	180	1748
25	81	81	127	127	169	169	230	230	264	264	300	300
26	16	94	41	157	67	216	106	291	129	340	153	371
27	0	383	1	753	1	1005	1	1387	2	1587	2	1792
28	26	415	62	862	97	1199	146	1657	173	1889	202	2128
29	49	49	100	100	149	149	218	218	257	257	297	297
30	22	22	53	53	84	84	129	129	154	154	180	180
31	0	71	1	153	1	232	1	345	2	409	2	476
32	6	74	14	158	22	248	33	356	39	424	45	495

Table 6.1 (Continued)

	Storm											
	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
Basin	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total
33	42	42	106	106	170	170	264	264	317	317	372	372
34	0	115	1	255	1	391	1	565	2	665	2	769
35	4	117	11	264	17	402	27	581	32	681	37	788
36	42	42	85	85	128	128	190	190	224	224	261	261
37	0	149	1	330	1	495	1	713	2	831	2	954
38	26	165	49	361	71	536	103	771	121	896	139	1027
39	103	103	184	184	261	261	371	371	432	432	497	497
40	0	235	1	485	1	707	1	1008	2	1173	2	1347
41	37	267	88	556	140	808	216	1153	259	1342	306	1540
42	30	287	61	596	92	861	138	1225	163	1425	191	1635
43	0	699	1	1451	1	2042	1	2822	2	3222	2	3630
44	24	712	47	1475	69	2072	101	2859	118	3261	137	3671
45	9	7	17	15	24	22	34	30	39	31	44	33
46	38	741	81	1524	123	2134	181	2917	213	3336	247	3751
47	39	39	71	71	101	101	144	144	168	168	193	193
48	0	753	1	1543	1	2154	1	2956	2	3367	2	3779
49	7	3	11	6	15	13	19	18	21	20	23	22
50	13	12	21	19	27	26	36	34	41	39	46	43
51	0	14	1	25	1	38	1	52	2	58	2	65
52	9	2	15	2	19	2	26	2	29	3	32	3
53	0	15	1	27	1	39	1	54	2	61	2	68
54	68	803	144	1620	217	2244	318	3052	373	3477	433	3890
55	9	5	15	8	20	12	26	17	30	19	33	21
56	32	35	54	59	73	80	98	108	112	123	126	139
57	23	23	42	42	60	60	85	85	99	99	114	114
58	0	57	1	98	1	136	1	188	2	215	2	243
59	29	79	60	149	91	208	136	288	161	332	188	377
60	26	846	42	1683	54	2318	69	3135	77	3562	84	3995

Evaluation of the information presented in Table 6.1 allows for predicting the relative significance of an upstream basin to a downstream basin. Table 6.3 presents, for selected locations, a comparison of the Table 6.1 total peak flows (predicted by PSRM) with a "peak" flow obtained by a direct addition of the peak flows applicable to each basin. The differences in flow is due to the difference in timing between the runoff hydrographs from the contributing basins.

Table 6.2

SUMMARY OF PEAK RUNOFF FLOWS/AREA RATIOS
EXISTING CONDITIONS
(cubic feet per second per acre)

	Storm					
Basin	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
2	0.2	0.4	0.6	0.9	1.1	1.3
13	0.2	0.4	0.6	0.9	1.1	1.3
18	0.3	0.4	0.8	1.1	1.2	1.4
22	0.1	0.3	0.5	0.8	1.0	1.1
28	0.2	0.4	0.6	0.9	1.1	1.2
29	0.2	0.4	0.6	0.9	1.0	1.2
33	0.1	0.3	0.5	0.8	0.9	1.1
39	0.2	0.4	0.6	0.9	1.1	1.2
42	0.2	0.3	0.5	0.8	0.9	1.0
54	0.2	0.4	0.7	1.0	1.1	1.3
59	0.2	0.4	0.6	0.9	1.1	1.3
60	1.0	1.3	1.6	2.3	2.6	2.6

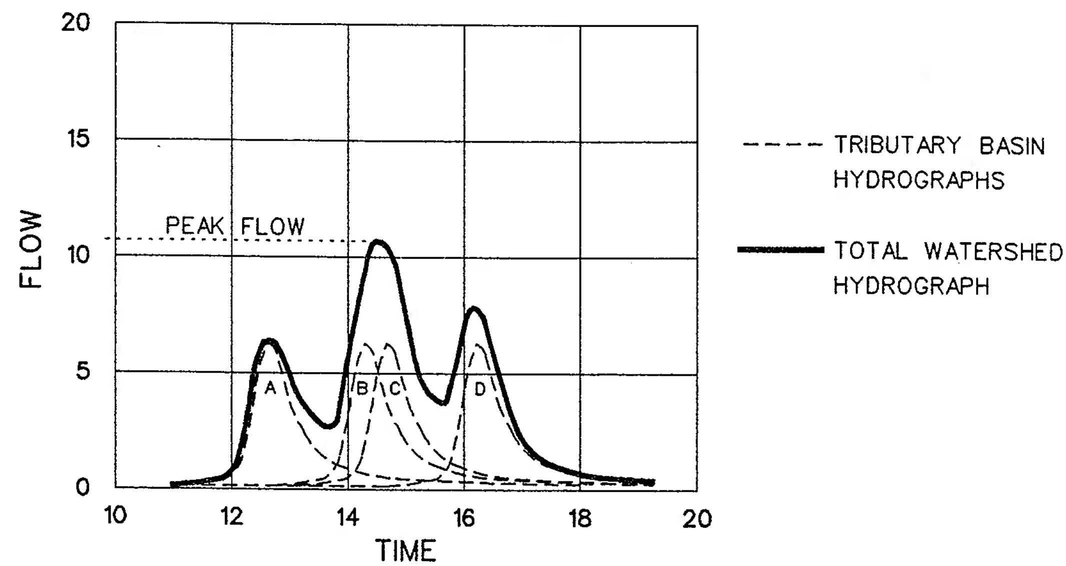
Table 6.3

SIGNIFICANCE OF TIMING - 10-YEAR STORM
EXISTING CONDITIONS AT SELECTED LOCATIONS

Basin	Predicted Total Basin Flow (cfs)	Sum of Individual Contributory Peak Flows (cfs)
Upper Flaugherty Run	987	1220
Boggs Run	861	1134
Confluence, Upper Flaugherty Run and Boggs Run	2042	2687
Spring Run	208	243
Mouth of Flaugherty Run	2318	3557

FIGURE 6-1

EXAMPLE BASIN HYDROGRAPH



The times at which the peak flows from each upstream basin occur do not usually coincide in downstream basins. Each basin hydrograph is delayed by differing amounts, and thus the timing element is required to determine the actual contribution of upstream basin runoff flows to downstream total flows. The significance of this timing element is shown in Table 6.2. As can be seen for the 10-year storm, the PSRM-predicted actual peak flow at the mouth of Flaugherty Run is 2,318 cfs, which accounts for the different timing of the individual basin hydrographs. The total sum of the individual basin peak flows would be 3,557 cfs. Without the consideration of timing, it can be seen how a gross overestimate of the peak flows can be made.

Similarly, stormwater management without the consideration of timing can result in gross underestimates of peak flows downstream. This occurs precisely because the timing element in a stormwater management philosophy such as "no increase in peak flow from the site" is ignored. This philosophy presumes that the proportion of a downstream basin's peak flow is equal to a ratio of the individual basin peak flows.

The objective of Act 167 stormwater management is to preserve the effects of the timing in the watershed, which will help maintain existing downstream peak flows, while still allowing the generation of increased runoff volumes as would be created by development. This is the basis for the concept of release rates, which is discussed in Section 7.

Model Calibration and Validation

Limited data was available to calibrate the PSRM for existing conditions. Two methods were used to provide reasonable validation of the PSRM analyses (see Appendix F). In the first method, two high water marks, at the Flaugherty House and at a residence near Boggs Run (see Figure 4.3) were identified by residents. The specific events causing the flooding were not known, however. Therefore, the events were assigned a range of probable return periods, and corresponding flow ranges from the PSRM were determined. A flow estimate based on the hydraulic capacity of the channel and flood plain at each location was then made. The flow estimates were compared to the probable range of flows predicted by the PSRM, and reasonable agreement was obtained at each site.

The second method used empirical equations developed by the Soil Conservation Service (SCS), the U.S. Geological Survey, and the U.S. Army Corps of Engineers (USACE). The equations developed by the U.S. Army Corps of Engineers were specifically for streams in the Ohio River Basin, and use parameters different from the parameters in the PSRM. The equations were applied at three locations: the mouth of Boggs Run, Flaugherty Run just upstream of Boggs Run, and at the mouth of Flaugherty Run. The USACE and USGS equation predicted lower flows, and the SCS equations predicted higher flows than the PSRM flows. The variance in flows can be understood by the absence of a significant watershed slope or timing factor in the USACE and USGS equation. Considering all equation and methodologies, reasonable calibration of the PSRM flows was obtained.

Projected Future Conditions

The results of the PSRM Modelling under the projected future conditions are presented in Table 6.4. Column "Basin" in Table 6.4 presents the peak runoff flows for the individual basins (similar to Table 6.1), and Column "Total" presents the peak total flows for the outlet of each basin (similar to Table 6.1). Table 6.5 provides a direct comparison of the predicted flood flows between existing conditions and projected future conditions. Ratios of the total peak flows for selected basins are presented in Table 6.5. The peak flows can be seen to increase from 10% (1.1) to 60% (1.6).

It is noted that the imposition of a "no increase in peak flows from a site above existing peak flows" philosophy, as currently exists in the watershed, would also increase the peak flood flows under projected future development conditions. This occurs because:

- Development generally produces a greater volume of runoff than existing conditions, which, under the "no increase in peak flow" philosophy, is discharged from a detention facility at or near the peak flow rate for an extended period of time, and

Table 6.4

PROJECTED FUTURE CONDITIONS - PEAK RUNOFF FLOWS AND TOTAL FLOWS FROM THE INDIVIDUAL BASINS
(cubic feet per second)

	Storm											
	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
Basin	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total
1	48	48	68	68	84	84	105	105	116	116	127	127
2	78	123	194	131	179	256	246	340	282	383	320	427
3	76	76	126	126	170	170	232	232	266	266	301	301
4	25	25	40	40	53	53	70	70	79	79	88	88
5	0	99	160	1	1	212	1	285	2	327	2	370
6	8	104	168	16	24	229	34	305	39	348	45	393
7	0	219	345	1	1	447	1	581	2	651	2	725
8	41	17	29	65	84	46	109	64	122	72	135	79
9	46	261	408	75	100	533	136	698	156	782	176	870
10	26	19	27	46	64	38	87	55	100	75	113	95
11	38	38	71	71	100	100	141	141	162	162	185	185
12	0	55	95	1	1	130	1	186	2	219	2	267
13	28	77	139	53	76	183	110	254	129	291	149	342
14	26	26	51	51	76	76	110	110	129	129	148	148
15	0	101	188	1	1	247	1	323	2	366	2	420
16	29	119	228	57	84	307	123	396	145	448	169	499
17	0	377	621	1	1	832	1	1088	2	1225	2	1360
18	17	386	637	32	46	852	67	1118	79	1249	91	1389
19	85	85	131	131	170	170	224	224	253	253	283	283
20	106	106	149	149	184	184	228	228	252	252	276	276
21	0	189	273	1	1	342	1	433	2	482	2	532
22	70	214	330	122	171	414	241	535	280	598	321	655
23	0	577	937	1	1	1248	1	1635	2	1836	2	2028
24	46	592	969	77	107	1292	149	1691	172	1901	197	2100
25	92	92	142	142	188	188	252	252	287	287	325	325
26	20	106	173	46	72	234	112	330	135	353	159	400
27	0	652	1097	1	1	1478	1	1961	2	2211	2	2464
28	26	670	1128	62	97	1522	146	2013	173	2253	202	2505
29	88	88	149	149	203	203	280	280	322	322	367	367
30	47	47	83	83	118	118	166	166	193	193	221	221
31	0	132	222	1	1	310	1	435	2	503	2	575

Table 6.4 (Continued)

	Storm											
	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
Basin	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total	Basin	Total
32	6	132	234	14	22	325	33	448	39	514	45	584
33	92	92	162	162	230	230	328	328	383	383	441	441
34	0	212	353	1	1	478	1	659	2	757	2	863
35	4	210	360	11	17	491	27	678	32	780	37	886
36	75	75	126	126	172	172	238	238	274	274	312	312
37	0	270	443	1	1	601	1	823	2	947	2	1077
38	31	289	480	57	80	654	113	893	131	1024	150	1162
39	171	171	271	271	359	359	480	480	547	547	616	616
40	0	434	678	1	1	903	1	1214	2	1386	2	1568
41	51	468	753	102	154	1008	231	1363	274	1562	320	1771
42	38	487	786	68	98	1058	143	1439	168	1647	196	1864
43	0	1120	1834	1	1	2471	1	3283	2	3695	2	4104
44	24	1133	1857	47	69	2501	101	3319	118	3733	137	4146
45	9	7	15	17	24	22	34	30	39	31	44	33
46	38	1155	1907	81	123	2551	181	3376	213	3802	247	4236
47	39	39	71	71	101	101	144	144	168	168	193	193
48	0	1167	1924	1	1	2581	1	3412	2	3836	2	4256
49	7	3	6	11	15	13	19	18	21	20	23	22
50	13	12	19	21	27	26	36	34	41	39	46	43
51	0	14	25	1	1	38	1	52	2	58	2	65
52	9	2	2	15	19	2	26	2	29	3	32	3
53	0	15	27	1	1	39	1	54	2	61	2	68
54	68	1209	1999	144	217	2660	318	3509	373	3946	433	4377
55	9	5	8	15	20	12	26	17	30	19	33	21
56	32	35	59	54	73	80	98	108	112	123	126	139
57	23	23	42	42	60	60	85	85	99	99	114	114
58	0	57	98	1	1	136	1	188	2	215	2	243
59	29	79	149	60	91	208	136	288	161	332	188	377
60	26	1251	2057	42	54	2734	69	3590	77	4027	84	4476

Table 6.5

RATIO OF TOTAL PEAK FLOWS - PROJECTED FUTURE CONDITIONS TO EXISTING CONDITIONS FOR SELECTED BASINS

	Storm					
Basin	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Confluence, Upper Flaugherty Run and Boggs Run	1.6	1.3	1.2	1.2	1.1	1.1
Mouth of Flaugherty Run	1.5	1.2	1.2	1.1	1.1	1.1

- The response time of the site or basin is shortened, increasing the likelihood of coincident peak flows in downstream areas.

The shortened response time of an upstream basin can result in the peak flow from the upstream basin arriving when the downstream basin's peak runoff flow occurs. The lengthened period of time that the peak flow is maintained affects the existing timing of the watershed because there is now a greater time period during which peak flows from basins may coincide. A dramatic increase in flood flows, and consequently flood levels, at downstream areas may result. Section 7 presents a more detailed presentation of this phenomenon. For the Flaugherty Run watershed, this phenomenon has been evaluated with the projected future development operating under this philosophy. Assuming a 1-hour lengthened period centered around the existing condition peak, it is estimated that total peak flows in several basins would approach the summed contributory peak flows as are presented in Table 6.3. Consequently, it is concluded that there exists a definite benefit to implementing stormwater management in the Flaugherty Run watershed based on the watershed philosophy under Act 167.

7.0 TECHNICAL STANDARDS AND CRITERIA FOR CONTROL OF STORMWATER RUNOFF

Introduction

The development of a parcel of land is almost always accompanied by increases in runoff volumes and runoff peak flows. These increases come about due to changes in the land cover and in the drainage network. Development typically alters the land cover from one that facilitates infiltration, evaporation, transpiration, and/or surface detention, to a cover that tends to reduce these processes, and instead facilitates runoff and the collection and concentration of flows. Vegetative surfaces are replaced with paving, gravel, dirt or poorly vegetated areas, buildings, and an increased proportion of impervious surfaces. Storm inlets and piping collect and concentrate the runoff flows, directing flows to an outlet more quickly and, usually, more efficiently, than existing drainage paths. The objective of site stormwater management is to manage storm runoff flows from a development site in such a manner as to prevent flooding or flood-related problems at the site. Stormwater management under Act 167 extends the consideration of potential flooding to locations downstream of the site.

Stormwater Management

There are several philosophies on the management of stormwater. These range from the complete absence of management, to various policies of managing runoff flows and volumes. The adverse ramifications of the "no stormwater management" philosophy is demonstrated in Figures 7-1 through 7-4. Figure 7-1 shows the situation resulting from a development in Basin "A" without any stormwater management (SWM) controls. The increase in the runoff volume manifests itself as an increase in the peak flow from the development, and as a more rapid response (time for the peak flow to occur). Figure 7-2 shows how the hydrograph from Basin "A" would appear at a downstream location "B" before the development. Figure 7-3 shows the effect of the hydrograph from the developed site at the same downstream location. As can be seen, the absence of any SWM controls greatly increases the peak flow seen at the downstream location. The increased flow causes increased flood levels, and flood damages result.

Site-Oriented Stormwater Management

The site-specific "no increase from pre-development peak flows" philosophy of SWM is the most common form found in non-Act 167 watersheds. The increased runoff volume can be discharged from the site over an extended period of time at a rate of up to, but not exceeding, the pre-development peak flow for a specified set of design storms. No consideration is given to the impact of these flows beyond the boundaries of the site. The consequences of this type of SWM controls are shown on Figures 7-4 and 7-5. The increase in runoff volume and the shortened response time occasioned by the development causes an extended period during which, at the outlet of the site, the peak flow is maintained (see Figure 7-4 for Basin "A"). In the pre-development condition, the

FIGURE 7-1

HYDROGRAPHS @ "A"
PRE- & POST-DEVELOPMENT: NO SWM CONTROLS

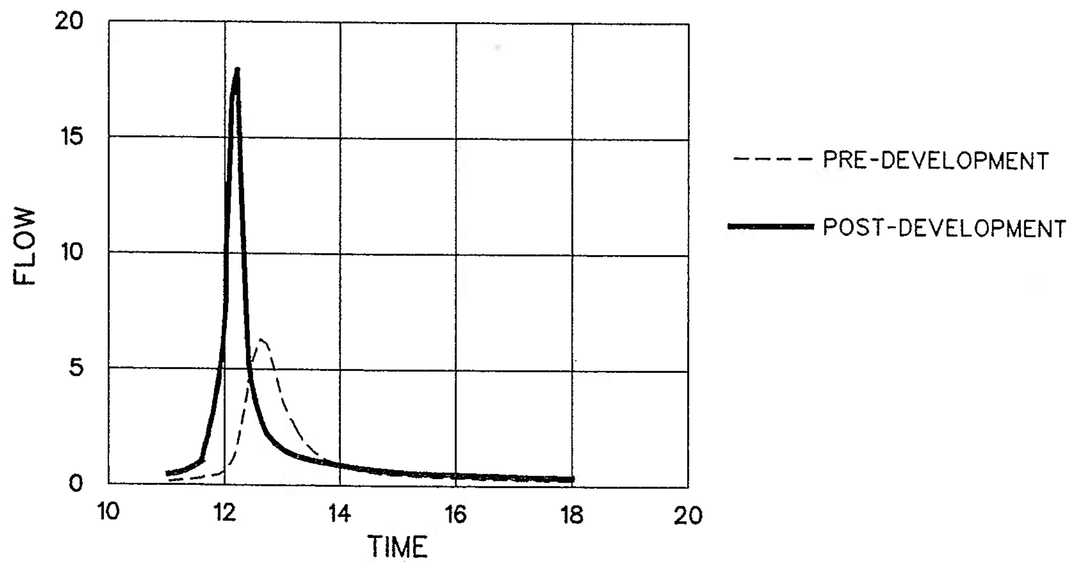


FIGURE 7-2

HYDROGRAPHS @ "B"
PRE-DEVELOPMENT

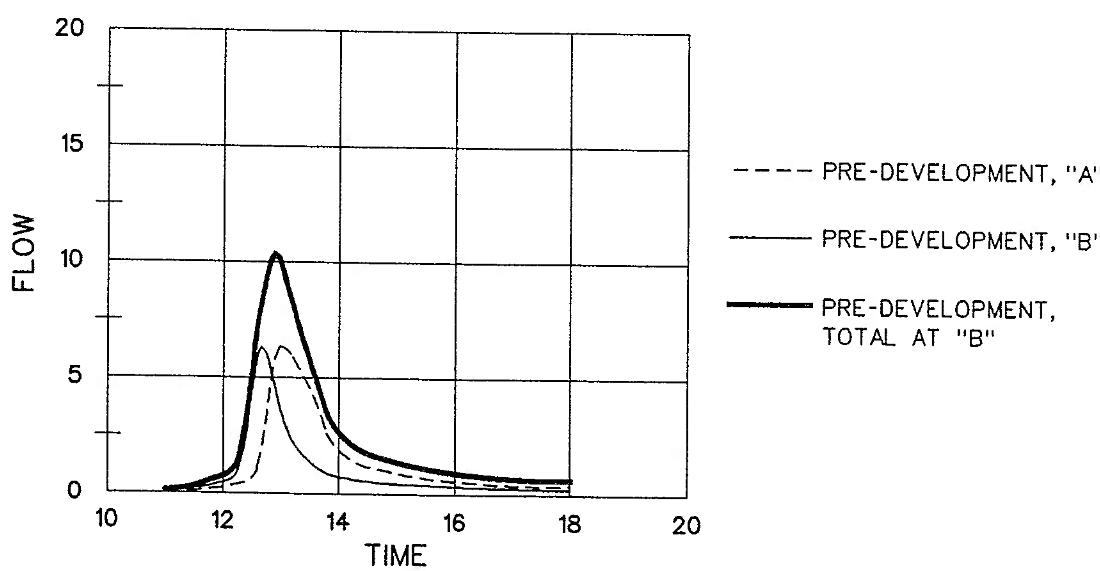


FIGURE 7-3

HYDROGRAPHS @ "B"
POST-DEVELOPMENT: NO SWM CONTROLS

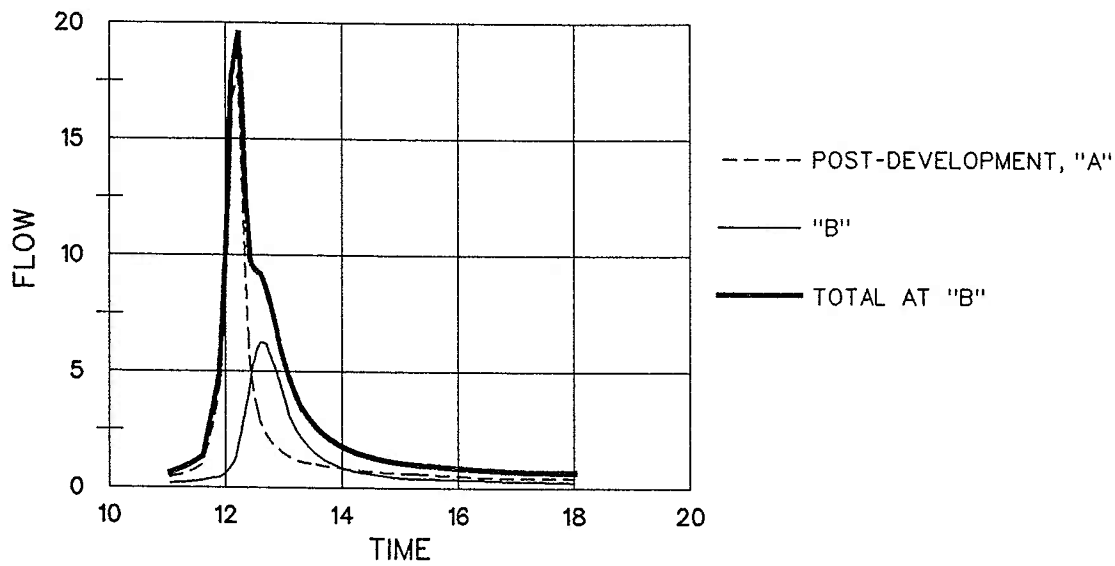


FIGURE 7-4

HYDROGRAPHS @ "A"
POST-DEVELOPMENT, WITH & WITHOUT SWM

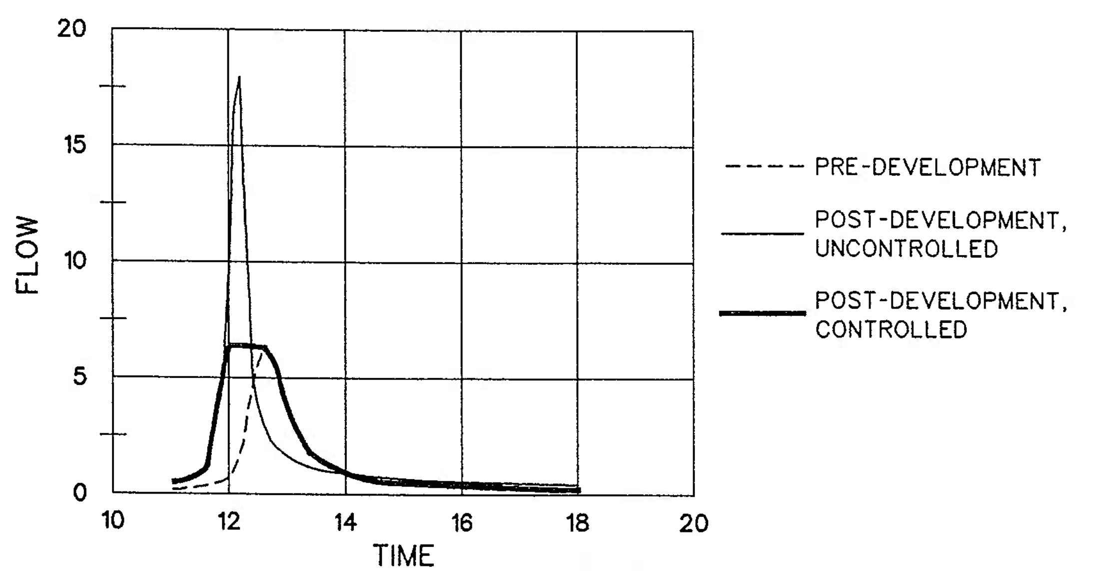
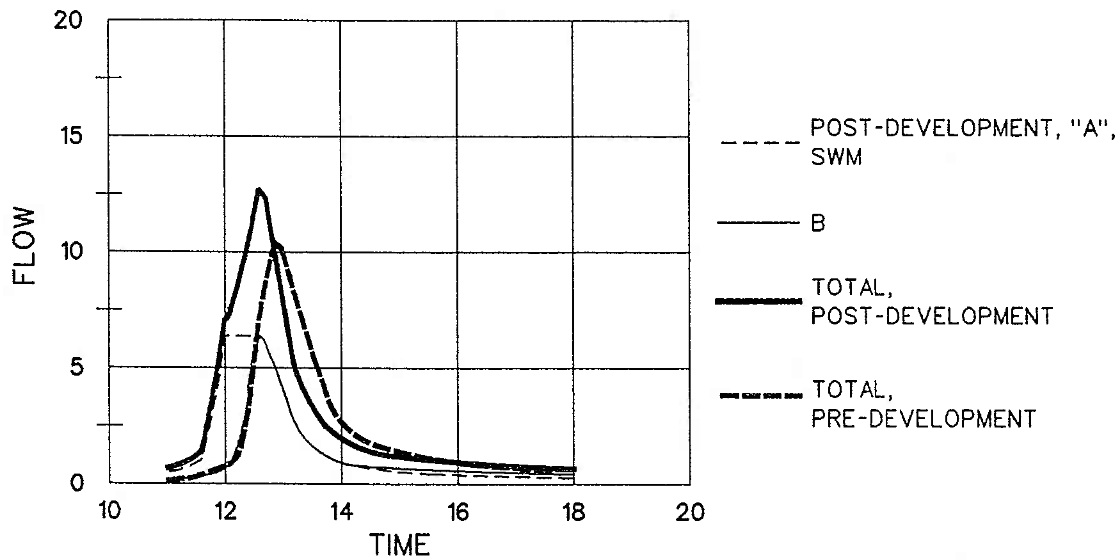


FIGURE 7-5

HYDROGRAPHS @ "B"
POST-DEVELOPMENT, WITH SWM



time at which the Basin "A" peak flow occurred in Basin "B" is after the Basin "B" peak flow. Under the post-development condition, however, the shortened response time of Basin "A" causes the peak flow to occur at nearly the same time as the Basin "B" peak flow. As a result, the total peak at the downstream location in Basin "B" is increased as shown in Figure 7-5. This SWM philosophy is, therefore, inappropriate toward preventing an increase in flood damages in downstream areas. Site-oriented stormwater management can worsen flood conditions at downstream locations. The objective, therefore, is to develop SWM controls that manage both the rate of flow and its timing, to prevent an increase in downstream flows.

Watershed-Oriented Stormwater Management

A more appropriate stormwater management philosophy would take into account the time differences of the individual runoff hydrographs that currently exist in the watershed. This can be accomplished by determining the proportion of flow that each upstream basin contributes to the total peak flow of a downstream basin. This can be visualized by plotting, for a selected location, the total flow hydrograph and its individual component basin hydrographs on a single plot. The sum of the individual hydrographs will give the total flow hydrograph. At the time at which the peak flow of the total hydrograph occurs, the corresponding individual basin flows can be read off the plot. These flows would be the runoff contribution of each upstream basin to the total peak at that downstream location. These flow contributions would be no greater, and would likely be less than the individual basin peak flows. Figure 7-2 can be used to obtain the Basin "A" flow contribution to the peak flow at "B." From Figure 7-2, the Basin "A" flow contribution to the total peak flow at Basin "B" is approximately 5.5. Dividing each basin's flow contribution to a downstream location by that basin's peak runoff flow would yield the proportion of that basin's peak flow which would maintain a no-increase in total peak flow at the downstream location. The proportion of flow calculated for each basin is commonly termed that basin's "Release Rate."

Mathematically, the Release Rate can be expressed as:

$$RR = \frac{Qi \ @ \ t = Tp}{Qpi} \times 100\%$$

where			
	RR	=	Release Rate
	Qi	=	Runoff flow from an upstream Basin "i"
	Qi@t = Tp	=	Qi corresponding to the time at which the total peak flow occurs at a downstream location
	Qpi	=	Peak runoff flow from Basin "i"

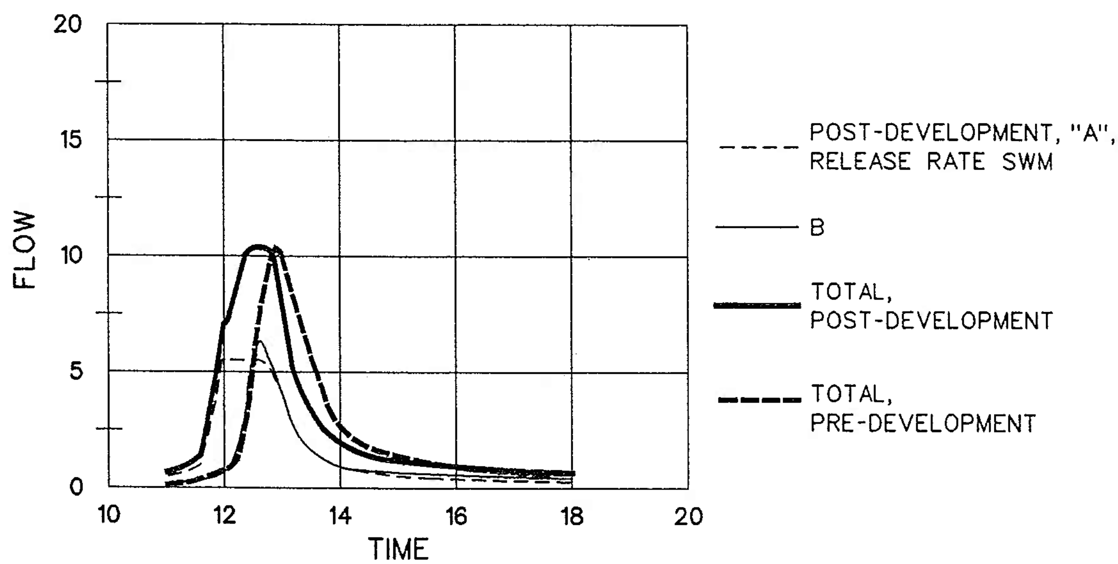
Dividing the Basin "A" flow contribution of 5.5 by the Basin "A" peak flow of 6.4 (from Figure 7-1) yields a Release Rate of 0.86, or 86 percent.

The Release Rate is, therefore, a percentage of the pre-development peak runoff flow from a basin, or a development site. The Release Rates determined by this study would allow computation of the maximum discharge flow from that basin or site which achieves the intent of Act 167 -- no increase in downstream flooding. In effect, the release rate increases the time period during which the excess runoff volume is discharged from a site. The increased runoff volume created by the land development is managed by controlling its rate of release from the development. The duration of the total peak flow at the downstream location may be lengthened, but the peak flow would not increase. This is indicated in Figure 7-6, which shows the total flow hydrographs at the downstream location under pre-development and post-development conditions. It is noted that an increase in the length of the total peak flow duration may cause increased flood or flood-related problems, and, therefore, this may also require investigation. These types of flood-related problems are generally beyond the purview of a site developer, however.

Each basin has a release rate for every downstream basin. Therefore, the approach just described would be repeated for every downstream basin. At some point, however, the contribution of an upstream basin to the total peak flow of a downstream basin becomes insignificant. The most upstream basin, for example, contributes only 3 percent (77 cubic feet per second, cfs) of the total 10-year storm peak flow of 2318 cfs at the mouth of Flaugherty Run. Imposing a release rate on the upstream basin based solely on the impacts at the mouth is unreasonable, since the former contributes so little to the latter's total peak flow. Therefore, a minimum flow level is generally established, based on the ratio of a basin's runoff flow contribution to a downstream area's total peak flow, below which the basin's runoff is considered to have an insignificant effect on the downstream

FIGURE 7-6

HYDROGRAPHS @ "B"
POST-DEVELOPMENT HYDROGRAPH - RELEASE RATE METHOD



basin. An investigation was, therefore, made to evaluate the computed release rates, taking into account the contributions of the basin to the peak flow downstream.

<u>Procedure to Develop Release Rates</u>

A multi-step procedure was used to develop the Release Rates for the Flaugherty Run watershed. The procedure consisted of a basin analysis, utilizing the basins in the PSRM, and leading to a regional analysis, utilizing collections of basins, or regions. In the first step, the release rate of each basin was calculated at every downstream basin for the 10-year and 100-year storms. The 10-year storm was selected to represent the level of storm at which significant flood plain flows may be expected to occur, and the 100-year storm was used for consistency with flood plain management criteria. The portion of each basin's flow contribution to every downstream basin's total peak flow was then computed.

Upon inspection of the computed results, a 10 percent contribution level was judged to be a reasonable lower limit to establish the appropriate release rates. In other words, where a basin's flow contribution to the downstream total peak flow was less than 10 percent, a release rate computation was not used. The reasons for this judgment are:

- It was noted that in several cases, the release rate did not significantly change beyond a certain downstream point. This indicates that an upstream basin may establish its timing position in the total watershed hydrograph at a point well upstream of the watershed outlet.

- In the majority of the remaining cases, the timing of the upstream basin placed its flow hydrograph either well before or well after the total watershed hydrograph. This would correspond to hydrographs "A" and "D" in Figure 6-1. The computed release rates were extremely low, 50 percent or less. (In previous Act 167 studies [References 24 and 25], a 50 percent release rate level was found to be a reasonable lower limit for release rates.)

- The 10 percent flow contribution was considered a sufficiently low level as to result in minimal impacts.

Therefore, where the proportion of the upstream basin's flow contribution to the downstream total peak flow was less than 10 percent, the release rate calculation was neglected. The minimum of the remaining computed release rates of each basin for each storm was then adopted to be evaluated in the second step.

<u>Basin Analysis for SWM Using Release Rates</u>

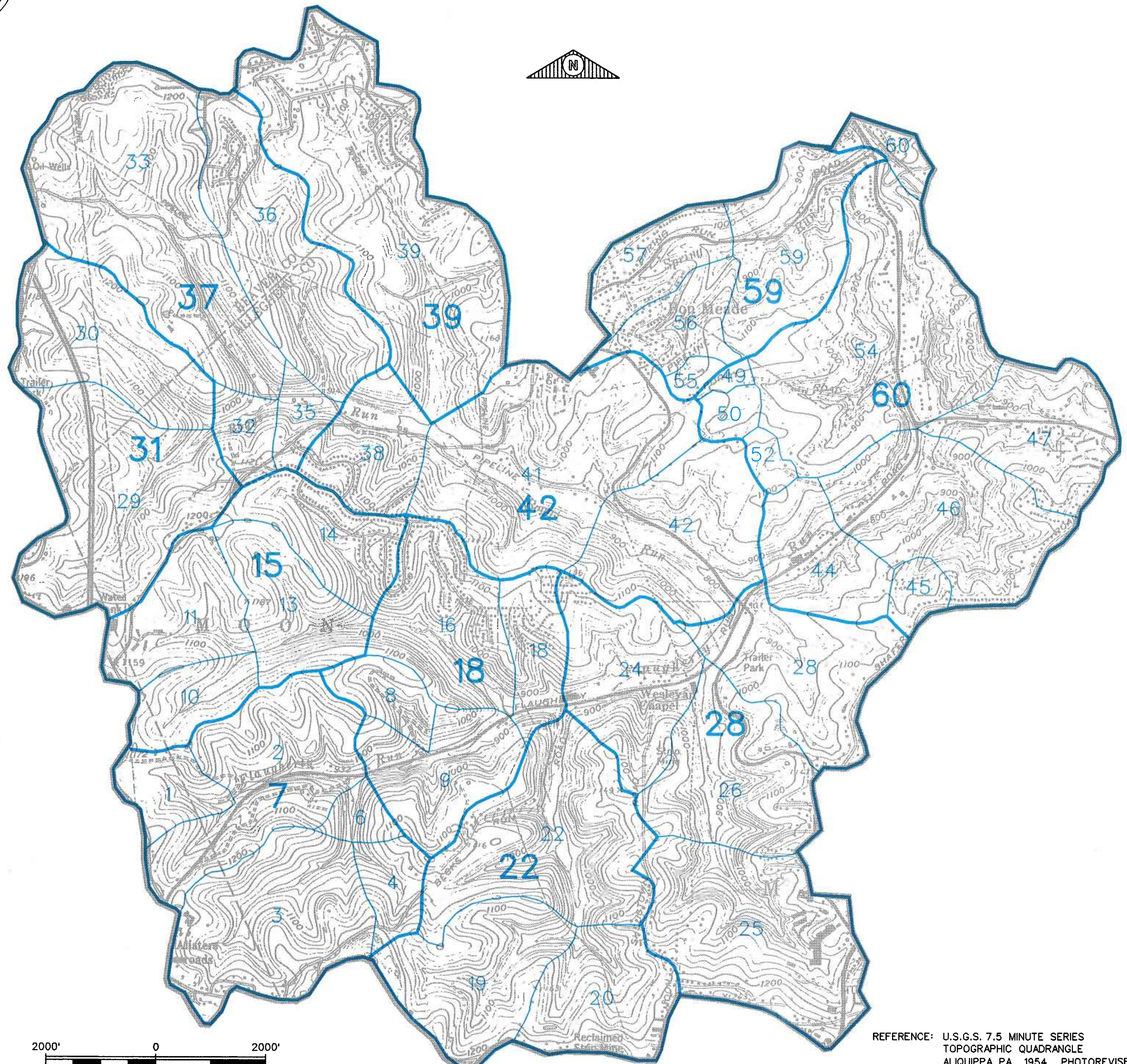
The lower of the two release rates presented for the individual basins would be the basin release rate. Release rates computed for a basin whose flow contribution to a downstream peak flow is less than 10 percent were assigned a Release Rate of 100.

<u>Regional Analysis for SWM Using Release Rates</u>

Upon inspection of the results of the basin analysis, it was noted that some disparities existed, and low release rates were still computed for several basins. It was also noted that a simpler plan would result if the basins could be combined, so as to reduce the number of basins to consider. A regional analysis was then performed to minimize the disparities and low release rates. Collections of basins, called "regions," were set up based on the watershed's drainage network, with each region producing approximately 10 percent of the total peak flow at the Ohio River. The regions are shown on Figure 7-7, and are identified by the most downstream basin in each region.

Following the same computational procedure used in the first step, except with the region flows instead of the basin flows, the release rates were recalculated. A summary of the regionalized release rates is presented in Table 7.1. Included in Table 7.1 are the ranges of release rates for the individual basins comprising each regional basin. Some discrepancies may be noted due to the lumping of individual basins in the regions, in which the basins have differing timing characteristics.

Table 7.2 presents the results of the initial step of this regional analysis. The release rates for the 10-year and 100-year storm events are based on the values presented in Table 7.1, using a composite of the regional values and the individual basin ranges for the regions. The regional release rate from Table 7.1 is presented where it is



2000' 0 2000'

SCALE: 1" = 2000'

REGION	INDIVIDUAL BASINS
7	1, 2, 3, 4, 5, 6, 7
15	10, 11, 12, 13, 14, 15
18	8, 9, 16, 17, 18
22	19, 20, 21, 22
28	24, 25, 26, 27, 28
31	29, 30, 31
37	32, 33, 34, 35, 36, 37
39	39
42	38, 40, 41, 42
59	55, 56, 57, 58, 59
60	43-54, 60

LEGEND

REGION BOUNDARY

60 REGION IDENTIFICATION NUMBER

WATERSHED BOUNDARY

REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

FIGURE 7-7

REGION DELINEATION MAP

FLAUGHERTY RUN
WATERSHED
STORMWATER
MANAGEMENT PLAN

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GAI DRAWING NO. 1503B018.DGN

Table 7.1

SUMMARY OF REGIONALIZED RELEASE RATES (release rates in percent)

	Release Rates		Comparison to Release Rates for the Individual Basins	
Region	10-Year	100-Year	10-Year	100-Year
7	90	95	83 - 88	78 - 100
15	93	96	78 - 84	59 - 68
18	68	52	73 - 100	57 - 100
22	92	94	72 - 96	51 - 99
28	88	90	79 - 100	56 - 100
31	56	39	71 - 95	52 - 79
37	88	83	74 - 100	70 - 100
39	71	78	69	69
42	80	69	67 - 100	56 - 100
59	95	95	82 - 95	72 - 95
60*	100	100	100	100

* This region contributes less than 10 percent to the total peak flow and, therefore, was assigned a Regionalized Release Rate of 100.

Table 7.2

INITIAL EVALUATION OF REGIONAL RELEASE RATES

	Release Rate		
Region	10-Year (percent)	100-Year (percent)	Initial Release Rate Estimate (percent)
7	88	95	88
15	84	68	68
18	73	57	57
22	92	94	92
28	88	90	88
31	71	52	52
37	88	83	83
39	71	78	71
42	80	69	69
59	95	95	95
60	100	100	100

within the range of the individual release rates. Where the regional release rate lies outside the range of the individual basin release rates, the appropriate upper or lower value of the range is presented. The "Initial Release Rate Estimate" values are the lesser of the 10-year and 100-year release rates.

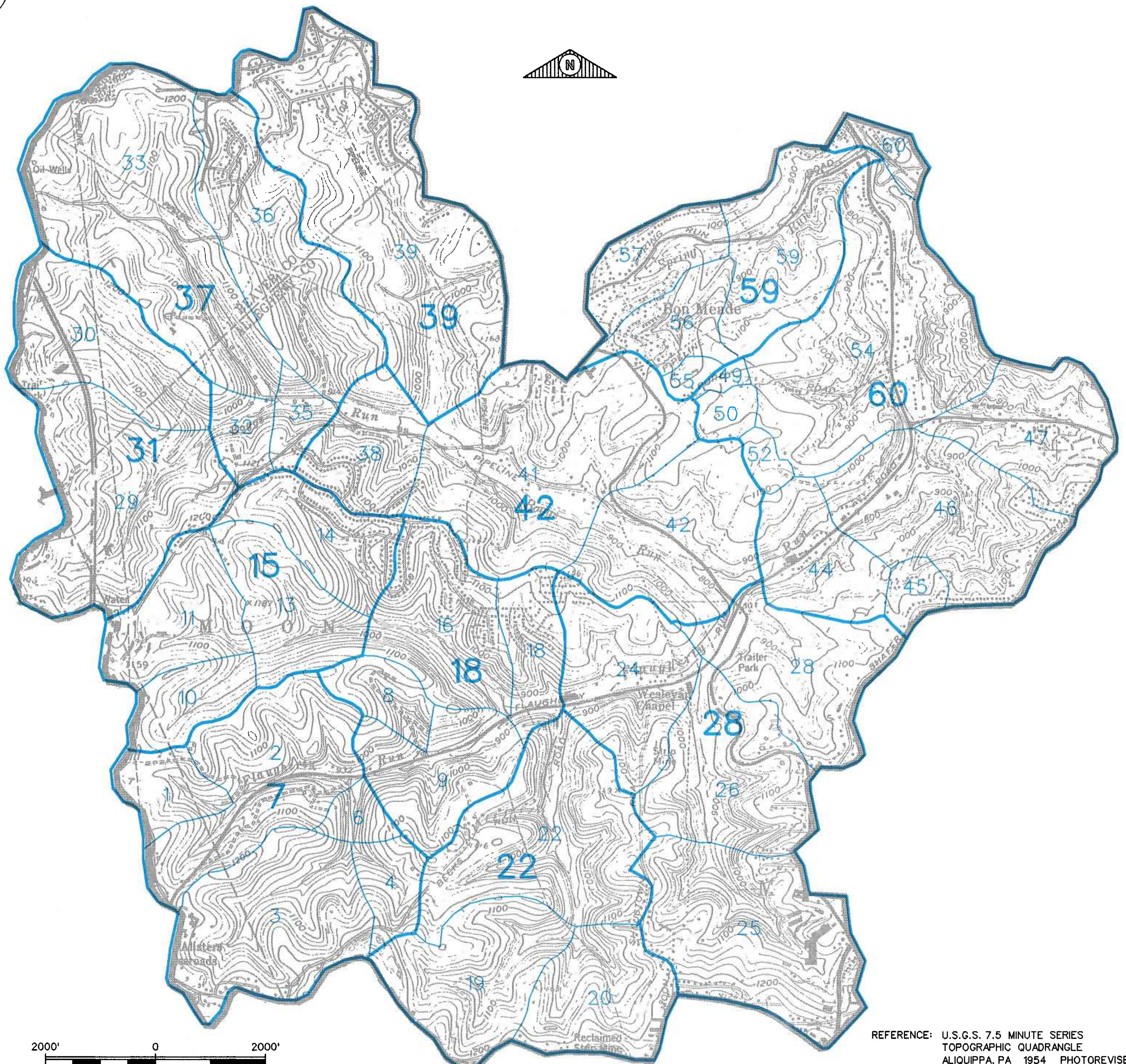
Regions 18 and 31 were noted to have relatively low release rates. It was also noted that the downstream regions of 59 and 60 were discharging their runoff flows prior to the arrival of flood flows from upstream regions. Sensitivity analyses were therefore performed to evaluate the effects of assigning a minimum standard release rate, and also of maximizing the release rates of downstream regions.

These subsequent evaluations were made to "smooth out" the differences in the Regional Release Rates. The Initial Release Rates were rounded off to 5 percent, with the rounding made to produce a more uniform range of values. The Release Rate for Region 60 was set at 100 percent; as it is considered imperative that the runoff from this area pass through the Flaugherty Run watershed as quickly as possible so as to not coincide with runoff flows from upstream areas. The Release Rate for Region 59 was set at 95 percent, to reflect the obstruction conditions along Spring Run. The recommended Regional Release Rates for the Flaugherty Run watershed are presented in Table 7.3 and Figure 7-8. The regional release rates range from 60 percent to 100 percent, and provide effectively the same level of stormwater management as the individual basin release rate analysis would achieve. A greater consistency in the rates between adjacent basins/ regions is achieved in the regional analysis, and both the number and areal extent of the lower release rates are reduced. The regional release rates presented in Table 7.3, and shown on Figure 7-8, are, therefore, proposed as the principal technical component of the stormwater management plan for the Flaugherty Run watershed.

Table 7.3

PROPOSED REGIONAL RELEASE RATES

Region	Release Rate (percent)
7	85
15	70
18	60
22	90
28	85
31	60
37	80
39	70
42	70
59	95
60	100



2000' 0 2000'
SCALE: 1" = 2000'

REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

REGION	RELEASE RATE
7	80
15	60
18	70
22	70
28	85
31	70
37	85
39	70
42	85
59	95
60	100

LEGEND

REGION BOUNDARY

60 REGION IDENTIFICATION NUMBER

WATERSHED BOUNDARY

FIGURE 7-8

REGIONAL RELEASE RATE MAP

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

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Application of Release Rates

It is emphasized that, although the 2-year, 5-year, 25-year, and 50-year storms were not used in the release rate development, these storms may still be included in the application of release rates to development. In particular, the 2-year storm should be used, since it represents the approximate bankfull capacity of the stream channels, and is considered to be the storm level most appropriate for dictating potential maintenance at the obstructions. Uncontrolled or inappropriate controls on the 2-year storm could result in increased flood flows and flood-related damage. The high frequency (approximately once per year) of this storm is of particular concern. The use of the 5-year and the 50-year storms is considered to be less critical, since lower and upper bounds (storms) would then exist for each of these storms. Incorporating the 25-year storm into stormwater management policy would provide consistency with existing SWM facilities. The 10-year storm provides a reasonable basis for minimizing the potential for increased flood plain damages. The 100-year storm provides for consistent flood plain management and general agreement with current dam safety regulations. Where an impounding structure would not be present, a waiver of the 100-year standard may be acceptable on a site-specific basis. In summary, it is recommended that the application of the release rates follow the approach in Table 7.4.

Table 7.4

RELEASE RATE COMPLIANCE STANDARDS

Storm	Recommended Release Rate Compliance Standard	Optional Release Rate Compliance Standard
2-year	X	
5-year		X
10-year	X	
25-year	X	
50-year		X
100-year	X	

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8.0 EXISTING INSTITUTIONAL CONTROLS

Introduction

Institutional controls in the Flaugherty Run watershed currently are in the form of municipal ordinances for the various townships. The townships have incorporated stormwater management into one or more ordinances. Moon and Findlay Townships have specific stormwater ordinances. The existing ordinances provide for stormwater management in the Flaugherty Run watershed on a site-oriented basis, with no consideration of potential downstream impacts. The result is four sets of SWM requirements which provide adequate on-site management, but which do not address downstream impacts, and which may, in effect, worsen downstream flooding conditions. To date, development under the existing ordinances may have only slightly aggravated flooding conditions, attributable to the relatively low level and distribution of development in the downstream valleys. At the December 6, 1995 Watershed Public Advisory Committee meeting, it was reported that some reports of minor flooding have been received in Moon Township. Projected development would increasingly occur in the headwater areas, and thus development under the existing ordinances would more significantly and increasingly worsen existing flooding problems.

Existing Ordinances

Each township provided copies of ordinances addressing stormwater management for review. A matrix was established to summarize the ordinance subject (zoning, grading, etc.), the responsibilities of the various local officials, governing boards, and commissions, and existing planning activities. The matrices for the townships are presented in Appendix A.

It is noted that each township has attempted to incorporate stormwater management into existing ordinances and plans. Where a stormwater management ordinance does exist, the philosophical approach used does not take timing into account, and is, therefore, similar to that employed by the other townships.

Summary

The existing ordinances which address stormwater management do not provide a watershed-wide approach. The ordinances have evolved in response to the site-specific needs, and do not necessarily present efficient or effective watershed management beyond the site boundaries. A watershed-wide stormwater management plan which would minimize adverse impacts due to projected development is desirable. In fact, the Flaugherty Run watershed may have reached or may be reaching a critical point in stormwater management. Subsequent sections will present a model ordinance which may be used by the townships to implement this stormwater management plan.

9.0 ALTERNATIVE RUNOFF CONTROLS

This chapter addresses stormwater management techniques that reduce peak flow, stream velocity, and flow depth. These objectives can be accomplished by maximizing natural infiltration processes, reducing impervious surfaces, preserving flood plains, and controlling storm flows in the watershed.

When it is determined that the post-development runoff flows exceed the release rate flows established for the basin, the first attempt should be to reduce the increase in runoff flows and volumes by utilizing on-site stormwater management techniques. There are numerous technically-acceptable alternatives that have varying degrees of applicability in the study area, depending on site and watershed characteristics. Some of the most widely-used are catalogued here along with a brief discussion of their key features, advantages, and disadvantages.

It will be up to each developer to select the alternatives that are most appropriate to the type of project and characteristics of the site. It is likely that in many situations a combination of on-site controls will be the most effective and least costly stormwater management system. A first step may be methods to reduce runoff volumes, such as by maximizing the amount of pervious surface and/or creating areas where infiltration will occur. These methods would reduce the amount of detention storage required to hold and discharge surface runoff at the established release rate. To determine the most appropriate set of techniques for a particular site, several factors should be evaluated:

- Soil characteristics (i.e., soil permeability, erodibility);
- Topography;
- Subsurface conditions;
- Drainage patterns (i.e., proximity to stream flooding problems);
- Operation and Maintenance;
- Costs; and
- Aesthetics.

General advantages and disadvantages of each technique discussed are summarized later in this section (see Table 9.4). It is emphasized that while operation and maintenance requirements may vary among the methods, these requirements will dictate the effectiveness of each method.

On-Site Stormwater Control Methods

Reduction of Runoff with Infiltration Storage. Infiltration storage is designed to release all or part of the stored runoff into the groundwater. The infiltrated water may eventually appear a short distance downstream as surface water, but its appearance should occur well after the flood peaks. Ideally, a large quantity of runoff would be stored, transmitted in the aquifer system, and released much later at a point remote from the surface-water drainage system. The water quality of the storm runoff would be of importance in evaluating these methods.

Areas having sandy and silty sand soils are well suited to all types of infiltration controls. Sandy and silty sand soils allow rapid transmission of the runoff away from the surface drainage system. When poorly-drained soils, such as fine silts and clays, underlie the infiltration control device, the effectiveness of the device will be diminished. This unfortunately will be the case for large portions of the Flaugherty Run watershed and, therefore, infiltration storage devices should be used with caution. If this method is proposed as a means to reduce runoff for large development sites, or for any site located in landslide-prone soils, a soils engineer's report should be prepared, which specifically assesses the effectiveness of the method and the potential risks at the site.

Dutch Drains. Dutch drains are gravel-filled ditches which provide storage of runoff in the gravel voids. Dutch drains are applicable for relatively small areas, such as single family residences. The ditch may be entirely gravel-filled or it may be covered with top soil and seeded. When the surface of the drain is very wide, it is usually covered with brick lattice or porous block (Figure 9-1). The drains may be located directly under roof eaves along the length of a building, or runoff can be directed to the dutch drain from a downspout.

In order to eliminate the need for storm sewers in a residential development completely, the dutch drains would have to be sized large enough to store runoff from the area's maximum design rainfall. More often, dutch drains, two to four feet deep, are incorporated into complete stormwater management systems as partial control of runoff from rooftops and plaza areas.

Porous Pavement. Porous pavement is a special asphalt mixture designed to pass water at a high rate to a specially prepared subbase. The special subbase is thicker than a normal gravel subbase and is composed of coarse graded stone which supplies large void space for runoff storage capacity. Table 9.1 is included to indicate normal requirements for surface and subbase thicknesses. This table provides a guide for estimated runoff storage capacity. Figure 9-2 shows a typical porous pavement cross section and design elements.

It is cautioned that studies have raised serious doubt regarding the effectiveness of porous pavement. Several factors influence the porosity of the asphalt surface, which can deteriorate over time. Current research results should be studied before this method is considered.

FIGURE 9-1

DUTCH DRAINS

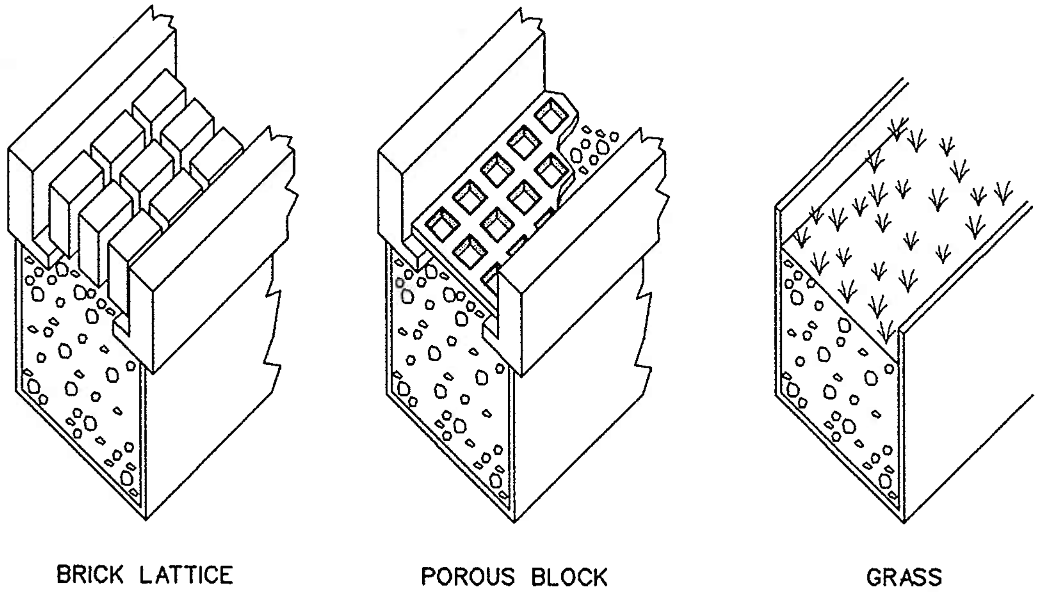


FIGURE 9-2

TYPICAL CROSS SECTION OF POROUS PAVEMENT

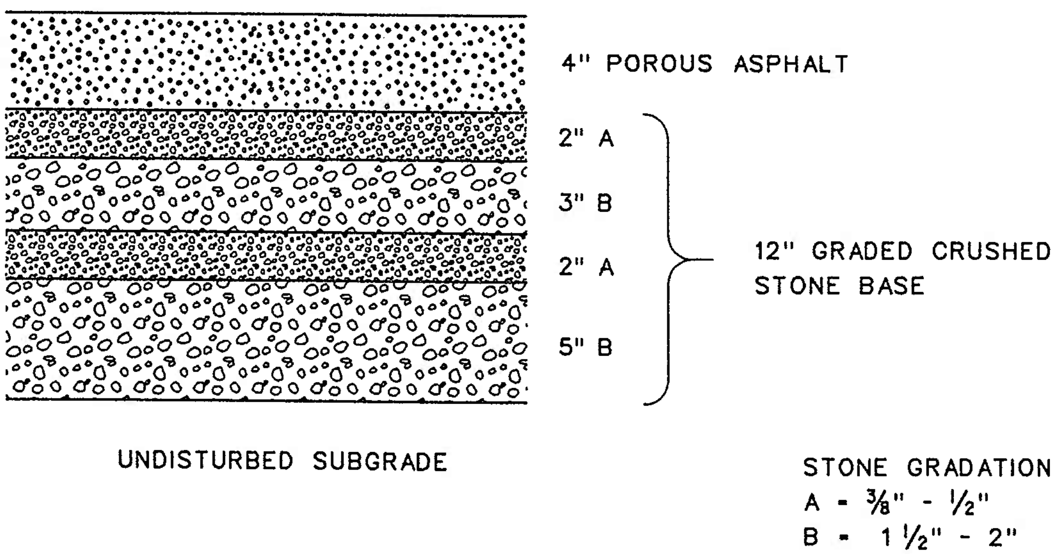


Table 9.1

POROUS PAVEMENT REQUIREMENTS FOR SURFACE AND BASE COURSE

Traffic Load	CBR	DTN	Surface Thickness (in.)	Base Thickness (in.)	Reservoir Capacity Inches of Rainfall		
					Surface	Base	Total
	2	1	4	6	.60	1.80	2.40
Light	2	10	4	12	.60	3.60	4.20
	2	20	4½	13	.66	3.90	4.56
Medium	2	50	5	14	.75	4.20	4.95
	2	100	5	16	.75	4.80	5.55
Heavy	2	1000	6	20	.90	6.00	6.90
	2	5000	7	22	1.05	6.60	7.65

CBR California Bearing Ratio
DTN Design Traffic Number

Notes:

(1) A minimum surface thickness of 4 inches is used regardless of DTN.
(2) The estimated volume of voids in the base aggregate is 40 percent.
(3) Frost heaving: If the combined surface and base thickness is less than anticipated frost penetration, additional base is required.

SOURCE: University of Delaware, Water Resource Center, April 1974.

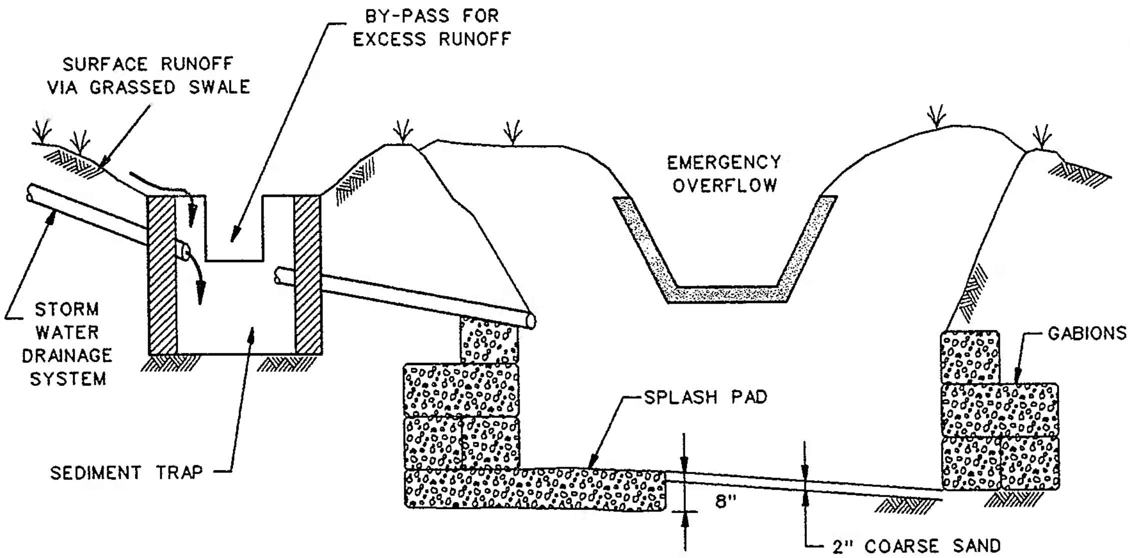
Seepage Basins or Recharge Basins. Seepage or recharge basins are large excavations designed to allow a large percentage of the annual rainfall to recharge the aquifer. Generally these basins are located in aquifer recharge areas, but they may be used wherever the water table is at least 48 inches below the ground surface. Runoff from a development is collected in various storm drainage systems and conveyed into the basin.

If a basin is sized to recharge as much stormwater as possible, then it should be excavated to take the area's maximum design rainfall from all impervious areas. However, to be economically feasible, the basins are usually designed to recharge a certain percentage of the annual rainfall and control flood peaks by overflowing early during intense rainfall events.

The construction of a seepage or recharge basin is rather complex. The regional and site-specific ground water levels must be determined, and the infiltration capacity of the underlying soils must be estimated. The recharge occurs through the bottom and, to a lesser extent, through side walls of the basin. The bottom of the basin must be kept free of silt, which can sharply reduce its seepage capacity (see Reference 26). An upstream sediment trap to limit the accumulation of bottom silt is a required portion of the overall system design. In addition, an emergency overflow structure to bypass excess runoff is required. Figure 9-3 depicts a typical system design.

FIGURE 9-3

SEEPAGE OR RECHARGE BASIN

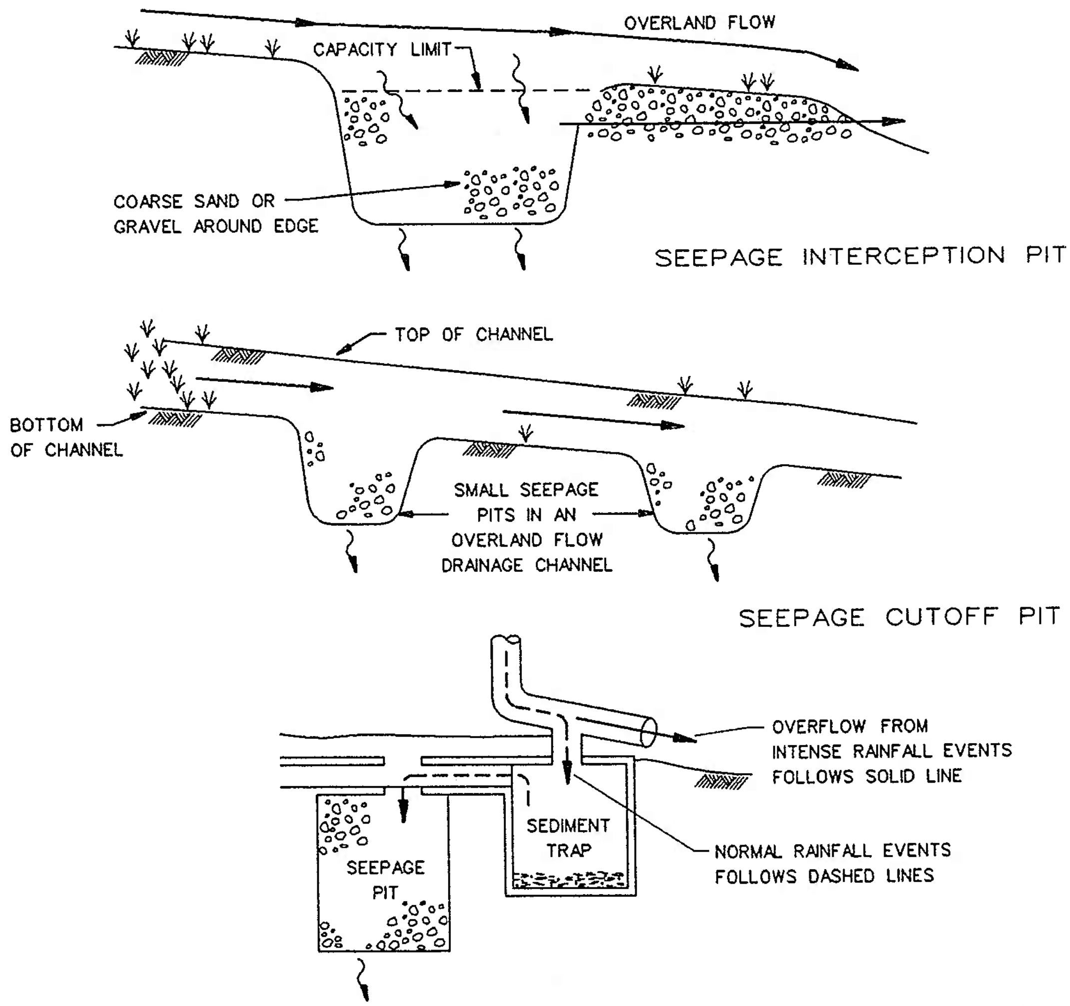


<u>Seepage Pits</u>. Seepage pits are small excavations designed to provide infiltration storage to reduce flood peaks, but to overflow during intense storms. Sites that have soil permeability over 0.15 ft/day and do not have seasonally high water tables are acceptable for utilization of seepage pits as stormwater runoff controls.

Figure 9-4 shows three alternatives for providing overflow capabilities when the seepage pit's capacity is reached. Some additional construction guidelines are: (1) the minimum size of a pit should be sufficient to maintain infiltration at pre-development levels (the minimum size is dependent on both the porosity of the soil and the number of rainfalls per year); (2) the water table should be no less than 48 inches below the bottom of the pit; and (3) the ratio of the bottom area to the side area should not exceed 1:2.

FIGURE 9-4

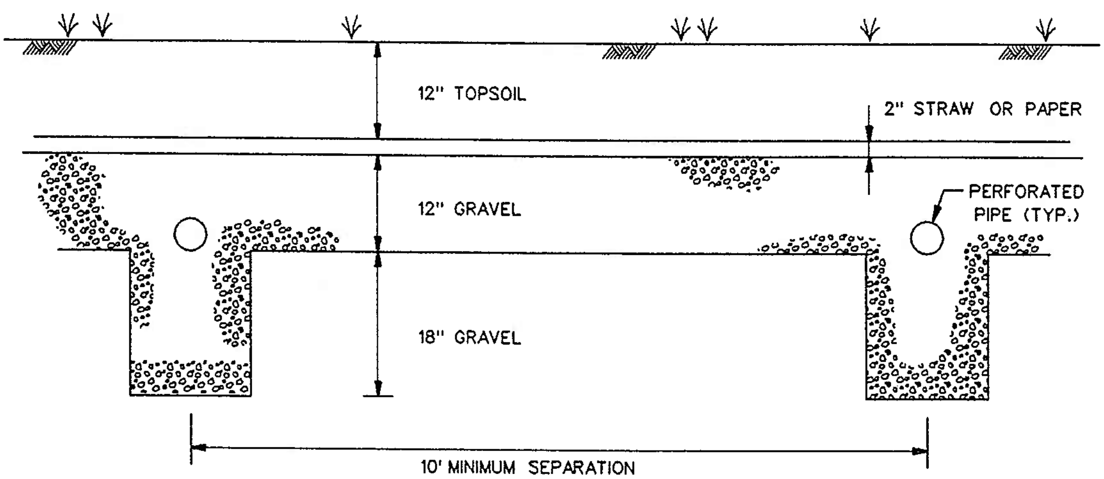
SEEPAGE PITS



Current research has indicated that infiltration is greatest through the bottom, although clogging can diminish the efficiency. Also, deep, narrow pits tend to perform better than wide, shallow pits once clogging of the bottom has started (Reference 26).

Seepage Beds or Ditches. Seepage beds dispose of runoff by infiltration into the soil through a system of perforated drainage pipes laid in ditches. The runoff should pass through a sediment trap prior to entering the distribution system. The sediment trap can be designed, as shown in Figure 9-3, with a structure to bypass runoff from extreme rainfall events. Sites with periodically high water tables or where the drainage of soil is extremely poor are unsuitable for this application. A typical seepage bed site is shown in Figure 9-5.

FIGURE 9-5
SEEPAGE BED



Terraces, Diversions, Runoff Spreaders, Grassed Waterways, and Contoured Landscapes. These measures are normally used to increase the time of concentration of runoff and will provide the additional benefit of reducing total runoff by infiltration on sites with well-drained soils. For detailed design information, the Soil Conservation Service's *Engineering Field Manual for Conservation Practices* (Reference 27) should be consulted.

Summary of Infiltration Techniques. Table 9.2 summarizes some of the major considerations relevant to the design and use of the various infiltration techniques. Because numerous factors must be evaluated in the selection of the techniques, it is not possible to prescribe uniform application of them. The determination must be made on a site-by-site basis.

Table 9.2

SUMMARY OF CONSIDERATIONS RELEVANT TO THE DESIGN AND USE OF VARIOUS INFILTRATION TECHNIQUES

	Dutch Drains	Seepage Pits	Seepage Basins	Seepage Beds	Porous Pavement
Land Acquisition	X	X	X	X	
Excavation and Fill	X		X	X	
Erosion Protection	X		X	X	X
Fencing		X	X		
Inlet Structure			X	X	
Sediment/Debris Control	X	X	X	X	X
Soil Permeability	X	X	X	X	X
Groundwater Level	X	X	X	X	X
Structural Soil Limitations					X
Landscaping	X	X	X	X	
Engineering and Site Design	X	X	X	X	X
Operation and Maintenance	X	X	X	X	X
Financing			X	X	X
Sewer Septic Fields		X	X	X	X
Depth to Bedrock		X	X	X	X

Delay of Runoff. The delay of runoff is accomplished by the two basic principles of detention and retention. Detention reduces the peak rate of discharge by attenuating the hydraulic response of storm runoff. Retention involves a much longer delay and smaller release rates. In retention a much larger volume of stormwater is impounded and stored for a period of up to 48 hours.

Rooftop Retention. Rooftop retention utilizes the built-in structural capabilities of rooftops to store a certain amount of rainfall. In many cases, existing roof structures may require little modification to function as retention structures. Flat rooftops are best suited for this purpose; however, small runoff checks, or "fin dams," can be installed on sloping roofs to provide some attenuation of the resulting runoff hydrograph. Figure 9-6 shows a sketch of roof ponding through the use of fin dams.

On flat rooftops, the major change involves the installation of simple outlet control devices. New flat-roofed commercial buildings should consider the use of rooftop storage. An emergency overflow system must be provided in order to prevent stormwater from spilling over the edge of the roof. A rainfall detention ponding ring for flat rooftops is shown in Figure 9-7.

FIGURE 9-6

ROOF PONDING WITH GRAVEL DIKES
(FIN DAMS)

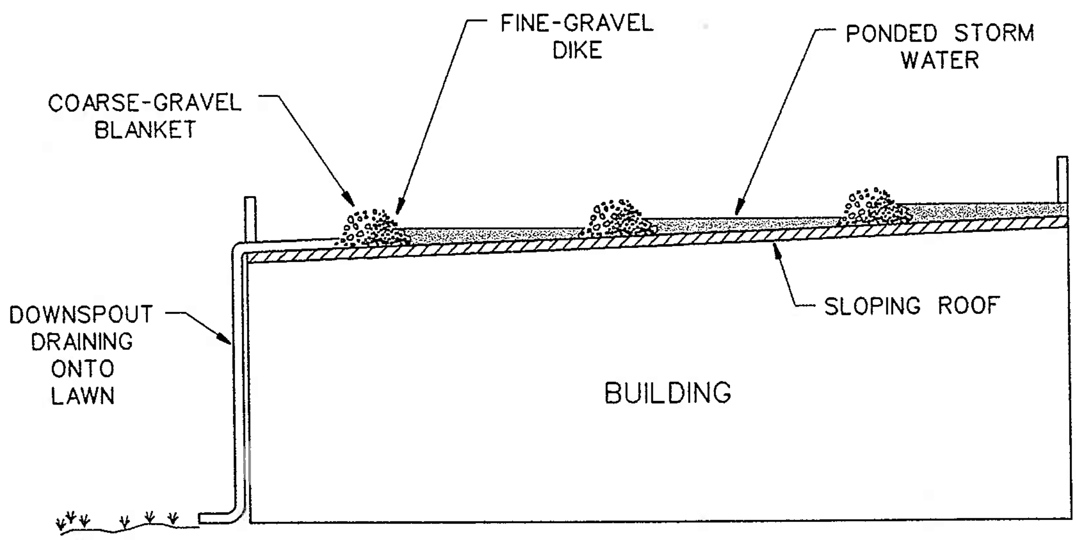
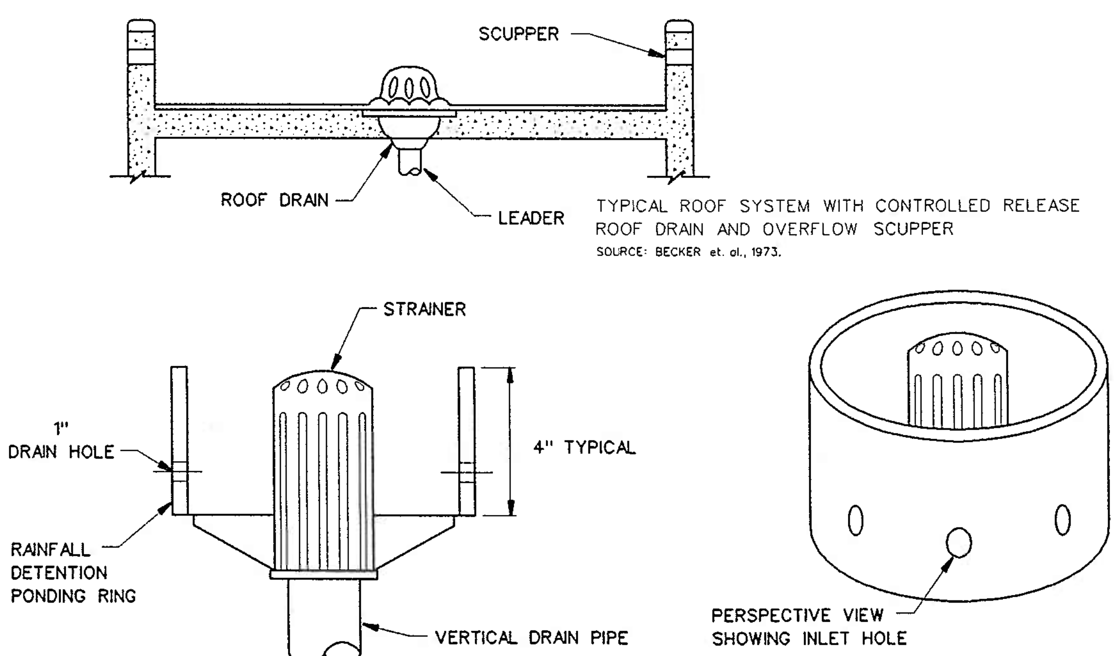


FIGURE 9-7

ROOFTOP RETENTION DEVICES

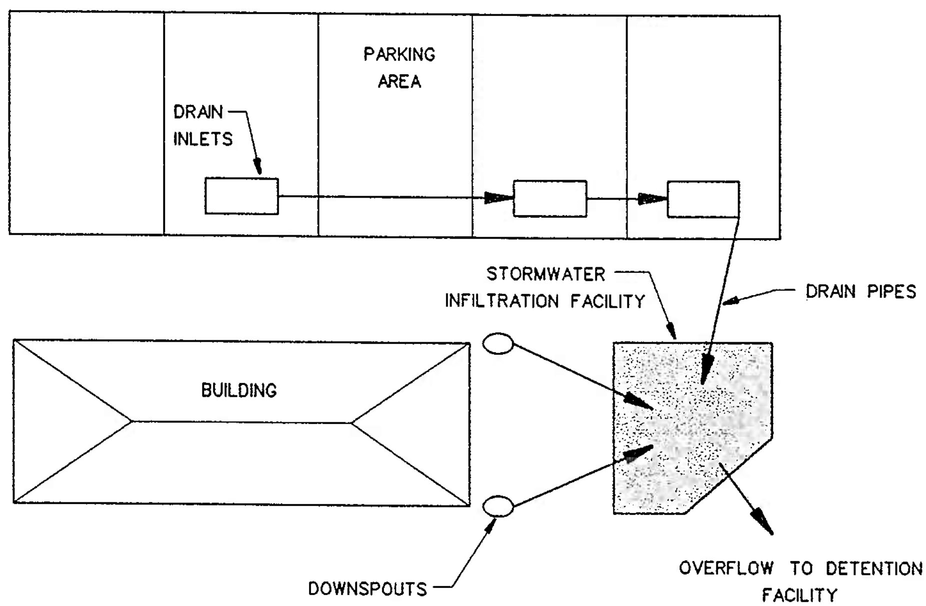


SOURCE: ALLEGHENY COUNTY, ACT 167 PILOT STORMWATER MANAGEMENT PLANS, 1982.

The effectiveness of rooftop storage is a function of the actual area affected by such storage. Rooftop storage is most effective when used as an integral part of a larger stormwater runoff control program. An example of a coordinated SWM system is presented on Figure 9-8. There are inherent disadvantages to rooftop storage that must be considered prior to its use. The structural capability of the roof and structure to withstand water and ice/snow loadings is critical.

FIGURE 9-8

EXAMPLE APPLICATION OF ROOF DETENTION
AND
PARKING LOT INFILTRATION SYSTEM

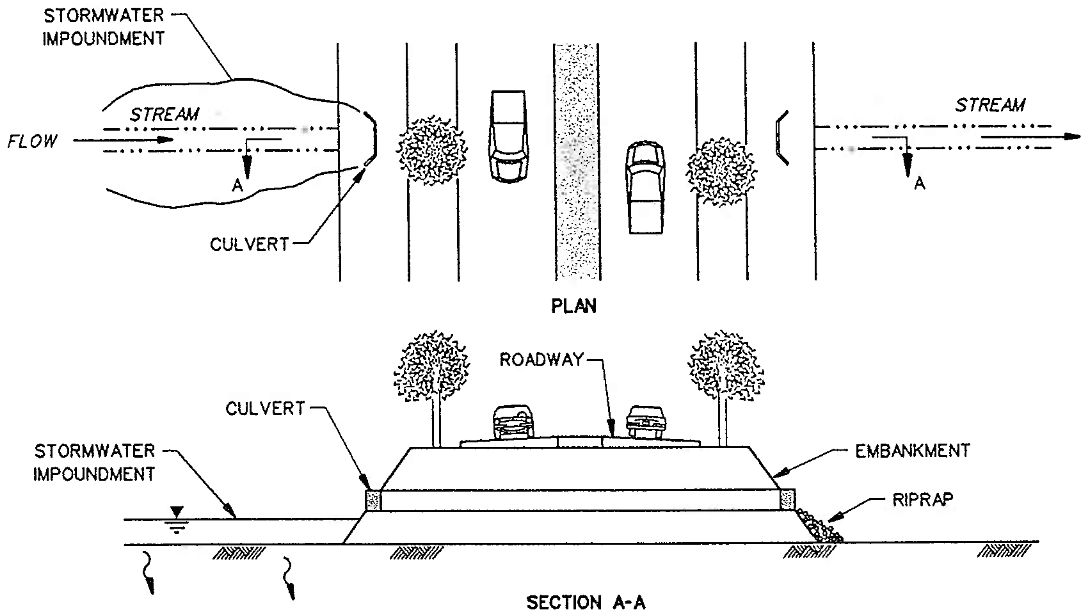


Road Embankment Stormwater Detention. Topographical characteristics of many low areas adjacent to roadway embankments make them adaptable for use as detention facilities. This can be achieved by designing the culverts to pond where appropriate, as shown in Figure 9-9. Many PennDOT, county, and municipal structures can be designed to operate in this fashion. Stepped slopes and benching on embankments also are effective in detaining flow and reducing the time of concentration, thereby slowing the runoff flow velocity. The use of these structures for detention should be in conformance with PennDOT and local requirements and approvals.

Parking Lot Detention. Parking lot detention involves the design of pavement surface, curbing, and stormwater inlet structures to temporarily store and release stormwater runoff. Figure 9-10 shows an example of parking lot detention. Initial construction costs implementing these measures are usually only a small percentage above the cost of constructing conventional parking lots.

FIGURE 9-9

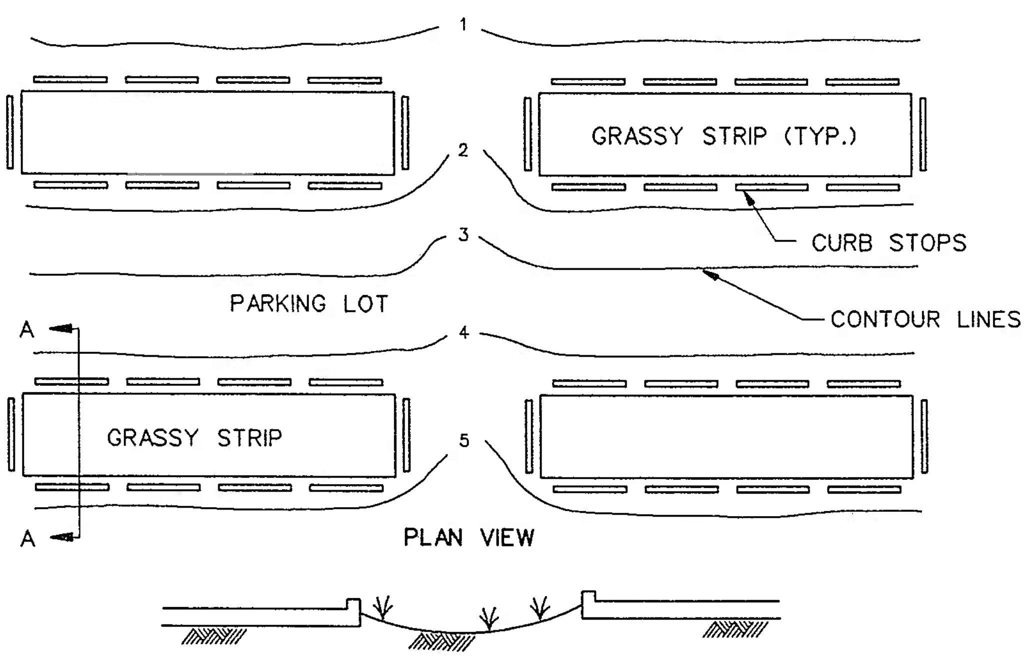
ROAD EMBANKMENT STORMWATER DETENTION



ROAD EMBANKMENT STORMWATER DETENTION

FIGURE 9-10

PARKING LOT DETENTION ON SWALES



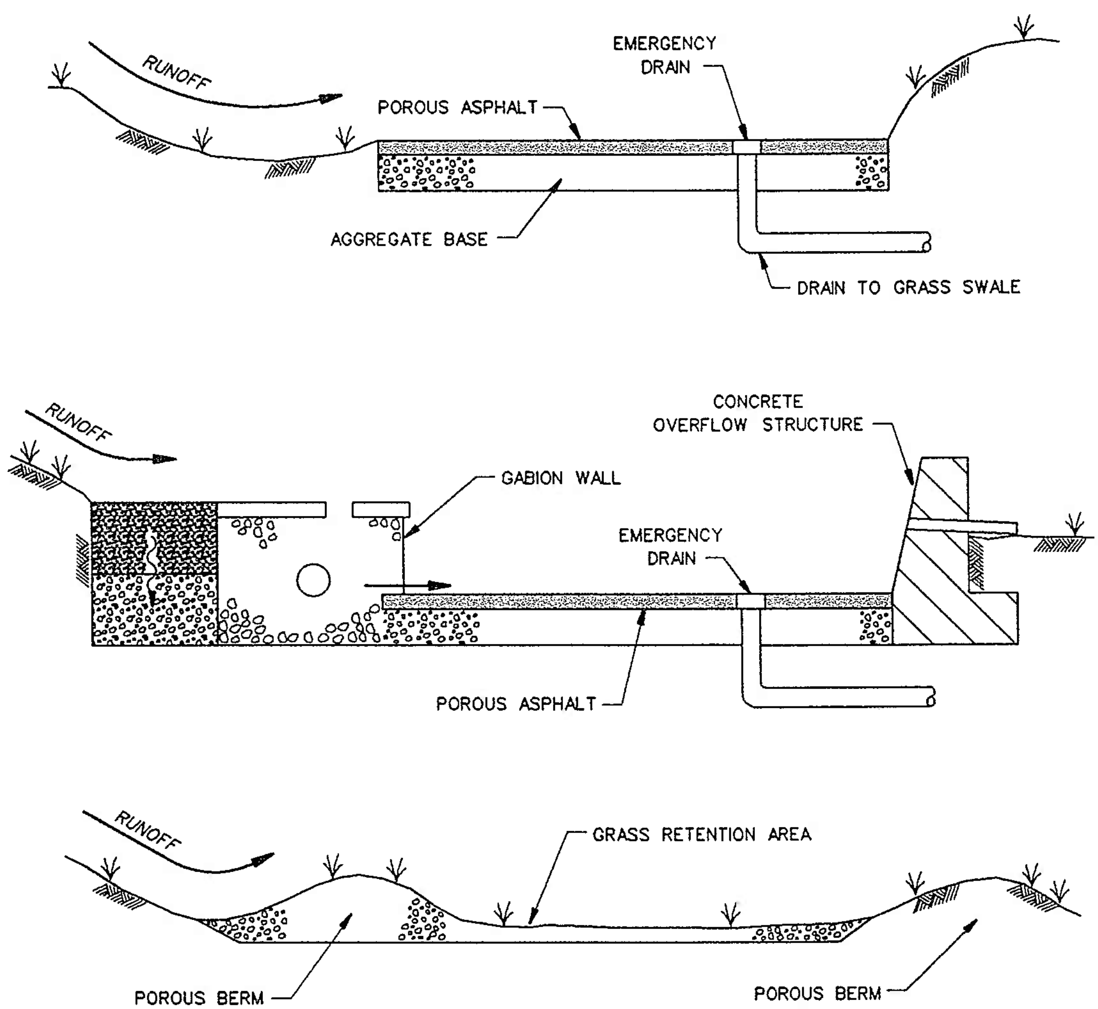
SECTION A-A (ENLARGED SCALE)

These measures should be designed specifically to control runoff from the particular parking area and avoid handling any additional runoff. The facility should be designed to drain completely and avoid the formation of ice.

Multiple-Use or Open Space Impoundment Areas. These areas utilize sites having primary functions other than runoff control. In new developments, such multiple use should be incorporated into the preliminary design. Figure 9-11 shows some conceptual designs for open space impoundment areas.

FIGURE 9-11

OPEN SPACE DETENTION AREAS



A hard-surfaced basketball or tennis court can be designed to drain adjacent grassed or paved areas. The stormwater would collect in grass swales around the edge of the court, seep through a gravel drain to retain the sediment load, and discharge onto a porous asphalt surface. An emergency drain should be provided to slowly drain the water.

Grassed areas also can be landscaped to serve as small retention areas. Direct discharge from a pipe to these areas should be avoided.

Detention Ponds. Detention ponds are dry impoundments designed to store a portion of the stormwater runoff during a storm event and then release the stored volume slowly. Typically, they are used in areas where runoff volume has been increased and it is desirable to reduce the discharge rate. Three design elements must be calculated:

- The inflow hydrograph, which is the rate of stormwater runoff entering the pond;
- The outflow hydrograph, which is the discharge released from the pond;
- The storage capacity of the pond computed in acre-feet by elevation in the pond. A pond two acres in average area, for example, has an average of two acre-feet of storage for each foot of depth in the pond.

As was discussed in Section 7, the post-development discharge with no detention storage is greater than the pre-development value. Detention storage is used to reduce the discharge to an allowable quantity. The detention pond must store the volume of runoff into the basin until the discharge from the pond exceeds the inflow to the pond. As the inflow rate into the pond reduces to less than the outflow rate, the pond begins to drain.

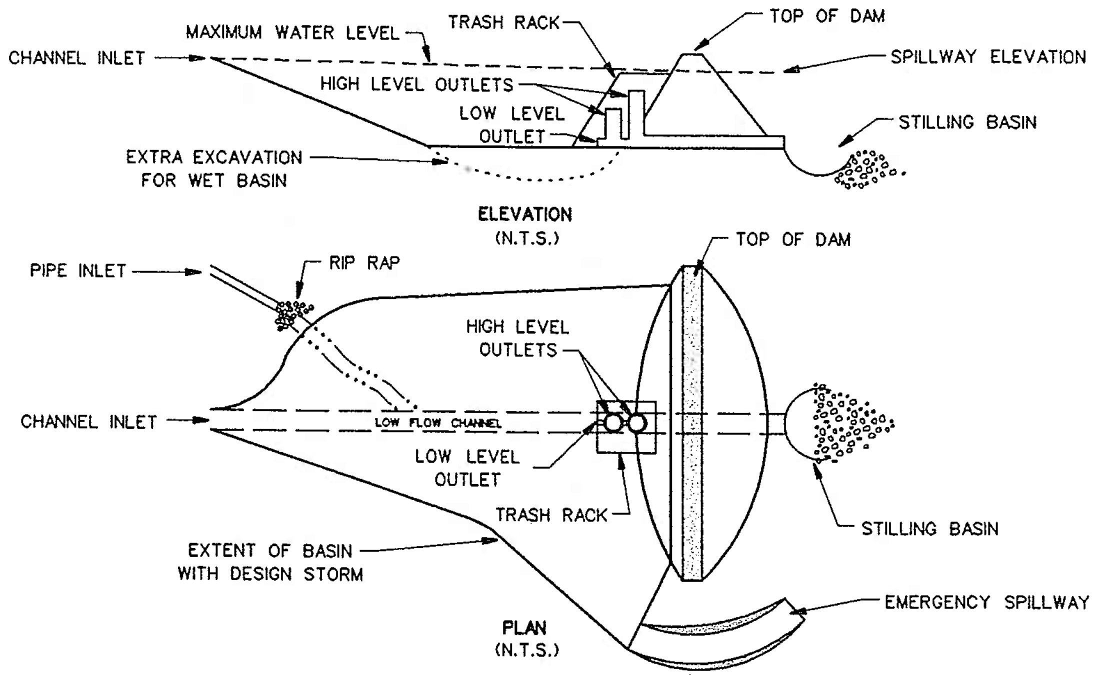
The design of a detention pond must be coordinated with the release rate percentage to ensure that flooding problems do not result as the maximum discharge rate from the site is extended over time. The maximum design flow from the pond should be less than or equal to the appropriate release rate flow.

Multi-stage outlet structures must be used for all detention ponds in order to provide discharge control for different storm frequency events. The objective is to control the characteristics of the pre-development runoff rate for several storm events, typically ranging from the 2-year to the 100-year design storms. This can be accomplished by locating outlet structures at various elevations in the pond.

Figure 9-12 shows a cross section of a typical detention pond. The elevation of Pipe A is set at the design height that the 10-year event is expected to reach in the pond, and Pipe B is set for the 100-year event. The drain pipe is designed for a 2-year design storm. The peak discharge rate from the pond will vary in response to the design storm event.

FIGURE 9-12

TYPICAL DETENTION BASIN DESIGN



Permanent Ponds. Permanent ponds may be designed to function as detention/retention structures by providing an elevation difference between the principal and emergency spillways. This elevation difference, above normal pond levels, must provide adequate storage volume for detention capacity. These ponds are unquestionably more aesthetically appealing than a typical dry impoundment pond. In addition, the pond can be designed to provide some recreational benefits.

Underground Detention/Retention Tanks. In areas where land is of very high value, these tanks can serve the same function as basins but also conserve land. This method is generally more expensive because of the high costs of materials and construction, and possible pumping requirements.

Retention Ponds. These structures are used when extreme limits on downstream flow rate or velocity are required. The outflow rate will be relatively low and will extend over a longer period of time when compared with the outflow period of a detention pond. This requires a large storage capacity for detaining stormwater for periods greater than 24 hours. Retention ponds, therefore, have greater storage capacity then detention ponds. The aesthetics of the facility may be improved by the retention of a permanent pool, which can be incorporated into the landscaping. Retention ponds are useful in improving the water quality of the site runoff, by providing sedimentation of materials picked up by the runoff.

Table 9.3 summarizes some of the management considerations relevant to the selection and design of detention and retention techniques. The table highlights key elements that should be evaluated during the design process. Additional elements for consideration will exist for each site to reflect the individual characteristics of the area.

Summary of Detention/Retention Techniques. Tables 9.4 and 9.5 highlight the advantages/disadvantages and operation and maintenance considerations for the detention/ retention stormwater management techniques described above. As noted previously, no one technique is uniquely suited to a particular runoff problem; rather, a combination of techniques will result in an effective stormwater management system for the site.

For example, in a development consisting of homes built on quarter-acre lots, the residential streets and parking areas could be porous pavement. The roof downspouts could lead to dutch drains which also could be grassed waterways picking up overflows from other controls. Mulch planting could be located beside lattice sidewalks. The excess runoff from all these controls would be collected either by a detention pond or a seepage basin at the lowest downslope area(s) of the development.

Each internal technique would provide a portion of the required stormwater runoff control, with the drainage routed overland from each facility to the detention pond or seepage basin. Storage would be provided by the detention pond or seepage basin. Some additional storage plus induced infiltration would be provided by the areas of porous pavement, mulch planting, lattice walks, and dutch drains. Runoff to the pond could be conveyed by a waterway over a dutch drain with an overplanting of grass.

Should the soils underlying the site be only moderately drained, then the infiltration controls could be linked by underdrains or gravel trenches. Any excess runoff would drain slowly to the downslope detention facility and eventually to the receiving stream.

The overall stormwater management plan would provide the required reduction of peak runoff without causing on-site flooding. By the use of relatively inexpensive infiltration mechanisms and combined runoff control methods, the expense of stormwater conveyance systems and detention storage is greatly reduced. The operation and maintenance responsibilities and requirements of the proposed SWM system should be closely evaluated, and presented in a clear and concise manner. When planning all new developments, sufficient time should be provided for careful investigation and selection of the most cost-effective means of stormwater management.

Table 9.3

SUMMARY OF MANAGEMENT CONSIDERATIONS RELEVANT TO
THE SELECTION AND DESIGN OF DETENTION AND RETENTION TECHNIQUES

	Detention/ Retention Ponds	Detention/ Retention Tanks	Permanent Ponds	Parking Lot Detention	Rooftop Detention	Open Space Detention	Road Embankment Detention
Land Acquisition	X		X			X	X
Excavation and Fill	X	X	X				
Erosion Protection	X		X	X		X	X
Fencing	X		X				X
Pumping Facility	X	X				X	
Piping	X	X	X	X	X	X	
Inlet Structure	X	X	X	X	X	X	
Hydrology Control Device (Outlet)	X	X	X	X	X	X	X
Spillway Structure (Outfall)	X	X	X			X	X
Multi-Purpose Use	X		X	X	X	X	
Modification of Existing Features			X	X		X	X
Modification of Existing Structures			X	X	X		X
Landscaping	X		X			X	X
Engineering and Site Design	X	X	X	X	X	X	X
Operation and Maintenance	X	X	X	X	X	X	X
Financing	X	X	X	X	X	X	X
Easement/Access	X	X	X			X	X

Table 9.4

ADVANTAGES/DISADVANTAGES OF ON-SITE CONTROL METHODS

Method	Advantages	Disadvantages
Reduction of Runoff/Infiltration Storage		
Dutch Drains	• Reduce the total volume of runoff. • Reduce the peak runoff discharge rates. • Enhance the ground-water supply. • Provide additional water for vegetation in the area. • Reduce the size of downslope stormwater control facilities.	• Loses efficiency if intensive storms follow in rapid succession. • Subject to clogging by sediment. • Limited to application for small sources of runoff only, i.e., roof drains, small parking lots, tennis courts. • Maintenance is difficult when the facility becomes clogged. • Limited application in poor infiltration soils.
Porous Pavement	• Reduces the total volume of runoff. • Reduces the peak runoff discharge rates. • Enhances the ground-water supply. • Provides additional water for vegetation in the area. • Reduces the size of downslope stormwater control facilities. • Less costly than conventional pavements for most applications. • Safety features - superior skid resistance and visibility of pavement markings. • Provides pavement drainage without contouring. • Prevents puddling on the surface.	• More prone to water stripping than conventional mixtures. • Subject to clogging by sediment. • Water freezing within the pores takes longer to thaw and limits infiltration. • Motor oil drippings and gasoline spillage may pollute ground water. • Limited application in poor infiltration soils. • Recent studies suggest that porous pavement's advantages will diminish with time.

Table 9.4 (Continued)

Method	Advantages	Disadvantages
Seepage/ Recharge Basins	• Reduce the total volume of runoff. • Reduce the peak runoff discharge rates. • Enhance the ground-water supply. • Construction borrow pits often can be converted to a large seepage basin to serve multiple areas.	• Must be fenced and regularly maintained. • If porosity is greatly reduced, it may be necessary to bore seepage holes or pits in the base. • No filtering supplied by the topsoil. • Usefulness limited in poor infiltration soils.
Seepage Pits	• Reduce the total volume of runoff. • Reduce the peak runoff discharge rates. • Enhance the ground-water supply. • Provide additional water for vegetation in the area. • Reduce the size of downslope stormwater control facilities.	• Loses efficiency if intensive storms follow in rapid succession. • Subject to clogging by sediment. • Maintenance is difficult when the facility becomes clogged. • Limited utility in poor infiltration soils.
Seepage Beds/Ditches	• Reduce the total volume of runoff. • Reduce the peak runoff discharge rates. • Enhance ground-water supply. • Reduce the size of downslope stormwater control facilities. • Distribute stormwater over a larger area than other infiltration techniques. • Beds may be placed under paved areas if the bearing capacity of the paved area is not affected. • Safer than seepage or recharge basins.	• More expensive than other infiltration techniques. • Replacement of the entire system necessary if clogging by sediment should occur. • Maintenance of sediment traps must be frequent and consequently they are more expensive. • Limited utility in poor infiltration soils.

Table 9.4 (Continued)

Method	Advantages	Disadvantages
Terraces, Diversions, Runoff Spreaders, Grassed Waterways, and Contoured Landscapes	• Increase the overland flow time, increasing the time of concentration and allowing for increased infiltration. • Vegetative swales are less expensive than curb and gutter systems.	• On poorly drained soils, these techniques may leave ground waterlogged for extended period after storms. • Vegetative channel may require more maintenance than curb and gutter systems. • Roadside swales become less feasible as the number of driveway entrances requiring culverts increase.
<u>Delay of Runoff</u>		
Rooftop Retention	• No additional land requirements. • May be adapted to existing structures. • Aesthetics (out of sight). • Reduced safety hazard (trespassing/attractive nuisance).	• Leaks may cause damage to buildings and contents. • Stored runoff will greatly increase the load imposed on structural support. This increased construction expense may be greater than the savings resulting from reducing the size of downslope stormwater management facilities.
Parking Lot Detention	• Adaptable to both existing and proposed parking facilities. • Parking lot storage is usually easy to incorporate into parking lot design and construction.	• May cause an inconvenience to people. • Ponding areas are prone to icing, requiring more frequent maintenance.
Multiple-Use Impoundment Area	• Serves more than one purpose. • Where the surface is grass, a certain amount of stormwater will infiltrate and improve the quantity of water recharged by natural filtering processes. • If porous pavement is used on basketball or tennis courts, additional infiltration will be provided.	• Difficult to maintain the porosity of multi-use areas. • May require access controls.

Table 9.4 (Continued)

Method	Advantages	Disadvantages
Detention/ Retention Ponds	• Offer design flexibility for adapting to a variety of uses. • Construction of ponds is relatively simple. • May have some recreational and aesthetic benefits if runoff is not carrying heavy sediment loads. • Reduce downstream litter and debris.	• Facilities that empty out completely can be unsightly and aesthetically unpleasing. • Significant operation and maintenance program. • In a residential development it may be difficult to determine whose responsibility it is to pay for the maintenance program. • Consumes land area which could be used for other purposes. • May require PaDEP permit.
Permanent Ponds	• Will provide both a reduction in peak runoff rates and a source of recreation in any residential area. • Only minor modifications may be required to adapt an existing pond for use as a permanent stormwater management facility. • Aesthetics. • Environmental quality.	• Stormwater runoff having a high sediment or pollutant load should not be controlled in existing ponds because of its adverse impact on the natural conditions. • May require PaDEP permit.
Underground Retention/Detention Tanks	• Minimal interference with traffic or people. • Can be used in existing as well as newly developed areas. • Potential for using stormwater for non-potable uses.	• Subsurface excavation could be extremely expensive depending upon the type and amount of rock encountered. • Increased operation and maintenance requirements

Table 9.5

OPERATION AND MAINTENANCE CONSIDERATIONS FOR ON-SITE CONTROL METHODS

	Dredging	Debris/ Sediment Removal	Weed Control	Insect Control	Mechanical Maintenance	Mowing	Cleaning	Bottom Retilling	Repair	Inspection
Detention/ Retention Basins	X	X	X	X		X	X		X	X
Detention/ Retention Tanks		X		X	X		X		X	X
Ponds	X	X	X	X		X			X	X
Parking Lot Detention		X					X		X	X
Rooftop Retention		X		X			X		X	X
Open Space Detention		X				X				X
Road Embankment Detention		X	X	X			X		X	X
Seepage Basins		X	X	X		X		X	X	X
Seepage Beds		X				X	X		X	X
Porous Pavement							X		X	X
Open Channels		X	X	X		X			X	X
Pipe Systems		X			X		X		X	X

10.0 PRIORITIES FOR IMPLEMENTATION OF THE PLAN

This stormwater management plan has been developed for the four townships (Crescent, Moon and Findlay Townships in Allegheny County and Hopewell Township in Beaver County) in the Flaugherty Run watershed. The purpose of this plan is to require those who engage in the development of land, whether as private or public entities, to implement reasonable measures to prevent harm to persons or properties downstream in accordance with the provisions of Act 167. This is to be accomplished on a watershed-wide basis.

These measures must include actions:

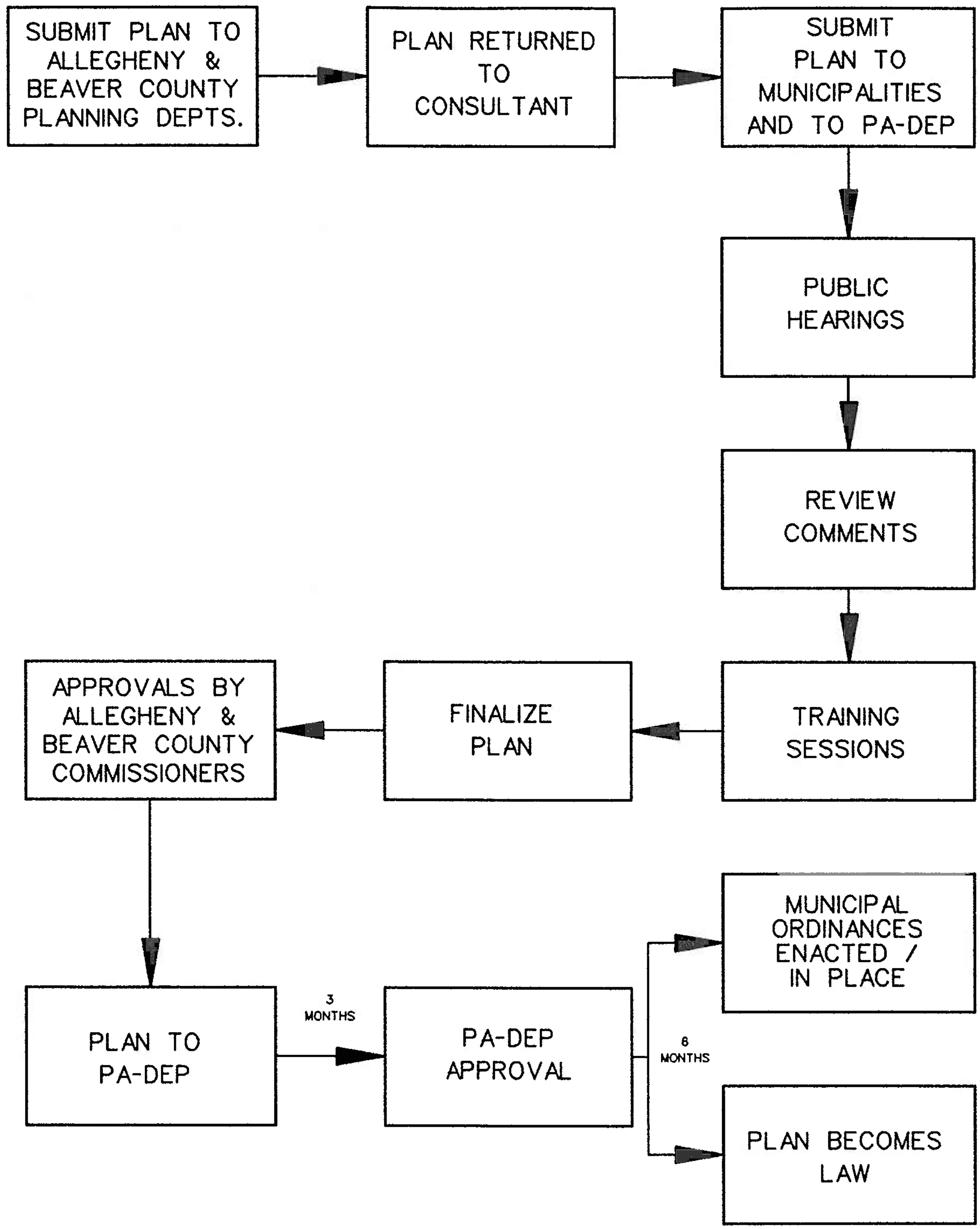
- "To assure that the maximum rate of stormwater runoff is no greater after development than prior to development activities; and
- To manage the quantity, velocity, and direction of resulting stormwater runoff in a manner which otherwise adequately protects health and property from possible injury."

This plan contains recommendations which will meet the basic standards of Act 167. Act 167 places the responsibility for implementation of the Flaugherty Run Stormwater Management Plan in the hands of each of the four townships. Each township should incorporate the Flaugherty Run Watershed Stormwater Plan into their appropriate municipal ordinances. Zoning, subdivision, and land development (erosion/sedimentation and grading), and building ordinances should be adopted or amended to provide a comprehensive ordinance package capable of covering all types of land alteration activities.

A flow chart for the implementation of the Flaugherty Run Watershed Stormwater Management Plan is shown in Figure 10-1.

Provisions for Updating the Plan

The County of Allegheny, Department of Economic Development (CoA, DED) has been furnished data which should be periodically updated at least every 5 years. This would require updating the data on land use and other significant and relevant data, and rerunning the PSRM models, if appropriate. The resultant information would then be evaluated, and revised release rates may be established for the watershed. This data would then be furnished to the appropriate agencies for their use. The stormwater management plan should assign an individual to monitor all stormwater management plans; to see that these revisions are made at the appropriate time, and that the information is provided to the responsible agencies. The CoA, DED shall assume these responsibilities for the Flaugherty Run Watershed Plan.



PRIORITIES AND SCHEDULE FOR IMPLEMENTATION

FIGURE 10-1

FLAUGHERTY RUN WATERSHED STORMWATER MANAGEMENT PLAN

GAI CONSULTANTS
570 Beatty Road, Monroeville, PA 15146 412/856-6400

11.0 MODEL STORMWATER MANAGEMENT ORDINANCE

This section presents a model ordinance for stormwater management which can be used by a municipality for implementation of the Flaugherty Run Act 167 Stormwater Management Plan. It is anticipated that the municipality will have its solicitor review and tailor the model ordinance prior to adoption. It is noted that Moon Township and Findley Township each have stormwater management ordinances in place, and therefore only minor revision to their ordinances may be required. Crescent Township and Hopewell Township will require an ordinance similar to that presented on the following pages.

For convenience, the model ordinance has been organized so that it may be a stand-alone entity within the Flaugherty Run Plan.

11.0 MODEL STORMWATER MANAGEMENT ORDINANCE

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1.00.01 PURPOSE.

These regulations are adopted and implemented to achieve the following general purposes and objectives:

1. To manage stormwater runoff resulting from land alteration and disturbance activities in accordance with the watershed stormwater management plans adopted by Allegheny County as required by the Pennsylvania Storm Water Management Act (Act 167 of 1978, as amended);

2. To utilize and preserve the desirable existing natural drainage systems and to preserve the flood-carrying capacity of streams;

3. To encourage natural infiltration of rainfall to preserve ground water supplies and streamflows; and

4. To provide for adequate maintenance of all permanent stormwater management facilities in the Municipality.

1.00.02 APPLICABILITY.

The provisions of this article shall apply to all subdivisions and land developments unless specifically exempted or otherwise modified herein.

1.00.03 STATUTORY AUTHORITY.

The Municipality is empowered to regulate land use activities that affect stormwater runoff by the authority of the Act of October 4, 1978, The Storm Water Management Act, 32 P.S., P.L. 864 (No. 167), Section 680.1 et seq., as amended by Act 63 of May 24, 1984, and the (*applicable municipal code*).

1.00.04 REPEALER.

This ordinance shall repeal all other ordinances, or parts thereof, which are contrary to or conflict with the provisions of this ordinance to the extent necessary to give this ordinance full force and effect.

1.00.05 SEVERABILITY.

Should any part of this article be declared invalid, such decision shall not affect the validity of any other part, nor the article as a whole.

1.00.06 DEFINITIONS.

For the purposes of this article, these terms shall be defined as follows. The words "shall" and "must" shall be mandatory, single and plural, and feminine and masculine are equivalent.

"Applicant": A landowner or developer, as defined by this article, who has filed an application for development, including his/her heirs, successors and assigns.

"Channel": A natural stream that conveys water; a ditch or open channel excavated for the flow of water.

"Conservation District (ACCD)": The Allegheny (or Beaver) County Conservation District.

"County": The County of Allegheny (or Beaver), Pennsylvania.

"Culvert": A closed conduit for the free passage of surface drainage under a highway, railroad, canal, or other embankment.

"Design criteria": Engineering guidelines specifying construction details and materials, or objectives, results, or limits which must be met by a facility, structure or process in performance of its intended functions.

"Design storm": The magnitude of precipitation from a storm event measured in probability of occurrence, such as the 100-year storm, and duration, such as twenty-four hour, and used in designing stormwater management control systems.

"Detention": The slowing, dampening, or attenuating of runoff entering the natural drainage pattern or storm drainage system by temporarily holding water in areas such as detention basins, reservoirs, roof tops, streets, parking lots, or within the drainage system itself.

"Detention basin": A basin designed to retard stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate. A detention basin is designed to drain completely after a storm; also called a dry basin.

"Developer": Any landowner, agent of such landowner or tenant with the permission of such landowner, who makes or causes to be made a subdivision or land development.

"Development": Any activity, construction, alteration, change in land use or similar action that affects stormwater runoff characteristics.

"Development site": A lot, parcel, or tract of land on which development is taking place or is proposed.

"Discharge": The rate of flow, specifically fluid flow. A volume of fluid (in this case water) per unit of time flowing in or from a conduit or channel, usually expressed in cubic feet per second.

"Drainage": The interception and removal of excess surface water or groundwater from land by artificial or natural means.

"Drainage area": The area which contributes runoff to a designated point of a drainage system, usually expressed in acres or square miles; also called a catchment area, watershed, or river basin.

"Drainage easement": A right granted by a landowner to a grantee allowing the use of private land for stormwater management purposes.

"Embankment": A mound of earth or stone constructed above the natural ground surface, and in stormwater management, with the specific purpose of detaining or diverting stormwater runoff.

"Engineer": The professional engineer duly appointed as the engineer for the Municipality.

"Erosion": The wearing away of the land surface by running water, wind, ice, or other geologic agents, including such process as gravitational creep.

"Erosion control": The application of measures to reduce erosion of land surfaces.

"Flood plain": A normally dry land area adjacent to stream channels that is susceptible to being inundated by overbank stream flows. For regulatory purposes, the Pennsylvania Flood Plain Management Act (Act of October 4, 1978, P.L. 851, No. 166) and regulations pursuant to the Act define the flood plain as the area inundated by the 100-year flood and delineated on a map by FEMA (Federal Emergency Management Agency) or by the applicant in accordance with municipal ordinance requirements.

"Ground cover": Materials covering the ground surface.

"Ground Water Recharge": Replenishment of ground water naturally by precipitation or runoff or artificially by spreading or injection.

"Hydraulics": The branch of science concerned with the mechanics of fluids, especially liquids. As applied in stormwater management, the study of the characteristics of water flowing in conveyance channels, and from control facilities.

"Hydrology": The science dealing with waters of the earth and their distribution and circulation through the atmosphere.

"Infiltration": The flow or movement of water through the interstices or pores of a soil or other porous medium, or the absorption of liquid by the soil.

"Land Development": The improvement of one lot or two or more contiguous lots, tracts, or parcels of land for any purpose involving a group of two or more residential or nonresidential buildings, whether proposed initially or cumulatively, or a single nonresidential building on a lot, or lots regardless of the number of occupants or tenure, or the division or allocation of land or space between or among two or more existing or prospective occupants by means of or for the purpose of streets, common areas, leaseholds, condominiums, building groups, or other features, or a subdivision of land.

"Land disturbance": Any activity involving grading, tilling, digging, or filling or stripping of vegetation; or any other activity which causes land to be exposed to erosion.

"Maintenance": The upkeep necessary for efficient operation of physical properties.

"Municipality": Crescent Township, Findlay Township, Moon Township, Allegheny County; Hopewell Township, Beaver County, Pennsylvania.

"NRCS": The National Resources Conservation Service (formerly the Soil Conservation Service), U.S. Department of Agriculture.

"Outfall": The point or location at which stormwater leaves a site, which may include streams, storm sewers, swales or other well defined natural or artificial drainage features, as well as areas of dispersed overland flow.

"Outlet control structure": A structure designed to control the rate of stormwater runoff released from a detention system.

"Peak Discharge": The maximum rate of flow of water at a given point and time resulting from a specified storm event.

"Peak Flow": Maximum flow.

"Performance standard": A standard which establishes an end result or outcome which is to be achieved, but does not prescribe specific means for achieving it.

"Pervious": A surface which permits the passage or entrance of water or other liquid.

"Point of interest": A point of hydraulic concern such as a bridge, culvert, or channel section, for which the rate of runoff is computed or measured.

"Rate of runoff": The instantaneous rate of water flow, usually expressed in cubic feet per second.

"Release rate percentage": The percentage of predevelopment peak rate of runoff from a watershed subbasin (as delineated in the watershed plan), which defines the allowable post-development peak discharge from any development site in that subbasin.

"Retention Pond": A basin, usually enclosed by artificial dikes, that is used to retard stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate.

"Return Period": The average interval in years over which an event of a given magnitude can be expected to recur.

"Runoff": The part of precipitation which flows over the land.

"Runoff characteristics": The hydrologic, geologic, and land cover characteristics of any watershed which affect the rate, amount, and direction of stormwater runoff. These may include but are not limited to: vegetation, soils, slopes, and man-made landscape alterations.

"SCS": The Soil Conservation Service, U. S. Department of Agriculture.

"Sediment": Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site or origin by air, water, gravity, or ice and has come to rest on the earth's surface.

“Small development”: Any subdivision or land development which results (or will result when fully constructed) in the creation of 5,000 or less square feet of impervious surface area.

"Soil cover complex method": A method of runoff computation developed by the SCS and utilized in its publication, "Urban Hydrology for Small Watersheds", Technical Release No. 55, SCS, June, 1986 (or the most current edition).

"Storm sewer": A sewer that carries intercepted surface runoff, street water, and other drainage, but excluding domestic sewage and domestic wastes.

"Stormwater collection/conveyance system": Natural or engineered structures which collect and transport stormwater through or from a drainage area to the point of final outlet, including but not limited to, any of the following: conduits and appurtenant features, canals, channels, ditches, streams, culverts, streets, and pumping stations.

"Stormwater management plan": The plan for managing stormwater runoff from a specific development site.

"Stormwater runoff": Water generated in a drainage basin resulting from snow melt or precipitation events.

"Stormwater runoff volume": The quantity of water resulting from a storm event, usually expressed in cubic feet, acre feet, or inches over acreage of the watershed.

"Stream": A watercourse, whether perennial or intermittent.

"Subbasin": A portion of the watershed that has similar hydrologic characteristics and drains to a common point.

"Swale": A low-lying stretch of land which gathers or carries surface water runoff.

"Time of concentration": The time period necessary from surface runoff to reach the outlet of a subarea from, hydraulically, the most remote point in the tributary drainage area.

"Watercourse": Any channel for conveyance of surface water having a defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

"Watershed": The entire area drained by a river, stream, or other body of water whether natural or manmade. A "designated watershed" is an area delineated by the Pennsylvania Department of Environmental Protection.

"Watershed stormwater management plan": The plan for managing stormwater runoff throughout a designated watershed adopted by Allegheny County as required by the Pennsylvania Stormwater Management Act.

1.00.07 STORMWATER PLAN REQUIREMENTS.

(a) General Requirements. No final subdivision or land development plan shall be approved, no permit authorizing construction issued, or any earth-moving or land disturbance activity initiated until the final stormwater management plan for the development site is approved in accordance with the provisions of this article.

(b) Exceptions for Small Developments.

(1) At the time of application, the Municipality shall determine if the subdivision or land development qualifies as a "small development" and, therefore, is eligible for a simplified stormwater plan submission.

(2) Small developments shall be exempt from the preparation of a stormwater management plan as specified by subsections (c) and (d) hereof. However, such developments shall still provide safe management of stormwater runoff in accordance with the performance standard of Section 1.00.08(b) and as approved by the Municipal Engineer. Any stormwater management facilities constructed as part of the development shall be designed to control the peak stormwater runoff in accordance with Sections 1.00.08 and 1.00.09.

(3) Applications for small developments shall include a plan which describes, narratively and graphically, the type and location of proposed on-site stormwater management techniques or the proposed connection to an existing storm sewer system. The plan should show accurately site boundaries; contours at five-foot intervals for areas of greater than twenty-five percent (25%) slope gradient and at two-foot intervals for areas with less than twenty-five percent (25%) slope; location of watershed and/or subarea boundaries on the site (if applicable); and any watercourses, flood plains, or existing drainage facilities or structures located on the site.

(4) Stormwater management plans for small developments do not have to be prepared by a registered professional engineer or land surveyor. Whenever the submission of runoff calculations are required by the Municipal Engineer, they shall be prepared in accordance with Section 1.00.09.

(5) The Municipal Engineer shall review and approve the proposed provisions for stormwater management for a small development. Where the applicant is proposing to connect to an existing storm sewer, the applicant shall demonstrate that sufficient capacity exists in the storm sewer from the point of connection to the point of outlet in the natural drainage system. The Municipal Engineer shall determine if the proposed development site is part of a larger parcel or tract for which a stormwater management plan was approved previously and, therefore, subject to any specific stormwater management control contained in the prior plan.

(6) For a parcel or tract of land held under single ownership, only one application for a small development, as defined above, shall be permitted before requiring a stormwater management plan for the entire parcel.

(c) <u>Stormwater Plan Contents: Preliminary S/LD Plan Submission</u>.

(1) <u>General format</u>. The stormwater plan shall be prepared using the general requirements for plan format contained in the subdivision regulations with the following additions:

A. Watershed location. Provide a key map showing the development site location within the watershed and watershed subbasin(s) (consult Watershed Stormwater Plan for boundaries). On all site drawings, show the boundaries of the watershed(s) and (where applicable) subbasin(s) as they are located on the development site and identify watershed name(s) and subbasin number(s).

B. Flood plain boundaries. Identify 100-year flood plains on the development site (as appropriate), or determine the 100-year flood plain for any watercourse or water body on the development site.

C. Natural features. Show all bodies of water (natural and artificial), watercourses (permanent and intermittent), swales, wetlands, and other natural drainage features on the development site, or which shall be affected by runoff from the development.

D. Soils. Provide an overlay showing soil types and boundaries within development site.

E. Contours. Show existing and final contours at intervals of two feet; in areas with slopes greater than twenty-five percent (25%), five-foot contour intervals may be used.

F. Stormwater management controls. Show any existing stormwater management or drainage controls and/or structures, such as storm sewers, swales, culverts, etc. which are located on the development site, or which are located off-site but shall be affected by runoff from the development.

(2) Professional certification. The stormwater management plan (including all calculations) shall be prepared and sealed by a registered professional engineer, land surveyor or landscape architect, demonstrating competence in stormwater management, and who are qualified to make certification under the laws of Pennsylvania.

(3) Runoff calculations. Calculations and pertinent plans and drawings for estimating pre- and post-development discharge rates and for designing proposed stormwater control facilities shall be submitted with the stormwater management plan. All calculations shall be prepared using the methods and criteria prescribed by Section 1.00.08 and 1.00.09.

(4) Stormwater controls. All proposed stormwater runoff control measures shall be shown on the plan, including methods for collecting, conveying, and storing stormwater runoff on-site which are to be used both during and after construction. Erosion and sedimentation controls should be shown. The preliminary plan and accompanying drawings should provide information on the general type, location, layout, operation, and sizing of all proposed facilities and their relationship to the existing watershed drainage system.

(5) Easements, rights of way, deed restrictions. All existing and proposed easements and rights of way for drainage and/or access to stormwater control facilities shall be shown, and the proposed owner identified. Any areas subject to special deed restrictions relative to or affecting stormwater management on the development site must be shown.

(6) Other permits/approvals. A list of any approvals/permits relative to stormwater management that shall be required from other governmental agencies, such as, an obstructions permit from the Pennsylvania Department

of Environmental Protection, and anticipated dates of submission, receipt should be included with the preliminary plan submission. Copies of applications may be requested by the Municipality where they may be helpful for the stormwater plan review.

(7) Maintenance program. The preliminary application shall contain a proposed maintenance plan for all stormwater control facilities, in accordance with the following:

A. Identify the proposed ownership entity, such as Municipality, property owner, homeowner's association, or other management entity.

B. A maintenance program for all facilities, outlining the type of maintenance activities, probable frequencies, personnel and equipment requirements, and estimated annual maintenance costs; and

C. Identify the method of financing continuing operation and maintenance if the facility is to be owned by other than the Municipality or other governmental agency.

(d) Stormwater Plan Contents: Final S/LD Plan Submission.

(1) All information pertaining to stormwater management from the preliminary plan along with any changes.

(2) Final maps showing the exact nature and location of all temporary and permanent stormwater management controls along with design and construction specifications. Details for the construction of all facilities shall be included as part of the construction drawings.

(3) A schedule for the installation of all temporary and permanent stormwater control measures and devices.

(4) An accurate survey showing all current and proposed easements and rights of way and copies of all proposed deed restrictions.

(5) A maintenance program establishing ownership and maintenance responsibilities for all stormwater control facilities (identify specific person or entity) and detailing financial requirements and sources of funding. Submit any legal agreements required to implement the maintenance program and copies of the maintenance agreement as specified by Section 1.00.11(b).

(6) Financial guarantees, consistent with the subdivision regulations, to ensure that all stormwater controls are installed properly and functioning satisfactorily.

1.00.08 STORMWATER PLAN REVIEW PROCEDURES.

(a) Preliminary and Final Stormwater Plan Reviews.

(1) Requirements. Five sets of the stormwater management plans, in accordance with the requirements of Section 1.00.04, shall be submitted with the preliminary and final application.

(2) Review by Municipal Engineer and County. Preliminary and final plans shall be reviewed by the Municipal Engineer and the County.

(3) Review by County Planning. A copy of the preliminary plan, along with all runoff calculations, shall be forwarded by the Municipality to the Allegheny County Planning Department. A report of the findings shall be returned to the Municipality within thirty days. No plan shall be approved which receives a negative watershed impact review by the County.

(4) Notification of affected municipalities. When a plan is submitted for review, municipalities downstream of the proposed project shall be notified by the Municipality in writing. As part of the notification, a date shall be established by which any comments from the affected municipalities shall be received. Copies of the plans shall be made available to the municipalities upon request. Comments received shall be submitted to the Planning Commission and Governing Body.

(5) Municipal Engineer review. The Municipal Engineer shall approve or disapprove the preliminary and final stormwater management plan based on the requirements of the Municipality ordinances, the standards and criteria of the Watershed Stormwater Management Plan and good engineering practice. The Engineer shall submit a written report, along with supporting documentation, to the Municipality Planning Commission for consideration as part of the overall plan review.

(6) Municipal Engineer approval. The Municipal Engineer's decision to approve or disapprove a stormwater management plan shall be final.

(7) Approval. No preliminary or final approval for any application involving land disturbance shall be granted until a stormwater management plan for the site has been approved.

(8) Permits. Where the application requires an obstruction or erosion/ sedimentation control permit from the Pennsylvania Department of Environmental Protection, then final plan approval shall be contingent upon receipt of such permits. However, no building permit shall be issued, or construction started, until the permits are received and copies filed with the Municipality.

1.00.09 STORMWATER PLAN AFTER FINAL APPROVAL.

Upon recording of the final plat, the applicant may commence to install or implement the approved stormwater management controls, subject to the provisions of Section 1.00.05(b)(6). If site development or building construction does not begin within eighteen months of the date of the final approval of the plan, then before doing so, the applicant shall resubmit the stormwater management plans to verify that no condition has changed within the watershed that would affect the feasibility or effectiveness of the previously approved stormwater management controls. Furthermore, if for any reason development activities are suspended for eighteen months or more, then the same requirement for resubmission of the stormwater management plan shall apply. The terms of these subsequent reviews shall be subject to the provisions of the subdivision regulations.

1.00.10 STORMWATER PLAN MODIFICATION.

Requests for modifications of the final approved stormwater management controls shall be submitted to the Municipal Engineer as follows:

(a) If the request is initiated before construction begins, the stormwater plan shall be resubmitted and reviewed according to the procedures in Section 1.00.05.

(b) If the request is initiated after construction is underway, the Municipal Engineer shall have the authority to approve or disapprove the modifications, based on field inspection, provided the requested changes in stormwater controls do not result in any modifications to other approved Municipality land use/development requirements (such as required building setbacks, yards, etc.). A plan modification, in accordance with applicable Municipality procedures, shall be necessary if any such requirements are affected. The Municipal Engineer shall submit a record of all approved changes for the stormwater management controls to the Municipality prior to the acceptance of any improvements by the Municipality. Modifications shall not affect the compliance of the plan with the performance standards set forth in Section 1.00.08 and 1.00.09.

1.00.11 STORMWATER MANAGEMENT PERFORMANCE STANDARDS.

(a) Watersheds.

(1) For the purposes of stormwater management, the Municipality is divided into the following watersheds:

A. Flaugherty Run.

(1) The location and boundaries of the watersheds and subbasins are adopted as overlay districts to the Municipality Zoning Map and are shown on the map in the Watershed Stormwater Management Plan for the subject watershed.

(2) The release rate percentages, which shall be applied as stated in Figure 7-8 of the Watershed Stormwater Management Plan for the subject watershed; and

(3) The design criteria are given in the Appendix, Part B, of this model ordinance.

(b) General Performance Standards. The following provisions shall be considered the overriding performance standards against which all proposed stormwater control measures shall be evaluated, and they shall apply in all watersheds in the Municipality.

(1) Any landowner and any person engaged in the alteration or development of land which may affect stormwater runoff characteristics shall implement such measures as are reasonably necessary to prevent injury to health, safety, or other property.

(2) The stormwater management plan for the development site shall consider all the stormwater runoff flowing over the site, including runoff from upland and off-site areas.

(3) Where the existing storm sewers are reasonably accessible, proposed developments may be required to connect with the storm sewer system unless insufficient capacity or other reasons can be demonstrated to prevent the connection.

1.00.12 WATERSHED MANAGEMENT STANDARDS.

(a) Design Storms. The two, ten, 25- and 100-year design storm frequencies shall be used for analyzing stormwater runoff for pre- and post-development conditions as well a for designing runoff control facilities in all Municipality watersheds. The SCS twenty-four hour, Type II Rainfall Distribution shall be used for all analyses. The twenty-four hour rainfall volumes for each of these design storms is shown below:

Design Storm Frequency	Rainfall Depth in Inches
2-year	2.60
10-year	3.80
25-year	4.40
100-year	5.00

For additional information or data on other return periods, consult the SCS Publication Technical Release No. 55 (TR-55) or "Rainfall Duration Frequency Tables for Pennsylvania", published by The Pennsylvania Department of Environmental Resources, Office of Resource Management, Bureau of Dams and Waterways Management, Division of Stormwater Management, Harrisburg, Pennsylvania, February, 1983.

(b) Calculation Methods.

(1) Development sites. For the purposes of computing peak flow rates, runoff hydrographs and storage requirements for development sites, the SCS Soil Cover Complex Methods as presented in the most recent version of Technical Release 55 (TR-55) shall be used.

(2) Stormwater collection/conveyance systems. For the purposes of designing storm sewers, open swales, and other stormwater runoff collection and conveyance facilities, the Rational Method shall be applied. Rainfall Intensities for design shall be obtained from the Pennsylvania Department of Transportation Rainfall Charts unless otherwise specified by the Municipal Engineer.

(3) Predevelopment conditions. For the purposes of calculating predevelopment peak flow rates, all sites shall be considered to be in a heavily forested cover type at the time of development.

(c) Release Rate Percentage.

(1) Application. All subdivisions and land development activities which result in an increase in the peak rate, quantity, velocity, or direction of stormwater runoff from any outfall on the development site shall be subject to the release rate percentage for the watershed subbasin in which the site (or outfall) is located. A listing of the released rate percentage for each subbasin appears in Appendix A of the Model Ordinance.

(2) Definition. The release rate percentage defines the percentage of the pre-development peak rate of runoff that can be discharged from the site after development. It applies uniformly to all land developments or alterations within a subbasin, and the post-development rate of runoff discharged from the development site, including upland and off-site areas, cannot exceed the release rate percentage for the subbasin in which it is located.

(3) Procedure for use. The steps that shall be followed to use the release rate percentage for a particular development site are:

A. Identify from the map in the Watershed Stormwater Management Plan the specific subbasin(s) in which the development site is located, and obtain the subbasin release rate percentage(s) from Appendix A.

B. Compute the pre- and post-development runoff hydrographs for the site using the prescribed calculation method, for the two, ten, 25- and

100-year design storms, applying no on-site detention for stormwater management. If the post-development peak runoff rate is less than or equal to the allowable post-development peak runoff rate, then additional stormwater control shall not be required. If the post-development peak runoff rate is greater than the allowable post-development value, then stormwater detention shall be required and proceed to the next step in subsection (c) hereof.

C. Multiply the subbasin release rate percentage(s) by the predevelopment peak rate of runoff from the development site for each subbasin affected to find the allowable release rate from the development site for the two, ten, 25- and 100-year storm events.

(d) No Harm Evaluation.

(1) An applicant may seek to exceed the otherwise applicable subbasin release rate percentage by performing the "no harm evaluation" which requires an independent engineering analysis to demonstrate that other reasonable options exist to protect downstream areas from harmful storm runoff impacts.

(2) The "no harm evaluation" shall be prepared by a registered Professional Engineer experienced in hydrology and hydraulics, in accordance with the procedure contained in Appendix E of the Watershed Plan.

(3) The analysis for the "no harm evaluation" shall be submitted to the Municipal Engineer and the County for review and approval.

1.00.13 EROSION AND SEDIMENTATION CONTROLS.

(a) Erosion and sedimentation controls shall be provided, both during and after construction, in accordance with Municipal regulations and Chapter 102, "Clean Streams Law.".

(b) Proposed erosion and sedimentation controls should be submitted with the stormwater management plan as part of the applicant's preliminary plans.

(c) Prior to the initiation of grading, a letter from the County Conservation District approving the erosion and sedimentation control plan shall be submitted.

1.00.14 MAINTENANCE OF STORMWATER CONTROL FACILITIES.

(a) Maintenance Responsibilities.

(1) The stormwater management plan for the development site shall establish responsibilities for the continuing operation and maintenance of all proposed stormwater control facilities.

(2) The Governing Body shall make the final determination of the continuing maintenance responsibilities as part of the final application review based on the recommendation of the Planning Commission. The Governing Body reserves the right to accept or reject the ownership and operating responsibility of any or all of the stormwater management controls.

(b) Maintenance Agreement.

(1) Prior to final approval of the stormwater management plan for the site, the property owner shall sign and record a maintenance agreement covering all stormwater control facilities which are to be privately owned. The agreement shall have the following stipulations:

A. The owner shall maintain all facilities in accordance with the approved maintenance schedule and shall keep all facilities maintained in a safe and attractive manner.

B. The owner shall convey to the Municipality easements and/or rights of way to assure access for periodic inspections by the Municipality and maintenance if required.

C. The owner shall keep on file with the Municipality the name, address, and telephone number of the person or company responsible for maintenance activities. In the event of a change, new information shall be submitted to the Municipality within ten days of the change.

D. The owner shall establish any special maintenance funds or other financing sources, in accordance with the approved maintenance plan.

E. If the owner fails to maintain the stormwater control facilities, following due notice by the Municipality to correct the problems, the Municipality shall perform the necessary maintenance or corrective work. The owner shall reimburse the Municipality for all costs.

(2) Other items may be included in the agreement where determined necessary to guarantee the satisfactory maintenance of all facilities. The maintenance agreement shall be subject to the review and approval of the Municipal Solicitor.

1.00.15 INSPECTIONS OF STORMWATER MANAGEMENT CONTROLS.

(a) The Municipal Engineer or a designated representative shall inspect the construction of the temporary and permanent stormwater management controls for the development site. The permittee shall notify the Municipality forty-eight hours in advance of the completion of the following key development phases:

(1) At the completion of preliminary site preparation, including stripping of vegetation, stockpiling of topsoil, and construction of temporary stormwater management and erosion control facilities;

(2) At the completion of rough grading, but prior to placing topsoil, permanent drainage or other site development improvements and ground covers;

(3) During construction of the permanent stormwater facilities at such times as specified by the Municipal Engineer;

(4) At the completion of permanent stormwater management facilities, including established ground covers and plantings; and

(5) At the completion of any final grading, vegetative control measures, or other site restoration work done in accordance with the approved plan and permit.

(b) No work shall commence on any subsequent phase until the preceding one has been inspected and approved. If there are deficiencies in any phase, the Municipal Engineer shall issue a written description of the required corrections and stipulate the time by which they shall be made.

(c) If, during construction, the contractor or permittee identifies any site conditions, such as subsurface soil conditions, alterations in surface or subsurface drainage, which could affect the feasibility of the approved stormwater facilities, he shall notify the Municipal Engineer within twenty-four hours of the discovery of such condition and request a field inspection. The Municipal Engineer shall determine if the condition requires a stormwater plan modification.

(d) In cases where stormwater facilities are to be installed in areas of landslide-prone soils, or where other special site conditions exist, the Municipality may require special precautions, such as soil tests and core borings, full-time resident inspectors and/or similar measures. All costs of any such measures shall be borne by the permittee.

1.00.16 MUNICIPAL LIABILITY DISCLAIMER.

(a) Neither the granting of any approval under the stormwater management provisions of this section, nor the compliance with the provisions of this section, or with any conditions imposed by a Municipal official hereunder, shall relieve any person from any responsibility imposed by law.

(b) The granting of a permit which includes any stormwater management facilities shall not constitute a representation, guarantee, or warranty of any kind by the Municipality, County, or by an official, employee, or consultant thereof, of the practicability or safety of any structure, use, or other plan proposed, and shall create no liability upon or cause of action against such designated representative, official, employee, or consultant for any damage that may result pursuant thereto.

1.00.17 REMEDY.

(a) Enforcement Remedies.

(1) Any person, who has violated or knowingly permitted the violation of the provisions of this Ordinance shall, upon being found liable therefor in a civil enforcement proceeding commenced by the municipality, pay a fine of not less than $50.00 and not more than $500.00 plus court costs, including reasonable attorney fees incurred by the municipality. No judgement shall commence or be imposed, levied or be payable until the date of the determination of a violation by the district justice.

(2) If the defendant neither pays nor timely appeals the judgement, the municipality may enforce the judgement pursuant to applicable rules of civil procedure.

(3) Each day that a violation continues shall constitute a separate violation unless the district justice further determines that there was a good faith basis for the person violating the ordinance to have believed that there was no such violation. In such case there shall be deemed to have been only one such violation until the fifth day following the date of the district justice's determination of a violation; thereafter each day that a violation continues shall constitute a separate violation.

(4) All judgements, costs and reasonable attorney fees collected for the violation of this Ordinance shall be paid over to the municipality.

(5) The court of common pleas, upon petition, may grant an order of stay, upon cause shown, tolling the per diem fine pending a final adjudication of the violation and judgement.

(6) Nothing contained in this section shall be construed or interpreted to grant to any person or entity other than the municipality the right to commence any action for enforcement pursuant to this section.

(b) Additional remedies. In addition to the above remedies, the municipality may also seek remedies and penalties under applicable Pennsylvania statutes, or regulations adopted pursuant thereto, including but not limited to the Storm Water Management Act (32 P.S. Section 693.1-693.27) and the Erosion and Sedimentation Regulations (25 Pennsylvania Code, Chapter 102). Any activity conducted in violation of this ordinance or any Pennsylvania approved watershed stormwater management plan may be declared a public nuisance by the municipality and abatable as such.

(c) In addition to other remedies, the municipality may institute and maintain appropriate actions by law or in equity to restrain, correct or abate a violation, to prevent unlawful construction, to recover damages and to prevent illegal occupancy of a building or premises.

(d) In accordance with the Planning Code (Sec. 515.1), the municipality may refuse to issue any permit or grant approval to further improve or develop any property which has been developed in violation of this chapter.

1.00.18 RIGHT-OF-ENTRY.

Upon presentation of proper credentials, duly authorized representatives of the municipality may enter at reasonable times upon any property to investigate or ascertain the condition of the subject property in regard to an aspect regulated by this ordinance.

1.00.19 NOTIFICATION.

In the event that the applicant, developer, owner or his/her agent fails to comply with the requirements of this ordinance or fails to conform to the requirements of any permit, a written notice of violation shall be issued. Such notification shall set forth the nature of the violation(s) and establish a time limit for correction of the violation(s). Upon failure to comply within the time specified, unless otherwise extended by the municipality, the applicant, developer, owner or his/her agent shall be subject to the enforcement remedies of this ordinance.

APPENDIX
STORMWATER MANAGEMENT
TECHNICAL REQUIREMENTS

A. NO HARM EVALUATION.

The procedure for performing the no-harm evaluation for the Flaugherty Run watershed is presented in Appendix E of the Stormwater Management Plan, and is generally described as follows:

1. Perform an on-site stormwater management analysis to compare peak flow discharges from the site for pre- and post-development conditions.

2. Identify the discharge control points, as shown in Appendix E, Table E.1 of the Watershed Plan, which are downstream of the proposed development site and at which the existing peak flow from the subbasin in which the development site is located is greater than ten percent (10%) of the watershed peak flow rate at that point. These points of interest so identified shall be used for comparison in subsequent steps of the no-harm evaluation.

3. Compute the pre- and post-development peak rate of run-off for the subbasin in which the development site is located for the 2-, 10-, 25- and 100-year design storms, using the PSRM method. Peak flows should match within ten percent (10%) of the peak flows reported in the Watershed Plan.

4. Using the same method of calculation, determine the pre- and post-development peak flow rate at the points of interest identified in Step 1. For determining the contributing flow of subbasins (other than that in which the development is located) at a point of interest, the applicant shall use the existing conditions runoff hydrograph for that subbasin as presented in the Watershed Plan.

5. When the computing post-development discharges for the 2-, 10-, 25- and 100-year storms at all designated points of interest do not exceed the computed pre-development discharges at the same points, then the applicant shall have demonstrated, within reasonable limits, that no harm or adverse effects shall occur downstream.

B. DESIGN CRITERIA FOR STORMWATER MANAGEMENT FACILITIES.

1. General Design Guidelines.

   a. Applicants may select runoff control techniques, or combinations of techniques, which are most suitable to control stormwater runoff from the development site. All controls are subject to the approval of the

Municipal Engineer. The engineer may request specific information on the design and/or operating features of the proposed stormwater controls in order to determine their suitability and adequacy in terms of the standards of this Code.

b. In selecting and designing stormwater management systems and controls, applicants may be guided by the following references:

1) "Urban Hydrology for Small Watersheds", Technical Release No. 55, USDA, Soil Conservation Service, 1975 (or most recent edition).

2) "Soil Erosion and Sedimentation Control Manual", Pennsylvania Department of Environmental Resources, March 1982.

3) "Standards and Specifications for Soil Erosion and Sediment Control", Maryland Water Resources Administration, 1983.

4) "Urban Stormwater Management", Special Report No. 49, American Public Works Administration, 1981.

5) "Water Resources Protection Measures in Land Development - A Handbook", University of Delaware Water Resources Center, April 1974.

6) "Design and Construction of Sanitary and Storm Sewers", WPCF Manual of Practice No. 9, Water Pollution Control Federation, 1970.

c. Methods of Stormwater Runoff Detention and Control: The following is a list of detention and control methods which may be used in stormwater management systems, if appropriate. The choice of control techniques is not limited to those appearing on this list.

1) Detention Basins - see standards in Section B.2., “Criteria for Stormwater Detention Facilities”, of this Appendix.

2) Roof-top storage.

3) Parking lot and street storage.

4) Seepage pits, seepage trenches, level spreaders, or other infiltration structures.

5) Porous pavement and concrete lattice block surfaces.

6) Grassed channels and vegetated strips.

7) Routed flow over grass.

8) Decreased impervious area coverage.

The use of other control methods which meet the criteria in this section shall be permitted when approved by the Municipal Engineer. Various combinations of methods should be designed to suit the particular requirements of the type of development and the topographic features of the project area.

d. Maintenance of Natural Drainage Ways: All natural streams, channels, swales, drainage systems, and/or areas of surface water concentration shall be maintained in their existing condition unless an alteration is approved by the Municipality. All encroachment activities shall comply with the requirements of Chapter 105 (Water Obstructions and Encroachments) of Title 25, Rules and Regulations of the Pennsylvania Department of Environmental Protection.

e. The applicant should consider the effect of the proposed stormwater management techniques on any special soils conditions or geological hazards which may exist on the development site. In the event such conditions are identified on the development site, the Municipality may require in-depth studies by a competent geotechnical engineer.

f. If the performance of a stormwater management control is dependent upon specific soil or geologic conditions at the site, an in-depth site-specific study by a competent geotechnical engineer, soil scientist, or hydrogeologist should be conducted to demonstrate that the conditions required for adequate performance of the control will exist.

2. Criteria for Stormwater Detention Facilities.

a. If detention facilities are utilized for the development site, the facility(s) shall be designed such that the post-development peak runoff rates from the developed site are controlled to those rates defined by the subbasin release rate percentage or no harm evaluation for the 2-, 10-, 25- and 100-year design storms.

b. All detention facilities shall be equipped with outlet structures to provide discharge control for the 2-, 10-, 25- and 100-year storm frequencies. Provisions shall also be made for auxiliary structures that are capable of passing the post-development 100-year storm runoff flows without damaging the facilities.

c. Shared storage facilities, which provide stormwater detention for more than development site, may be considered within a single subbasin. Such facilities shall meet the design criteria contained in this section. In addition, runoff from the development sites involved shall be conveyed to the facility in a manner so as to avoid adverse impacts, such as flooding or erosion, to channels and properties located between the development site and the shared storage facilities.

d. Where detention facilities are used, the design of multiple-use facilities, such as ballfields or similar recreational uses, is encouraged wherever feasible.

e. As a general rule, detention facilities shall be designed as dry basins, although wet facilities shall be considered in specific situations where they can be shown to represent a significant amenity to the development and/or the Municipality.

f. Except in approved wet basins, stormwater detention basins shall be designed to drain completely. All interior portions of the basin shall slope toward the outlet or low flow sluice at a minimum slope of two percent (2%).

g. In general, facilities should be designed to have design water depths as shallow as possible.

h. All detention facilities involving an earth embankment shall be designed with a minimum free board of one foot between the peak emergency spillway design flow elevation and the top of the embankment.

I. All embankments shall be designed according to sound engineering practice for such structures and shall meet the approval of the Municipality. Facilities with a design water depth in excess of ten feet shall require a supporting report from a Professional Engineer experienced in the design of earth embankments, and shall be constructed under the supervision of the Engineer.

j. The outside slopes of the embankment shall not exceed two horizontal to one vertical. The interior slopes of the structure within the pool area should not exceed a slope of three horizontal to one vertical.

k. Except where special erosion protection measures are provided, all disturbed areas shall be graded evenly, topped with four inches of topsoil, fertilized, seeded, and mulched by methods approved by the Municipality.

l. Each inlet and outlet to the facility shall be provided with erosion control measures approved by the Municipality.

m. Outlet control structures shall be constructed of reinforced concrete (cast-in-place, precast, or block) and provided with debris grades approved by the Municipal Engineer.

n. All impoundment areas shall be adequately underdrained to prevent long term ponding of water.

o. All detention facilities shall be provided with an access road (with a legal easement) for maintenance purposes. Such roads shall be a minimum of ten feet wide and have a maximum grade of fifteen percent (15%).

p. Control and removal of debris both in the storage facility and in all inlet or outlet devices shall be a design consideration.

q. Inflow and outflow structures, pumping stations, and other structures shall be protected and designed to minimize safety hazards.

r. Landscaping shall be provided for the facility which harmonizes with the surrounding area.

s. An as-built drawing shall be required for each stormwater detention facility constructed. The drawing shall represent an engineering certification of the volume of the facility and the depth versus storage relationship. This relationship shall be shown on the drawing in table form. The drawing shall be stamped by a registered Professional Engineer and submitted to the Municipality within sixty days of the completion of the facility. No facility shall be accepted until this requirement has been fulfilled.

3. Criteria for Collection/Conveyance Facilities.

a. As a general rule, no stormwater may be discharged to unprotected areas such as hillsides without special erosion and/or energy dissipation controls being installed. Stormwater shall either be conveyed to the nearest established stream channel as approved by the Municipal Engineer, or provided with an approved energy dissipation device. Conveyance shall be by pipe or erosion protected ditch.

b. The design for culverts, pipes, and other stormwater conveyance structures shall be consistent with the design of the other stormwater management facilities.

c. All sites shall be graded to provide drainage away from and around structures to prevent potential flooding damage.

d. Lots located on the hillside of streets shall extend roof and french drains to a properly sized storm sewer located within the street right of way. Low side lots may extend roof and french drains to a stormwater collection/conveyance system or natural watercourse in accordance with the approved stormwater management plan for the development site.

e. Collection/conveyance facilities should not be installed parallel and close to the top or bottom of major embankments to avoid the possibility of failing or causing the embankments to fail.

4. Criteria for Dry Sumps.

a. All dry sumps designed for accepting surface water from roof or driveway areas shall be designed according to the standard drawing shown in the Appendix unless other wise approved by the Municipal Engineer.

b. Each sump shall be designed to store a minimum water volume equivalent to two inches of water covering the tributary area. For example, a sump for a 1,200 square foot roof area would be designed to store a water volume of 200 cubic feet. The total storage area, assuming the sump is fifty percent (50%) rock and fifty percent (50%) voids, would be 400 cubic feet.

c. Dry sumps should be elongated in a minimum 3:1 length to width ratio and be oriented with the long dimension parallel to the contour.

d. Dry sumps shall be constructed in undisturbed ground only. No dry sumps shall be permitted in fill material.

e. The minimum distance between a dry sump and the property line shall be twenty feet.

f. Dry sumps shall not be permitted in or upslope of areas determined by the County or other competent person to be susceptible to landslides.

5. Disposal of Stormwater from Roof and Driveway Drains.

a. Unless otherwise approved by the Municipality, no stormwater from roofs or driveway drains shall be discharged to the street surface or curb underdrain.

b. Acceptable methods of disposal include properly designed dry sumps, grassed or other ground surfaces with adequate consideration being given to erosion protection, storm sewers, or any other method approved by the Municipality.

C. RELEASE RATE PERCENTAGES BY SUBAREA

Flaugherty Run Watershed

Region	Municipality	Release Rate Percentage
7	Moon, Findlay	80
15	Moon, Findlay	60
18	Moon	70
22	Moon	70
28	Moon	85
31	Moon, Findlay, Hopewell	70
37	Moon, Hopewell	85
39	Moon, Hopewell	70
42	Moon, Crescent	85
59	Moon, Crescent	95
60	Moon, Crescent	100

12.0 DISTRIBUTED STORAGE

Introduction

Distributed storage is a regional approach to stormwater management, utilizing an off-site facility(s) to serve a large area within the watershed. Distributed storage takes advantage of the timing differences which exist in the watershed to reduce downstream peak flood flows. Regional detention/retention facilities are the usual techniques for distributed storage. Strategically-situated regional SWM facilities may have several advantages over site SWM facilities, including lower total costs and operation and maintenance costs, enhanced land use, and more effective runoff control. The disadvantages of a regional facility include potentially greater capital costs and the need for effective cooperation and coordination among all of the watershed participants -- municipalities and developers.

The advantages of regional facilities frequently outweigh the disadvantages. Enhanced land use can be obtained directly by the elimination of individual site facilities, and indirectly, by incorporating water quality improvement, wetland replacement, and/or recreation into the regional facility's design. North Park Lake is an example of a regional facility which has both recreational and SWM functions.

Operation and maintenance costs are generally greatly reduced, and simplified, with the municipalities controlling a single facility instead of a myriad of facilities of varying designs, and operational and maintenance responsibilities. It is also much simpler to evaluate and control the operation (runoff control) of a single facility than of several facilities.

Conceptual Implementation

Distributed storage facilities may be owned and operated by one or more municipalities, or by a watershed entity akin to a water or sanitary sewer authority. There are advantages and disadvantages for any system of implementation, and the political realities generally influence the eventual outcome. One of the important considerations of a regional facility is how to assess charges or fees. The regional facility would benefit the entire watershed, not just the areas upstream and downstream. For example, the facility may possess some overcontrol capacity, which could then be used as credits to be utilized in portions of the watershed which are not tributary to the basin. However regional facility is implemented, an entity would be needed to handle financing, construction, operation and maintenance, and user fees or other funding.

Evaluation of Potential Distributed Storage Sites

Distributed storage facilities are most useful where they can best affect the timing characteristics in the watershed. This can be achieved by delaying the runoff from an area which would otherwise contribute significantly to downstream peak flows. The second consideration in the evaluation of potential sites is the potential for future development.

To maximize benefits, the facility should be located downstream of areas which are or are anticipated to be developed in the future. Whether sites meeting these characteristics would be practical would depend upon evaluation of existing site conditions.

A review of the Flaugherty Run watershed indicates that from a hydraulic timing standpoint, the upper Flaugherty Run subwatershed and the Boggs Run subwatershed would be potential sites. Since these two subwatersheds possess about 80 percent of the total watershed area, and their runoff peak flows nearly coincide, either or both subwatersheds would be acceptable candidates. Upon evaluation of the site conditions, the upper Flaugherty Run subwatershed is considered to be less acceptable, due to the presence of Flaugherty Run Road alongside the stream. Flaugherty Run Road is a major local transportation route, and relocation or alternate route costs would significantly increase the capital costs for a regional SWM facility. In the Boggs Run subwatershed, Boggs Run Road may preclude a suitable site on Boggs Run itself, but the tributaries of Boggs Run corresponding to basins 29, 30, 36, and 39 (see Figure 5-3) are considered to be candidates. A single regional facility would have the greatest impact on the largest basin, Basin 39, which has a drainage area of 398 acres (0.62 square mile), or approximately 7 percent of the total watershed, and 20 percent of the Boggs Run subwatershed. Basin 39 possesses the greatest potential of any basin for a regional SWM facility in the Flaugherty Run watershed, and is used to qualitatively assess the potential for a distributed storage facility.

<u>Evaluation of Basin 39</u>

A regional SWM facility in Basin 39 would have the ability to reduce downstream peak flood flows by 10-15 percent under existing conditions. Since the purpose of Act 167 is to prevent increases, and not to create decreases in downstream flood damage, this 10-15 percent reduction could be translated into credits which could be used upstream of the facility, downstream of the facility, or possibly even elsewhere in the watershed. The credits would permit a developer to employ a lesser degree of stormwater management at a site. The developer would pay an annual fee or charge for the credits, and in return would realize a reduced capital cost for SWM, reduced SWM operation and maintenance costs, and a greater return on his investment by the ability to utilize property that would otherwise be necessary for SWM.

The dollar value of the 10-15 percent reduction or credits would be dependent upon the costs associated with design, construction, operation, and maintenance of the regional facility, administrative costs, and the market value in relation to the use of on-site SWM facilities. An economic evaluation of this magnitude is beyond the scope of this plan. However, it is estimated that the capital costs of constructing the regional facility would be on the order of $1,000,000 to $1,500,000. Table 12.1 itemizes the major capital cost components. The economic and political feasibility of a regional facility in the Flaugherty Run watershed may be an avenue worth evaluation, considering the anticipated development in the watershed.

Table 12.1

ESTIMATED CAPITAL COSTS - REGIONAL SWM FACILITY

Component	Quantity	Component Cost
Land Acquisition	12 acres	$ 40,000
Land Preparation	12 acres	$ 40,000
Dam Construction	35,000 cy	$350,000
Discharge Structure	1	$200,000
Emergency Spillway	1	$500,000
Buildings, Roads, ...	1	$200,000

Additional Cost Components Not Quantified:

- Acquisition of Permits, Including Studies
- Engineering Design
- Wetlands Mitigation
- Administrative Costs for Responsible Entity
- Construction Monitoring and Supervision

91503s12.klf/cwi9

13.0 REFERENCES

1. "Soil Survey of Allegheny County, Pennsylvania," U.S. Department of Agriculture, Soil Conservation Service, August 1981.

2. "Soil Survey of Beaver and Lawrence Counties, Pennsylvania," U.S. Department of Agriculture, Soil Conservation Service, April 1982.

3. "National Wetland Inventory Maps, Aliquippa, Pennsylvania 11/82." U.S. Department of the Interior, Fish and Wildlife Service.

4. "National Wetland Inventory Maps, Ambridge, Pennsylvania 11/82," U.S. Department of the Interior, Fish and Wildlife Service.

5. GIS Database, Allegheny County Planning Department, 1992.

6. Climate of the States, Gale Research Company, Detroit, Michigan, 1980.

7. "Local Climatological Data. 1994. Annual Summary with Comparative Data, Pittsburgh, Greater Pittsburgh Airport," National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, North Carolina.

8. U.S. Geological Survey, Aliquippa Quadrangle, 7.5-Minute Series, 1954, Photorevised 1990.

9. U.S. Geological Survey, Ambridge Quadrangle, 7.5-Minute Series, 1960, Photorevised 1990.

10. "Moon Township Municipal Authority, Feasibility Study for the Flaugherty Run Watershed Treatment Plant Expansion," June 1990.

11. "Greater Pittsburgh International Airport Impact Area Plan," Allegheny County Planning Department, prepared by GAI Consultants, Inc., July 1988.

12. Unpublished Data, Southwestern Pennsylvania Regional Planning Commission, 1994.

13. "Flood Insurance Study, Crescent Township, Allegheny County, Pennsylvania", Flood Insurance Administration, 1981.

14. "Flood Insurance Study, Moon Township, Allegheny County, Pennsylvania," Flood Insurance Administration, 1979.

15. "Flood Insurance Study, Findlay Township, Allegheny County, Pennsylvania," Flood Insurance Administration, 1988.

16. "Flood Insurance Study, Hopewell Township, Beaver County, Pennsylvania," Flood Insurance Administration.

17. "Flood-Prone Area Map, Ambridge, Pennsylvania," U.S. Geological Survey, 1974.

18. "Flood-Prone Area Map, Aliquippa, Pennsylvania," U.S. Geological Survey, 1969.

19. "Urban Hydrology for Small Watersheds" Soil Conservation Service Technical Release No. 55 (TR-55), Second Edition, U.S. Department of Agriculture, June 1985.

20. "Penn State Runoff Model," G. Aron and D. F. Lakatos, Pennsylvania State University, Water Resources Program, Department of Civil and Environmental Engineering, 1992, 1995.

21. Soil and Water Conservation Engineering, Schwab, et al., Second Edition, J. Wiley and Sons, Inc., New York, 1966.

22. "Rainfall-Duration - Frequency Tables for Pennsylvania," Pennsylvania Department of Environmental Resources, Division of Storm Water Management and Sediment Control.

23. "Hydraulic Design of Highway Culverts," Federal Highway Administration, Hydraulic Design Series No. 5 (HDS-5), September 1985.

24. Lehigh-Northampton Counties Joint Planning Commission," Little Lehigh Creek Watershed Act 167 Storm Water Management Plan," March 1988.

25. Allegheny County and Westmoreland County Planning Departments, "Turtle Creek Act 167 Stormwater Management Plan (Draft)," prepared by Chester Engineers, 1990.

26. "Modeling of Infiltration from Trenches for Storm-Water Control," M. Duchene, E. McBean, and N. Thomson, Journal of Water Resources Planning and Management, Volume 120, No. 3, May/June 1994, pp. 276-293.

27. "Engineering Field Manual for Conservation Practices," Soil Conservation Service, United Stated Department of Agriculture, 1979.

28. "Storm Water Management Guidelines and Model Ordinances," Commonwealth of Pennsylvania, Department of Environmental Resources, Office of Resources Management, Bureau of Dams and Waterways Management, Division of Waterways and Storm Water Management.

APPENDIX A

MUNICIPAL QUESTIONNAIRE

FLAUGHERTY RUN WATERSHED
STORMWATER MANAGEMENT STUDY
MUNICIPAL ORDINANCE SUMMARY

		STATUS OF MUNICIPAL ORDINANCES						
MUNICIPALITY	COUNTY	SUBDIVISION/ LAND DEVEL.	BUILDING CODE	GRADING	FLOOD PLAIN	STORMWATER MANAGEMENT	OTHER RELEVANT ORDINANCES	COMPREHENSIVE PLAN
Crescent	Allegheny	✓	✓	✓	—	—		✓
Findlay	Allegheny	'91, 3/6/92	BOCA '84/86 upgrading to '94	9/4/83 see also zoning	11/9/88 overlap w/ zoning	10/10/90		'90
Moon	Allegheny	✓	✓			✓		
Hopewell	Beaver							

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FLAUGHERTY RUN WATERSHED
STORMWATER MANAGEMENT STUDY
EXISTING MUNICIPAL ORDINANCE MATRIX

EXISTING REGULATORY CONTROLS	MUNICIPALITY			
	CRESCENT	FINDLAY	MOON	HOPEWELL
Land Use Planning Standards	zoning	zoning	✓	zoning
Storm Water Control Provisions	in other ord.	SWM ord	SWM ord. 2yr - 25 yr	in other ord
Rate of Runoff Standard	—	Act 167 & non Act 167	Act 167 & non Act 167	— ?
Specific Calculation Method	—	SCS TR-55	SCS TR-55, Rational (small)	— ?
Design Standard for Stormwater Controls	pre- & post-	varies - Act 167 & non Act 167	varies - Act 167 & non Act 167	— ?
Erosion & Sedimentation Controls	Co & SCS	Co & SCS	Co & SCS	Co & SCS
Plan Review Process	elsewhere	✓	✓	elsewhere
Fees		ordinance	ordinance	
Inspection Schedule	—	✓	✓.	
Maintenance Provisions	by developer	✓	—	?

Moon: 2yr, 5yr, 10yr, 25yr for non-Act 167 watersheds and 100-yr for Montour Run (Act 167)

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3/30/94

MUNICIPALITY QUESTIONNAIRE

Please fill out the following questionnaire. If you have any questions or comments please contact

Please return the completed questionnaire to:

PART I - GENERAL INFORMATION

Municipality: CRESCENT TOWNSHIP County: ALLEGHENY

Municipal contact person: Name: THELMA STUCKE

Title: SECRETARY/MANAGER/ZONING OFFICER

Address: CRESCENT TOWNSHIP BLDG SPRING RUN ROAD

Phone: ____________

Person completing: Name: ____________

Address: ____________

Phone: ____________

Watershed Advisory Committee Designee ____________

PART II

Using the matrix on the following page, please indicate the items you currently use for regulatory enforcement of municipal ordinances/county regulations and for your subdivision and land development review process.

Thelma Stucke - Planning Commission (Since 1971)
Rich Borgetti - Engr
Dave Meredith
DF
KF
AB

Please attach copies of all ordinances with provisions addressing the matrix's activities, e.g. zoning and stormwater runoff.

Crescent Township
3/30/94

PART II - REGULATING ACTIVITIES

	Agency \ Activities	A Subdivision/ Land Development	B Zoning	C Erosion and Sediment	D Stormwater Runoff	E Floodplain Management	F Building	G Grading	H Sewage
1	Governing Body	✓	✓	✓					
2	Municipal Planning Commission	✓	✓	✓	✓	✓			
3	County Planning Commission	✓	✓	—					
4	County Conservation	✓	—	✓					
5	Municipal Manager/ Staff	✓	✓	✓					
6	Municipal Engineer (in-house)	N/A							
7	Municipal Authority – Water	✓	—	—					
	Municipal Authority – Sewer	✓	—	—					✓
8	Private Utility	—	—						
9	Fire Company	—	—						
10	Police Officers	—	—						
11	Zoning Officer	✓	✓	✓			✓	✓	
12	Sewage Enforcement Officer	NONE							
13	Building Codes Officer	✓	✓	✓	✓	✓	✓	✓	
14	Consulting Engineer	✓	✓	✓	✓	✓		✓	

CRESCENT TOWNSHIP
3/30/94

PART III - MUNICIPAL AND LOCAL PLANNING ACTIVITIES

Please indicate below whether your community has the corresponding plans and maps and the date of the most recent update.

Item	Date
PA Act 537 Sewage Facilities Plan	?
Comprehensive Land Use Plan	✓ 1971
Existing Land Use Maps	✓ 1971
Proposed Land Use Maps	No —
Existing Zoning Maps	✓ ~1988
Proposed Zoning Maps	No

Please include copies of all available land use and zoning maps.

PART IV - FLOOD INSURANCE PROGRAM AND COMPREHENSIVE LAND USE PLAN

Please indicate below whether your community participates in the National Flood Insurance Program and if your community has adopted a Comprehensive Land Use Plan.

Item		CHECK ONE Yes	No
Flood Hazard Boundary Map (FHBM)		✓	
Participate in FEMA Emergency Program	?		
Participate in FEMA Regular Program		✓	
Comprehensive Land Use Plan		✓	

PART V - EXISTING STORMWATER RELATED PROBLEMS

CRESCENT TOWNSHIP
3/30/94

		NATURE/TYPE OF PROBLEM									CAUSE OF PROBLEM								FREQUENCY				
#	Problem Area Location	Channel/Stream Flooding	Street/Intersection Flooding	Parking Lot Flooding	Private Property Flooding	Erosion (Soil Washoff)	Sedimentation	Water Pollution	Groundwater	Other (Explain under Comments)	Obstruction of Flow	Increased Runoff Due to Development	Excessive Velocities	Lack of Storm Drain Facilities	Number/Spacing of Storm Inlets	Roadway Improvements	Inadequate Drainage Patterns	Other (Explain under Comments)	1 Time Per Year	More Than 1 Time Per Year	Less Than 1 Time Per Year	Every Significant Rainfall	Comments*
1		✓				✓				✓		✓											Pordy Rd, runoff from Broadhead downhill – stream & property degradation
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							

* If additional comments are provided , please use a blank page. The additional comments should be labeled with the Problem A[illegible] [illegible]eference and the sheet should be attached to the questionnaire when it is returned.

2/11/94

MUNICIPALITY QUESTIONNAIRE

Please fill out the following questionnaire. If you have any questions or comments please contact
Please return the completed questionnaire to:

PART I - GENERAL INFORMATION

Municipality: Findlay Township | County: Allegheny

Municipal contact person: | Name: Gary Klingman/Chris Caruso
Title: Manager/
Address: Township Bldg Route 30
Clinton
Phone: 724/412 695 0500

Person completing: | Name: ______
Address: ______
______
Phone: ______

Watershed Advisory Committee Designee Mr. Ray Chappell

PART II

Using the matrix on the following page, please indicate the items you currently use for regulatory enforcement of municipal ordinances/county regulations and for your subdivision and land development review process.

Please attach copies of all ordinances with provisions addressing the matrix's activities, e.g. zoning and stormwater runoff.

Findlay Township

PART II - REGULATING ACTIVITIES

	Agency / Activities	A Subdivision/ Land Development	B Zoning	C Erosion and Sediment	D Stormwater Runoff	E Floodplain Management	F Building	G Grading	H Sewage
1	Township Governing Body	✓	✓	✓	✓	✓	✓	✓	✓
2	Municipal Planning Commission								
3	County Planning Commission								
4	County Conservation			✓					
5	Municipal Manager/ Staff								
6	Municipal Engineer (in-house)								
7	Municipal Authority								
8	Private Utility	water authority only private water company			private treatment plant				✓
9	Fire Company								
10	Police Officers								
11	Planning/ Zoning Officer								
12	Sewage Enforcement Officer								Chester & Allegheny County
13	Building Codes Officer								
14	Consulting Engineer (Baker)	✓	✓	✓	✓	✓	✓	✓	✓

Zoning Hearing Board – no variances for SW
– variances for zoning

PART III - MUNICIPAL AND LOCAL PLANNING ACTIVITIES

Findlay Township

Please indicate below whether your community has the corresponding plans and maps and the date of the most recent update.

Item	Date
PA Act 537 Sewage Facilities Plan	Jan '94
Comprehensive Land Use Plan	'90
Existing Land Use Maps	'90
Proposed Land Use Maps	'90
Existing Zoning Maps	'91 / '95
Proposed Zoning Maps	

Please include copies of all available land use and zoning maps.

PART IV - FLOOD INSURANCE PROGRAM AND COMPREHENSIVE LAND USE PLAN

Please indicate below whether your community participates in the National Flood Insurance Program and if your community has adopted a Comprehensive Land Use Plan.

Item	CHECK ONE Yes	No
Flood Hazard Boundary Map (FHBM)	✓	
Participate in FEMA Emergency Program		✓
Participate in FEMA Regular Program	✓	
Comprehensive Land Use Plan	✓	

PART V - EXISTING STORMWATER RELATED PROBLEMS

		NATURE/TYPE OF PROBLEM									CAUSE OF PROBLEM								FREQUENCY				Findlay Township
#	Problem Area Location	Channel/Stream Flooding	Street/Intersection Flooding	Parking Lot Flooding	Private Property Flooding	Erosion (Soil Washoff)	Sedimentation	Water Pollution	Groundwater	Other (Explain under Comments)	Obstruction of Flow	Increased Runoff Due to Development	Excessive Velocities	Lack of Storm Drain Facilities	Number/Spacing of Storm Inlets	Roadway Improvements	Inadequate Drainage Patterns	Other (Explain under Comments)	1 Time Per Year	More Than 1 Time Per Year	Less Than 1 Time Per Year	Every Significant Rainfall	Comments*
1																							
2																							nothing within Claugherty
3																							Run watershed
4																							(only small area
5																							w/in watershed)
6																							
7																							
8																							
9																							
10																							
11																							

* If additional comments are provided , please use a blank page. The additional comments should be labeled with the Problem Area for reference and the sheet should be attached to the questionnaire when it is returned.

MUNICIPALITY QUESTIONNAIRE

Please fill out the following questionnaire. If you have any questions or comments please contact
Please return the completed questionnaire to:

PART I - GENERAL INFORMATION

Municipality: Moon Township County: Allegheny

Municipal contact person: Name: Greg Smith

Title: Township Manager

Address: 1000 Beaver Grade Rd
Coraopolis

Phone: 412 262 1000

Person completing: Name: ______

Address: ______

Phone: ______

Watershed Advisory Committee Designee Jack Griffin Planning Director

PART II

Using the matrix on the following page, please indicate the items you currently use for regulatory enforcement of municipal ordinances/county regulations and for your subdivision and land development review process.

Larry Souleret - Engr (Consultant)
Greg Smith
Jack Griffin - Planning Director

DF
KF
AB

Please attach copies of all ordinances with provisions addressing the matrix's activities, e.g. zoning and stormwater runoff.

PART II - REGULATING ACTIVITIES

		A	B	C	D	E	F	G	H
	Activities / Agency	Subdivision/ Land Development	Zoning	Erosion and Sediment	Stormwater Runoff	Floodplain Management	Building	Grading	Sewage
1	Governing Body								
2	Municipal Planning Commission								
3	County Planning Commission								
4	County Conservation								
5	Municipal Manager/ Staff								
6	Municipal Engineer (in-house)								
7	Municipal Authority								
8	Private Utility								
9	Fire Company								
10	Police Officers								
11	Zoning Officer								
12	Sewage Enforcement Officer								
13	Building Codes Officer								
14	Consulting Engineer								

PART III - MUNICIPAL AND LOCAL PLANNING ACTIVITIES

Please indicate below whether your community has the corresponding plans and maps and the date of the most recent update.

Item	Date
PA Act 537 Sewage Facilities Plan	
Comprehensive Land Use Plan	'92
Existing Land Use Maps	'92
Proposed Land Use Maps	pending
Existing Zoning Maps	10/90
Proposed Zoning Maps	—

Please include copies of all available land use and zoning maps.

PART IV - FLOOD INSURANCE PROGRAM AND COMPREHENSIVE LAND USE PLAN

Please indicate below whether your community participates in the National Flood Insurance Program and if your community has adopted a Comprehensive Land Use Plan.

Item	CHECK ONE Yes	No
Flood Hazard Boundary Map (FHBM)	✓	
Participate in FEMA Emergency Program		
Participate in FEMA Regular Program	✓	
Comprehensive Land Use Plan	✓	

PART V - EXISTING STORMWATER RELATED PROBLEMS

#	Problem Area Location	NATURE/TYPE OF PROBLEM									CAUSE OF PROBLEM								FREQUENCY				Comments*
		Channel/Stream Flooding	Street/Intersection Flooding	Parking Lot Flooding	Private Property Flooding	Erosion (Soil Washoff)	Sedimentation	Water Pollution	Groundwater	Other (Explain under Comments)	Obstruction of Flow	Increased Runoff Due to Development	Excessive Velocities	Lack of Storm Drain Facilities	Number/Spacing of Storm Inlets	Roadway Improvements	Inadequate Drainage Patterns	Other (Explain under Comments)	1 Time Per Year	More Than 1 Time Per Year	Less Than 1 Time Per Year	Every Significant Rainfall	
1																							problems @ bridges
2																							mainly - PADER did
3																							stream rehab w/ gabions
4																							in 1984
5																							Becks Run area
6																							
7																							
8																							
9																							
10																							
11																							

* If additional comments are provided , please use a blank page. The additional comments should be labeled with the Problem Area for reference and the sh[illegible] hou[illegible] att[illegible]d t[illegible] qu[illegible]nnai[illegible] when [illegible] ret[illegible]d.

MUNICIPALITY QUESTIONNAIRE

Please fill out the following questionnaire. If you have any questions or comments please contact

Please return the completed questionnaire to: mtg w/ Beaver County Planning Department

PART I - GENERAL INFORMATION

Municipality: Hopewell

County: Beaver

Municipal contact person:

Jim Eichenlaub
USAir Accident
mtg postponed

Name: Jim Eichenlaub

Title: __________

Address: __________

Phone: __________

Person completing:

Name: __________

Address: __________

Phone: __________

Watershed Advisory Committee Designee __________

PART II

Using the matrix on the following page, please indicate the items you currently use for regulatory enforcement of municipal ordinances/county regulations and for your subdivision and land development review process.

INSTRUCTIONS

Please use the following codes to provide information

[illegible] reviews plans
[illegible] enforces regulations

(See explanation on following page)

Please attach copies of all ordinances with provisions addressing the matrix's activities, e.g. zoning and stormwater runoff.

MUNICIPALITY QUESTIONNAIRE

Please fill out the following questionnaire. If you have any questions or comments please contact

Please return the completed questionnaire to:

PART I - GENERAL INFORMATION

Municipality: HOPEWELL TOWNSHIP County: BEAVER

Municipal contact person: Name: Jim Eichenlaub

Title: Planning

Address: ____________

Phone: ____________

Person completing: Name: ____________

Address: ____________

Phone: ____________

Watershed Advisory Committee Designee ____________

PART II

Using the matrix on the following page, please indicate the items you currently use for regulatory enforcement of municipal ordinances/county regulations and for your subdivision and land development review process.

Please attach copies of all ordinances with provisions addressing the matrix's activities, e.g. zoning and stormwater runoff.

PART II - REGULATING ACTIVITIES

Hopewell Township (Beaver Co)

	Agency / Activities	A Subdivision/ Land Development	B Zoning	C Erosion and Sediment	D Stormwater Runoff	E Floodplain Management	F Building	G Grading	H Sewage
1	Governing Body								
2	Municipal Planning Commission								
3	County Planning Commission								
4	County Conservation			✓					
5	Municipal Manager/ Staff								
6	Municipal Engineer (in-house)								
7	Municipal Authority								
8	Private Utility								
9	Fire Company								
10	Police Officers								
11	Zoning Officer								
12	Sewage Enforcement Officer								
13	Building Codes Officer								
14	Consulting Engineer								

Please use the codes on the previous page. For example, in municipalities which have adopted their own sub-division ordinance, block A-1 would be filled in with an "E" meaning the governing body is the enforcing agency. Blocks "A-2" and "A-3" would be filled in with an "R" meaning these agencies are included in the review process.

PART III - MUNICIPAL AND LOCAL PLANNING ACTIVITIES

Please indicate below whether your community has the corresponding plans and maps and the date of the most recent update.

Item	Date
PA Act 537 Sewage Facilities Plan	________
Comprehensive Land Use Plan	________
Existing Land Use Maps	________
Proposed Land Use Maps	________
Existing Zoning Maps	✓
Proposed Zoning Maps	________

Please include copies of all available land use and zoning maps.

PART IV - FLOOD INSURANCE PROGRAM AND COMPREHENSIVE LAND USE PLAN

Please indicate below whether your community participates in the National Flood Insurance Program and if your community has adopted a Comprehensive Land Use Plan.

Item	CHECK ONE Yes	No
Flood Hazard Boundary Map (FHBM)	__	__
Participate in FEMA Emergency Program	__	__
Participate in FEMA Regular Program	__	__
Comprehensive Land Use Plan	__	__

PART V - EXISTING STORMWATER RELATED PROBLEMS

#	Problem Area Location	NATURE/TYPE OF PROBLEM									CAUSE OF PROBLEM								FREQUENCY				Comments*
		Channel/Stream Flooding	Street/Intersection Flooding	Parking Lot Flooding	Private Property Flooding	Erosion (Soil Washoff)	Sedimentation	Water Pollution	Groundwater	Other (Explain under Comments)	Obstruction of Flow	Increased Runoff Due to Development	Excessive Velocities	Lack of Storm Drain Facilities	Number/Spacing of Storm Inlets	Roadway Improvements	Inadequate Drainage Patterns	Other (Explain under Comments)	1 Time Per Year	More Than 1 Time Per Year	Less Than 1 Time Per Year	Every Significant Rainfall	
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							

* If additional comments are provided , please use a blank page. The additional comments should be labeled with the Problem Area for reference and the sheet should be attached to the questionnaire when it is returned.

APPENDIX B

OBSTRUCTION SURVEYS AND ANALYSES

APPENDIX B

OBSTRUCTION SURVEYS AND ANALYSES

TABLE OF CONTENTS

Table B.1

OBSTRUCTION CAPACITY SUMMARY

Obstruction Designation	Basin	Capacity (cfs) At Crown	Capacity (cfs) At Roadway	~ Return Period (years)
1	60	3,100	3,800	25 to 50
2	54	> 100 Years		> 100
3	48	7,000	7,900	> 100
4	44	2,600	4,300	15 to > 100
5	28	2,900	3,600	> 100
6	26	130	215	5 to 15
7	24	1,950	2,550	> 100
8	22	630	830	> 100
9	9	300	485	8 to 20
10	2	51	130	3 to 8
11	2	79	190	> 100
12	2	24	70	?
13	2	24	50	4 to 10
14	42	1,800	2,100	> 100
15	40	1,600	2,000	> 100
16	37	1,300	1,700	> 100
17	33	70	100	4 to 5
18	36	65	125	3 to 10
19	59	200	-	10
20	59	180	280	8 to 25
21	59	180	280	8 to 25
22	59	270	290	50
23	59	132	-	5
24	59	370	580	100 to > 100
25	59	180	220	10 to 25
26	59	135	280	8 to 50
27	59	180	220	10 to 25
28	59	90	150	4 to 15
29	59	67	110	3 to 6
30	59	260	500	100 to > 100
31	59	100	160	5 to 20

STREAM OBSTRUCTION DATA SHEETS

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: A 60

NAME OF OBSTRUCTION: #21 30° S/CW

DESCRIPTION OF OBSTRUCTION: ______

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 23'w x 14'h US ARCH
EXISTING DIMENSIONS OF OPENING: 8'w x 14'h

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: ______

OUTLET LOCATED ON PRIVATE PROPERTY

LENGTH: ______

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: ______
DOWNSTREAM INVERT ELEVATION: ______
CREST OF ROADWAY/EMBANKMENT: ______

SPECIFIC FEATURES:
HEADWALL: ______
ENDWALL: ______
WINGWALLS: ______
ENTRANCE/EXIT PAVED APRONS: ______
EROSION PROTECTION: ______

ESTIMATED FLOW IN STREAM: 1.8' deep

CURRENT WEATHER CONDITIONS: Cool & Clear [illegible]

PREVIOUS WEATHER CONDITIONS: Cool & Rain [illegible]

FIELD OBSERVATIONS:

See Photo 35

FIELD SURVEY PERFORMED BY [illegible] / RTG ON 5/5/94.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 54 FINAL

NAME OF OBSTRUCTION: ~~43~~ 2

DESCRIPTION OF OBSTRUCTION: PRIVATE DRIVEWAY BRIDGE.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: ____.
EXISTING DIMENSIONS OF OPENING: ____.

TYPE/MATERIAL OF OBSTRUCTION: ____.
CONDITION OF OBSTRUCTION: ____.

LENGTH: ____.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: ____.
DOWNSTREAM INVERT ELEVATION: ____.
CREST OF ROADWAY/EMBANKMENT: ____.

SPECIFIC FEATURES:
HEADWALL: ____.
ENDWALL: ____.
WINGWALLS: ____.
ENTRANCE/EXIT PAVED APRONS: ____.
EROSION PROTECTION: ____.

ESTIMATED FLOW IN STREAM: ____.

CURRENT WEATHER CONDITIONS: ____.

PREVIOUS WEATHER CONDITIONS: ____.

FIELD OBSERVATIONS: LARGE BRIDGE WITH 100 YEAR+ CAPACITY

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~B~~ 48

NAME OF OBSTRUCTION: #~~7~~ 3

DESCRIPTION OF OBSTRUCTION: ARCH / BRIDGE

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 16' 49' wide
EXISTING DIMENSIONS OF OPENING: 16' high x 16' wide

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: DETERIORATING TO REINFORCING RODS

LENGTH: 39'

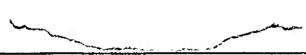
ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 – 23.6' = 76.4
DOWNSTREAM INVERT ELEVATION: 100 – 25.3' = 74.7
CREST OF ROADWAY/EMBANKMENT: 100 – 6.3' = 93.7

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS:
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.3' deep slow - med

CURRENT WEATHER CONDITIONS: Clear Cool 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
Slight Rain on 4/30

FIELD OBSERVATIONS:
SEDIMENT HAS FORMED CHANNEL
 SHAPE UNDER BRIDGE

SEE PHOTOS 22 & 23

FIELD SURVEY PERFORMED BY RAG / JRE ON 5-2-94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~F~~ 44

NAME OF OBSTRUCTION: #~~H~~ 4

DESCRIPTION OF OBSTRUCTION: BRIDGE

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 6.5' x 62' wide
EXISTING DIMENSIONS OF OPENING: 6.5' high x 41' w

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE & STEEL
CONDITION OF OBSTRUCTION: FAIR

LENGTH: 36'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 − 15.8' = 84.2
DOWNSTREAM INVERT ELEVATION: 100 − 16.3' = 83.7
CREST OF ROADWAY/EMBANKMENT: 100 − 5.6' = 94.4

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: 1 US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION: LARGE RIPRAP US / SILT FENCE DS

ESTIMATED FLOW IN STREAM: 0.5' DEEP SLOW

CURRENT WEATHER CONDITIONS: Cool Clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
Small Rain on 4/30

FIELD OBSERVATIONS:

SEE PHOTOS 20 & 21

FIELD SURVEY PERFORMED BY RAC / JRE ON 5-2-94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: #28

NAME OF OBSTRUCTION: #~~12~~ 5

DESCRIPTION OF OBSTRUCTION: BRIDGE

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 10' high x 36' wide
EXISTING DIMENSIONS OF OPENING: 10' high x 15' wide

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE & STEEL
CONDITION OF OBSTRUCTION: FAIR

LENGTH: 36'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 16.4' = 83.6'
DOWNSTREAM INVERT ELEVATION: 100 - 16.5' = 83.5
CREST OF ROADWAY/EMBANKMENT: 100 - 5.5' = 94.5

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION: RETAINING WALL US

ESTIMATED FLOW IN STREAM: 1.5' deep SLOW

CURRENT WEATHER CONDITIONS: Cool Clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
Small rain on 4/30

FIELD OBSERVATIONS:
US OF MAIN BRIDGE IS PRIVATE
BRIDGE BELONGING TO GARDEN CENTER

SEE PHOTOS 18 & 19

FIELD SURVEY PERFORMED BY RAG / JRE ON 5-2-??

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~I~~ 26

NAME OF OBSTRUCTION: # ~~13~~ 6

DESCRIPTION OF OBSTRUCTION: BOX CULVERT

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 7 x 9.3' wide
EXISTING DIMENSIONS OF OPENING: 2.4' high x 9.3 wide

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: FAIR - GOOD

LENGTH: 38'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 9.7' = 90.3'
DOWNSTREAM INVERT ELEVATION: 100 - 10.3' = 89.7'
CREST OF ROADWAY/EMBANKMENT: 100 - 5.1' = 94.9'

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.2' deep med-fast

CURRENT WEATHER CONDITIONS: Cool Clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
small rain on 4/30

FIELD OBSERVATIONS:
NEXT TO TRAILER PARK

See Photos 16 & 17

FIELD SURVEY PERFORMED BY PAG / JRE ON 5-2-94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~S~~ 24

NAME OF OBSTRUCTION: # ~~25~~ 7

DESCRIPTION OF OBSTRUCTION: BRIDGE / ARCH CULVERT

FIELD MEASUREMENTS:
- ORIGINAL DIMENSIONS OF OPENING: ≈ 8' high X 30' wide ARCH
- EXISTING DIMENSIONS OF OPENING: US 7.5' high x 9' wide DS 8' h x 16' w
- TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
- CONDITION OF OBSTRUCTION:

LENGTH: 29'

ELEVATIONS (RELATIVE TO THE SITE):
- UPSTREAM INVERT ELEVATION: 100 − 16' = 84'
- DOWNSTREAM INVERT ELEVATION: 100 − 17' = 83'
- CREST OF ROADWAY/EMBANKMENT: 100 − 5.4' = 94.6'

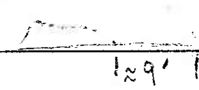
SPECIFIC FEATURES:
- HEADWALL:
- ENDWALL:
- WINGWALLS:
- ENTRANCE/EXIT PAVED APRONS:
- EROSION PROTECTION: RETAINING WALLS US

ESTIMATED FLOW IN STREAM: 1' deep med-fast

CURRENT WEATHER CONDITIONS: Cool Clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
small rain on 4/30

FIELD OBSERVATIONS:
FLOW RESTRICTED TO ½ OF ARCHWAY
BY ACCUMULATION OF ROCK & [illegible]



SEE PHOTOS 14 & 15

FIELD SURVEY PERFORMED BY RAH / JRE ON 5-2-94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~Y~~ 22

NAME OF OBSTRUCTION: #~~32~~ 8

DESCRIPTION OF OBSTRUCTION: BRIDGE

FIELD MEASUREMENTS:

ORIGINAL DIMENSIONS OF OPENING: 5.5' high x 17' wide

EXISTING DIMENSIONS OF OPENING: " "

TYPE/MATERIAL OF OBSTRUCTION: CONCRET WINGWALLS, STEEL BRDGE

CONDITION OF OBSTRUCTION: FAIR

LENGTH: 15'

ELEVATIONS (RELATIVE TO THE SITE):

UPSTREAM INVERT ELEVATION: 100 - 12.7' = 87.3'

DOWNSTREAM INVERT ELEVATION: 100 - 12.8' = 87.2'

CREST OF ROADWAY/EMBANKMENT: 100 - 5.8' = 94.2

SPECIFIC FEATURES:

HEADWALL:

ENDWALL:

WINGWALLS: US DS

ENTRANCE/EXIT PAVED APRONS:

EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.4' med-fast

CURRENT WEATHER CONDITIONS: Cool Clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool small rain on 4/30

FIELD OBSERVATIONS:

FLAUGHERTY RUN UNDER BECK'S RUN RD.

SEE PHOTOS 12 & 13

FIELD SURVEY PERFORMED BY DJG / JRE ON 5-2-96

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 49

NAME OF OBSTRUCTION: #269

DESCRIPTION OF OBSTRUCTION: CULVERT BOX

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 5.4' 8.5' BOX
EXISTING DIMENSIONS OF OPENING: 5.4' high x 8.5' wide

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: FAIR - GOOD

LENGTH: 38'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 13.1' = 86.9'
DOWNSTREAM INVERT ELEVATION: 100 - 13.5' = 86.5'
CREST OF ROADWAY/EMBANKMENT: 100 - 4.9 = 95.1'

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION: RIP-RAP - US

ESTIMATED FLOW IN STREAM: 0.2' deep, med - fast

CURRENT WEATHER CONDITIONS: Cool Clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
small rain on 4/30

FIELD OBSERVATIONS:
RIGHT NEXT TO SEWAGE PLANT
CONTRIBUTING ~ 50% of FLOW

SEE PHOTOS 9, 10, 11

FIELD SURVEY PERFORMED BY BAG / JRE ON 5-2-94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~AE~~ 2

NAME OF OBSTRUCTION: # ~~29~~ 10

DESCRIPTION OF OBSTRUCTION: Culvert

FIELD MEASUREMENTS:

ORIGINAL DIMENSIONS OF OPENING: 4.8' 4.8' + unless arch PROB CIRC

EXISTING DIMENSIONS OF OPENING: US 2.7' DS 1.6'

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE

CONDITION OF OBSTRUCTION: FAIR

LENGTH: 70'

ELEVATIONS (RELATIVE TO THE SITE):

UPSTREAM INVERT ELEVATION: 100 - 12.9' = 87.1'

DOWNSTREAM INVERT ELEVATION: 100 - 13.4' = 86.6

CREST OF ROADWAY/EMBANKMENT: 100 - 6.4' = 93.6'

SPECIFIC FEATURES:

HEADWALL:

ENDWALL:

WINGWALLS: US DS

ENTRANCE/EXIT PAVED APRONS:

EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.2' deep slow - med

CURRENT WEATHER CONDITIONS: cool & clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool

small rain on 4/30

FIELD OBSERVATIONS:

FLAUGHERTY RUN PASSES UNDER JACKSON ST.

See Photos 7 & 8

FIELD SURVEY PERFORMED BY BAG / JRE ON 5-2-94.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~AE~~ 2

NAME OF OBSTRUCTION: No. ~~28~~ 11

DESCRIPTION OF OBSTRUCTION: CULVERT

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 48" CIRC
EXISTING DIMENSIONS OF OPENING: 48"

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: FAIR
- ENDWALL STARTING TO CRUMBLE

LENGTH: 70'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 13.0' = 87'
DOWNSTREAM INVERT ELEVATION: 100 - 14.3' = 85.7'
CREST OF ROADWAY/EMBANKMENT: 100 - 3.4' = 96.6'

SPECIFIC FEATURES:
HEADWALL: DS
ENDWALL:
WINGWALLS: US
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: .7' deep - slow

CURRENT WEATHER CONDITIONS: cool & clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
small rain on 4/30

FIELD OBSERVATIONS:
See Photos 5 & 6

FIELD SURVEY PERFORMED BY DAG / JRE ON 5-2-9?

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~AE~~ 2

NAME OF OBSTRUCTION: No. ~~3~~ 12

DESCRIPTION OF OBSTRUCTION: Culvert

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 2.6' CIRC
EXISTING DIMENSIONS OF OPENING: 2.6'

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION:
OUTLET WALL COLLAPSED

LENGTH: 65'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 15.7 = 84.3
DOWNSTREAM INVERT ELEVATION: ≈ 100 - 27.0 = 73.0
CREST OF ROADWAY/EMBANKMENT: 100 - 6.0 = 94.0

SPECIFIC FEATURES:
HEADWALL: DS collapsed
ENDWALL:
WINGWALLS: US crumbling
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: TRICKLE

CURRENT WEATHER CONDITIONS: Cool Clear 60°

PREVIOUS WEATHER CONDITIONS: Cloudy Cool
small rain on 4/30

FIELD OBSERVATIONS:
Spring entering Flaugherty Run
See Photos 3 & 4

FIELD SURVEY PERFORMED BY DAG / JRE ON 5-2-94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~AI~~ 2.

NAME OF OBSTRUCTION: No. ~~30~~ 13 DAM.

DESCRIPTION OF OBSTRUCTION: SPILLWAY PIPE ROCK FILL DAM.

INLET NOT VISIBLE.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 1.85'.
EXISTING DIMENSIONS OF OPENING: 1.85.

TYPE/MATERIAL OF OBSTRUCTION: STEEL PIPE.
CONDITION OF OBSTRUCTION: CRACKED AND RUSTED.

LENGTH: 30'.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: X.
DOWNSTREAM INVERT ELEVATION: 100 − 11.4 = 88.6.
CREST OF ROADWAY/EMBANKMENT: 100 − 5.8 = 94.2.

SPECIFIC FEATURES:
HEADWALL: .
ENDWALL: .
WINGWALLS: .
ENTRANCE/EXIT PAVED APRONS: DS CONCRETE.
EROSION PROTECTION: .

ESTIMATED FLOW IN STREAM: ≃ 0.1' deep med-fast flow.

CURRENT WEATHER CONDITIONS: cool & clear ≈ 60°.

PREVIOUS WEATHER CONDITIONS: cloudy & cool
Rain on Saturday 4.30.

FIELD OBSERVATIONS:
See Photos. 1 & 2

FIELD SURVEY PERFORMED BY DAG/JRE ON 5-2-94.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~8~~ 42

NAME OF OBSTRUCTION: #14

DESCRIPTION OF OBSTRUCTION: BRIDGE - BOX

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 21' w x 10.5' h
EXISTING DIMENSIONS OF OPENING: US 13' w x 10.5' h DS 16'

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: FAIR

LENGTH: 38'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 16.5' = 83.5
DOWNSTREAM INVERT ELEVATION: 100 - 16.8' = 83.2
CREST OF ROADWAY/EMBANKMENT: 100 - 5.3' = 94.7

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: US 1' deep DS .4' d 1.5 fps

CURRENT WEATHER CONDITIONS: Cool & Clear

PREVIOUS WEATHER CONDITIONS: Cool Rainy

FIELD OBSERVATIONS: 30° Skew

See Photos 47-48

FIELD SURVEY PERFORMED BY RAG [illegible] ON 5/5/94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: F 40

NAME OF OBSTRUCTION: # 15

DESCRIPTION OF OBSTRUCTION: BRIDGE - ARCH

FIELD MEASUREMENTS:

ORIGINAL DIMENSIONS OF OPENING: 23' W x 9' h ARCH

EXISTING DIMENSIONS OF OPENING: 11' W x 9' h

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE

CONDITION OF OBSTRUCTION: [illegible]

LENGTH: 33'

ELEVATIONS (RELATIVE TO THE SITE):

UPSTREAM INVERT ELEVATION: 100 - 17.1 = 82.9

DOWNSTREAM INVERT ELEVATION: 100 - 18 = 82

CREST OF ROADWAY/EMBANKMENT: 100 - 5.4 = 94.6

SPECIFIC FEATURES:

HEADWALL:

ENDWALL:

WINGWALLS:

ENTRANCE/EXIT PAVED APRONS:

EROSION PROTECTION:

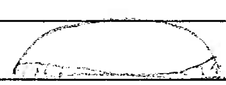
ESTIMATED FLOW IN STREAM: 0.5' deep 2 fps

CURRENT WEATHER CONDITIONS: Cool & Clear

PREVIOUS WEATHER CONDITIONS: Cool & Rainy

FIELD OBSERVATIONS:

See Photos 41 & 42



FIELD SURVEY PERFORMED BY [signature] ON 5/5/94.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: K 37

NAME OF OBSTRUCTION: #16

DESCRIPTION OF OBSTRUCTION: BRIDGE

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 8' [illegible] x 21' [illegible] BOX
EXISTING DIMENSIONS OF OPENING: 8' [illegible] x 11' [illegible]

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: GOOD

LENGTH: 32'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 14.9' = 85.1
DOWNSTREAM INVERT ELEVATION: 100 - 15.8' = 84.2
CREST OF ROADWAY/EMBANKMENT: 100 - 5.3' = 94.7

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.3' deep ~ 4 fps

CURRENT WEATHER CONDITIONS: Cool Clear ≈ 60°

PREVIOUS WEATHER CONDITIONS: Cool Rainy

FIELD OBSERVATIONS: 30° skew
Some Debr in stream

See Photos 36 & 37

* Could not get [illegible] ≠ 2' [illegible] [illegible]

FIELD SURVEY PERFORMED BY RAG/[illegible] ON 5/5/94.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~M~~ 33

NAME OF OBSTRUCTION: # ~~18~~ 17

DESCRIPTION OF OBSTRUCTION: Culvert / Pipe w/ Rock End Wall

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 4' diam. CIRCULAR
EXISTING DIMENSIONS OF OPENING: 4' diam.

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: FAIR
DS SIDE BEGINNING TO WEAR

LENGTH: 36'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 10.8 = 89.2
DOWNSTREAM INVERT ELEVATION: 100 - 12.3 = 87.7
CREST OF ROADWAY/EMBANKMENT: 100 - 5.3 = 94.7

SPECIFIC FEATURES:
HEADWALL:
ENDWALL: DS
WINGWALLS:
ENTRANCE/EXIT PAVED APRONS: DS
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.2' deep, 4 fps

CURRENT WEATHER CONDITIONS: Cool & Clear 55°

PREVIOUS WEATHER CONDITIONS: Cool & Rain

FIELD OBSERVATIONS:

See Photos 38, 39.

FIELD SURVEY PERFORMED BY PAG JHS ON 5/5/97.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~N~~ 36

NAME OF OBSTRUCTION: #~~20~~ 18

DESCRIPTION OF OBSTRUCTION: Culvert

FIELD MEASUREMENTS:
- ORIGINAL DIMENSIONS OF OPENING: 48" CIRCULAR
- EXISTING DIMENSIONS OF OPENING: 48"
- TYPE/MATERIAL OF OBSTRUCTION: CMP
- CONDITION OF OBSTRUCTION: FAIR

LENGTH: 36'

ELEVATIONS (RELATIVE TO THE SITE):
- UPSTREAM INVERT ELEVATION: 100 - 13.9' = 86.1
- DOWNSTREAM INVERT ELEVATION: 100 - 16' = 84
- CREST OF ROADWAY/EMBANKMENT: 100 - 6' = 94

SPECIFIC FEATURES:
- HEADWALL:
- ENDWALL:
- WINGWALLS:
- ENTRANCE/EXIT PAVED APRONS:
- EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.1' deep 1.5 fps

CURRENT WEATHER CONDITIONS: Cool & Clear

PREVIOUS WEATHER CONDITIONS: Cool & Rainy

FIELD OBSERVATIONS:

INLET IS IN MANHOLE WHERE [illegible]
OUTLETS IN 2.5' diam. pipe.
See Photos 43 & 44

[illegible]

FIELD SURVEY PERFORMED BY [illegible] ON 5/5/94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: A 59

NAME OF OBSTRUCTION: ~~#X~~ A

DESCRIPTION OF OBSTRUCTION: CULVERT

FIELD MEASUREMENTS:
- ORIGINAL DIMENSIONS OF OPENING: 6' diam. CIRCULAR
- EXISTING DIMENSIONS OF OPENING: 4' DS
- TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
- CONDITION OF OBSTRUCTION: FAIR

LENGTH: 370'

ELEVATIONS (RELATIVE TO THE SITE):
- UPSTREAM INVERT ELEVATION: 100 - 12.5 = 87.5
- DOWNSTREAM INVERT ELEVATION: 90.9 - 32 = 58.9
- CREST OF ROADWAY/EMBANKMENT: 90.9 - 0.8 = 90.1

SPECIFIC FEATURES:
- HEADWALL:
- ENDWALL: US
- WINGWALLS:
- ENTRANCE/EXIT PAVED APRONS:
- EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.3' deep

CURRENT WEATHER CONDITIONS: Cool & Clear 55°

PREVIOUS WEATHER CONDITIONS: Cool & Rainy

FIELD OBSERVATIONS:
DS Pipe — filled w/ sediment

See Photos 33 & 34

FIELD SURVEY PERFORMED BY RAG [illegible] ON 5/5/94.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL.

NAME OF OBSTRUCTION: #20.

DESCRIPTION OF OBSTRUCTION: PRIVATE DRIVEWAY CULVERT.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 6' ϕ.
EXISTING DIMENSIONS OF OPENING: SAME EXCEPT *.

TYPE/MATERIAL OF OBSTRUCTION: CMP?.
CONDITION OF OBSTRUCTION: .

LENGTH: 20' ±.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: .
DOWNSTREAM INVERT ELEVATION: .
CREST OF ROADWAY/EMBANKMENT: .

SPECIFIC FEATURES:
HEADWALL: NO.
ENDWALL: NO.
WINGWALLS: NO.
ENTRANCE/EXIT PAVED APRONS: .
EROSION PROTECTION: .

ESTIMATED FLOW IN STREAM: .

CURRENT WEATHER CONDITIONS: .

PREVIOUS WEATHER CONDITIONS: .

FIELD OBSERVATIONS: * A TWO FT. HIGH PILE OF SEDIMENT/ROCKS EXISTS AT INLET

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL.

NAME OF OBSTRUCTION: LH 21.

DESCRIPTION OF OBSTRUCTION: STREAM ENCLOSURE, FRONT LAWNS OF TWO HOUSES.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 6' ϕ.
EXISTING DIMENSIONS OF OPENING: SAME.

TYPE/MATERIAL OF OBSTRUCTION: CMP.
CONDITION OF OBSTRUCTION: .

LENGTH: 300' ±.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: .
DOWNSTREAM INVERT ELEVATION: .
CREST OF ROADWAY/EMBANKMENT: .

SPECIFIC FEATURES:
HEADWALL: NO.
ENDWALL: NO.
WINGWALLS: NO.
ENTRANCE/EXIT PAVED APRONS: .
EROSION PROTECTION: .

ESTIMATED FLOW IN STREAM: .

CURRENT WEATHER CONDITIONS: .

PREVIOUS WEATHER CONDITIONS: .

FIELD OBSERVATIONS: .

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL.

NAME OF OBSTRUCTION: ~~16~~ 22.

DESCRIPTION OF OBSTRUCTION: CONCRETE DECK BRIDGE FOR PRIVATE DRIVEWAY.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 6 1/2' SPAN x 8' RISE.
EXISTING DIMENSIONS OF OPENING: SAME EXCEPT HAS BRACES

TYPE/MATERIAL OF OBSTRUCTION: CONC. DECK BRIDGE.
CONDITION OF OBSTRUCTION: ______.

LENGTH: 8' ±.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: ______.
DOWNSTREAM INVERT ELEVATION: ______.
CREST OF ROADWAY/EMBANKMENT: ______.

SPECIFIC FEATURES:
HEADWALL: NO.
ENDWALL: NO.
WINGWALLS: ~NO.
ENTRANCE/EXIT PAVED APRONS: ______.
EROSION PROTECTION: ______.

ESTIMATED FLOW IN STREAM: ______.

CURRENT WEATHER CONDITIONS: ______.

PREVIOUS WEATHER CONDITIONS: ______.

FIELD OBSERVATIONS: ______

FIELD SURVEY PERFORMED BY SBR/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~4~~ 59

NAME OF OBSTRUCTION: Culvert under Tri Plastic Park Lot ~~[illegible]~~ 23 / Spring Run Rd Between 8 & 1

DESCRIPTION OF OBSTRUCTION: Concrete Pipe

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 5' diam. CIRCULAR
EXISTING DIMENSIONS OF OPENING: " "

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: DS end section falling from pipe

LENGTH: 250'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 10.7' = 89.3
DOWNSTREAM INVERT ELEVATION: 100 - 17.5' = 82.5
CREST OF ROADWAY/EMBANKMENT: 100 - 6' = 94

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS:
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: 0.15' deep x 3 fps

CURRENT WEATHER CONDITIONS: Cool & CLEAR 55

PREVIOUS WEATHER CONDITIONS: Cool & Rainy

FIELD OBSERVATIONS:

See Photos #49 & 50

FIELD SURVEY PERFORMED BY PAL - AB ON 5/5/94.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: ~~6~~ 59

NAME OF OBSTRUCTION: # ~~8~~ 24

DESCRIPTION OF OBSTRUCTION: BRIDGE - BOX CULVERT

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 10' x 6' US 10' x 7' DS
EXISTING DIMENSIONS OF OPENING: 3.5 x " DS

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: FAIR - GOOD

LENGTH: 36'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 14' = 86
DOWNSTREAM INVERT ELEVATION: 100 - 15' = 85
CREST OF ROADWAY/EMBANKMENT: 100 - 5.3' = 94.7

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: .2' deep 3 fps

CURRENT WEATHER CONDITIONS: Cool & Clear 55°

PREVIOUS WEATHER CONDITIONS: Cool & Rain

FIELD OBSERVATIONS:
STEEP DROP 4' BEFORE INLET 3'
DEBRIS - LARGE TREE PIECES, TIRES, CONCRETE
Photos 31 & 32

FIELD SURVEY PERFORMED BY DAG / AHB ON 5/5/94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL.

NAME OF OBSTRUCTION: ~~107~~ 25.

DESCRIPTION OF OBSTRUCTION: PRIVATE DRIVEWAY CULVERT.

FIELD MEASUREMENTS:
- ORIGINAL DIMENSIONS OF OPENING: 6' φ.
- EXISTING DIMENSIONS OF OPENING: SAME.
- TYPE/MATERIAL OF OBSTRUCTION: CMP.
- CONDITION OF OBSTRUCTION: .
- LENGTH: 20' ±.
- ELEVATIONS (RELATIVE TO THE SITE):
  - UPSTREAM INVERT ELEVATION: .
  - DOWNSTREAM INVERT ELEVATION: .
  - CREST OF ROADWAY/EMBANKMENT: .
- SPECIFIC FEATURES:
  - HEADWALL: NO.
  - ENDWALL: NO.
  - WINGWALLS: NO.
  - ENTRANCE/EXIT PAVED APRONS: .
  - EROSION PROTECTION: .
  - ESTIMATED FLOW IN STREAM: .
  - CURRENT WEATHER CONDITIONS: .
  - PREVIOUS WEATHER CONDITIONS: .

FIELD OBSERVATIONS:

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: E 59

NAME OF OBSTRUCTION: #9 26

DESCRIPTION OF OBSTRUCTION: BRIGDE BOX CULVERT

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 12' X 3' DS 10' x 3' US
EXISTING DIMENSIONS OF OPENING: 4' x 3' DS sediment

skewed ≈ 30°

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: FAIR - GOOD

LENGTH: 39'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 - 11.6' = 88.4
DOWNSTREAM INVERT ELEVATION: 100 - 11.9' = 88.1
CREST OF ROADWAY/EMBANKMENT: 100 - 5.2' = 94.8

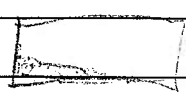
SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM: ≈ 0.3' deep 1 fps

CURRENT WEATHER CONDITIONS: Cool & Clear 55

PREVIOUS WEATHER CONDITIONS: Cool & Raining

FIELD OBSERVATIONS:
Sediment Build-up in culvert



Photos 29 30

FIELD SURVEY PERFORMED BY BAG [signature] ON 5/5/94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL

NAME OF OBSTRUCTION: ~~105~~ 27

DESCRIPTION OF OBSTRUCTION: PRIVATE DRIVEWAY CULVERT

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 6'Ø
EXISTING DIMENSIONS OF OPENING: SAME

TYPE/MATERIAL OF OBSTRUCTION: CMP
CONDITION OF OBSTRUCTION: POOR

LENGTH: 20' ±

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION:
DOWNSTREAM INVERT ELEVATION:
CREST OF ROADWAY/EMBANKMENT:

SPECIFIC FEATURES:
HEADWALL: NO
ENDWALL: NO
WINGWALLS: NO
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION:

ESTIMATED FLOW IN STREAM:

CURRENT WEATHER CONDITIONS:

PREVIOUS WEATHER CONDITIONS:

FIELD OBSERVATIONS:

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL.

NAME OF OBSTRUCTION: ~~60~~ 28.

DESCRIPTION OF OBSTRUCTION: PRIVATE DRIVEWAY CULVERT.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 6' Φ.
EXISTING DIMENSIONS OF OPENING: 4.5" HI.

TYPE/MATERIAL OF OBSTRUCTION: CMP.
CONDITION OF OBSTRUCTION: POOR.

LENGTH: 75' ±.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: ______.
DOWNSTREAM INVERT ELEVATION: ______.
CREST OF ROADWAY/EMBANKMENT: ______.

SPECIFIC FEATURES:
HEADWALL: NO.
ENDWALL: NO.
WINGWALLS: NO.
ENTRANCE/EXIT PAVED APRONS: ______.
EROSION PROTECTION: ______.

ESTIMATED FLOW IN STREAM: ______.

CURRENT WEATHER CONDITIONS: ______.

PREVIOUS WEATHER CONDITIONS: ______.

FIELD OBSERVATIONS: CULVERT HAS 1.5' OF SEDIMENT IN INVERT @ OPENING

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL.

NAME OF OBSTRUCTION: ~~103~~ 29.

DESCRIPTION OF OBSTRUCTION: PRIVATE DRIVEWAY CULVERT.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 4' φ.
EXISTING DIMENSIONS OF OPENING: SAME.

TYPE/MATERIAL OF OBSTRUCTION: CMP.
CONDITION OF OBSTRUCTION: POOR.

LENGTH: 20' ±.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: .
DOWNSTREAM INVERT ELEVATION: .
CREST OF ROADWAY/EMBANKMENT: .

SPECIFIC FEATURES:
HEADWALL: NO.
ENDWALL: NO.
WINGWALLS: NO.
ENTRANCE/EXIT PAVED APRONS: .
EROSION PROTECTION: .

ESTIMATED FLOW IN STREAM: .

CURRENT WEATHER CONDITIONS: .

PREVIOUS WEATHER CONDITIONS: .

FIELD OBSERVATIONS:

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: G 59

NAME OF OBSTRUCTION: # ~~10~~ 30

DESCRIPTION OF OBSTRUCTION: BRIDGE

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: US 12' × 4.2' DS 5' × 4.2' 30X skewed ≈ 30°
EXISTING DIMENSIONS OF OPENING: " "

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE
CONDITION OF OBSTRUCTION: GOOD

LENGTH: 45'

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: 100 − 12.5' = 87.5
DOWNSTREAM INVERT ELEVATION: 100 − 15.5' = 84.5
CREST OF ROADWAY/EMBANKMENT: 100 − 4.7' = 95.3

SPECIFIC FEATURES:
HEADWALL:
ENDWALL:
WINGWALLS: US DS
ENTRANCE/EXIT PAVED APRONS:
EROSION PROTECTION: RETAINING WALL US DS

ESTIMATED FLOW IN STREAM: 0.3' deep 1 fps

CURRENT WEATHER CONDITIONS: Cool Clear ≈ 55°

PREVIOUS WEATHER CONDITIONS: Cool Rainy

FIELD OBSERVATIONS:

Photos 25 26 27 28

FIELD SURVEY PERFORMED BY RHG / [illegible] ON 5/5/94

STREAM OBSTRUCTION DATA SHEET
FOR USE WITH CULVERTS & BRIDGES
FLAUGHERTY RUN WATERSHED

SUBWATERSHED: 59 FINAL.

NAME OF OBSTRUCTION: ~~101~~ 31.

DESCRIPTION OF OBSTRUCTION: PRIVATE DRIVEWAY CONC. CULVERT.

FIELD MEASUREMENTS:
ORIGINAL DIMENSIONS OF OPENING: 4.5' ɸ.
EXISTING DIMENSIONS OF OPENING: ~ SAME.

TYPE/MATERIAL OF OBSTRUCTION: CONCRETE.
CONDITION OF OBSTRUCTION: FAIR.

LENGTH: 20' ±.

ELEVATIONS (RELATIVE TO THE SITE):
UPSTREAM INVERT ELEVATION: ________.
DOWNSTREAM INVERT ELEVATION: ________.
CREST OF ROADWAY/EMBANKMENT: ________.

SPECIFIC FEATURES:
HEADWALL: NONE.
ENDWALL: NONE.
WINGWALLS: ________.
ENTRANCE/EXIT PAVED APRONS: ________.
EROSION PROTECTION: ________.

ESTIMATED FLOW IN STREAM: ________.

CURRENT WEATHER CONDITIONS: ________.

PREVIOUS WEATHER CONDITIONS: ________.

FIELD OBSERVATIONS: ________

FIELD SURVEY PERFORMED BY SER/KLF ON 10/31/95.

OBSTRUCTION CAPACITIES

SUBJECT FLAUGHERTY RUN

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 1 OF 29

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OBSTRUCTION CAPACITIES

ESTIMATE CULVERT CAPACITIES

ESTIMATE ORIGINAL CAPACITY AT CROWN AND AT ROADWAY CREST ASSUMING INLET CONTROL. ESTIMATE EXISTING CAPACITY IF POSSIBLE.

REFERENCE: 1) STREAM OBSTRUCTION DATA SHEETS

2) "HYDRAULIC DESIGN OF HIGHWAY CULVERTS" HDS 5 SEPT 1985

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 2 OF 29

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PROJECT: ______

STATION: ______

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

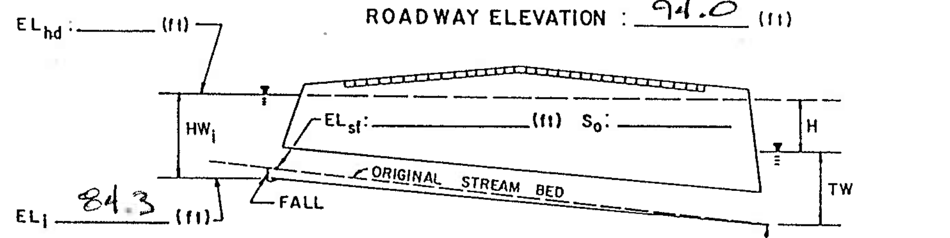
SEE ADD'L SHTS

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.0 (ft)



$S \approx S_o - FALL / L_a$

S = 0.17 Ft/FT

L_a = 65

CULVERT DESCRIPTION / HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 3' 12	24		1	2.6										86.9		AT CROWN
" 4' 12	70		3.73	9.7										94.0		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 1

CULVERT BARREL SELECTED:

SIZE: 2.6 FT ϕ

SHAPE: CIRC

MATERIAL: CONC n: ______

ENTRANCE: TYPE 1

SUBJECT: FLAUGHERTY RUN

BY: JER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 3 OF 29

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PROJECT: ______ STATION: ______ SHEET ___ OF ___

CULVERT DESIGN FORM

DESIGNER/DATE: ______ / ______

REVIEWER/DATE: ______ / ______

HYDROLOGICAL DATA

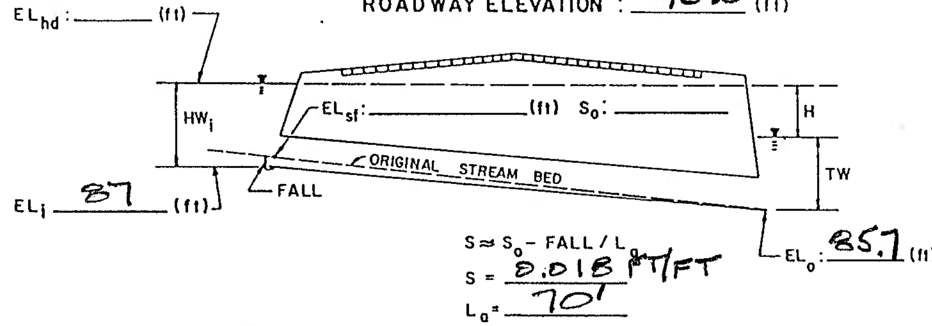
SEE ADD'L. SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 96.6 (ft)



$S \approx S_o$ − FALL / L_a

S = 0.018 FT/FT

L_a = 70'

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT ~~28~~ 11	79		1	4										91		AT CROWN
" ~~28~~ 11	190		2.4	9.6										96.6		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW /D OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 1

CULVERT BARREL SELECTED:

SIZE: 48" φ

SHAPE: CIRC

MATERIAL: CONC. n: ______

ENTRANCE: TYPE 2

SUBJECT: FLAUGHERTY RUN

BY: JER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 4 OF 29

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PROJECT: ____________

STATION: ____________
SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ____ / ____
REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

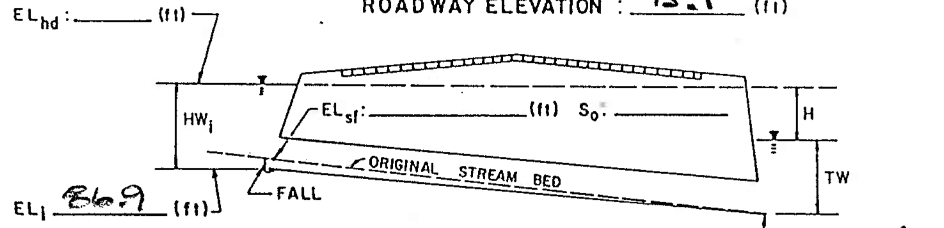
SEE ADD'L SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 95.1 (ft)



$S \approx S_o$ - FALL / L_a

S = 0.011 ft/ft

L_a = 38'

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 269	300	35	1	5.4										92.3		AT CROWN
" 269	485	57	1.52	8.2										95.1		AT RDWY

(HEADWATER CALCULATIONS)

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 5.4'H x 8.5'W
SHAPE: BOX
MATERIAL: CONC. n
ENTRANCE: TYPE 1

SUBJECT: FLAHERTY RUN

BY: SER DATE: 6/8/94
CHKD. BY: RAG DATE: 6/13/94
PROJ. NO. 91-503-11
SHEET NO. 5 OF 29

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CULVERT DESIGN FORM

PROJECT: ______

STATION: ______
SHEET ____ OF ____

DESIGNER / DATE: ____ / ____
REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

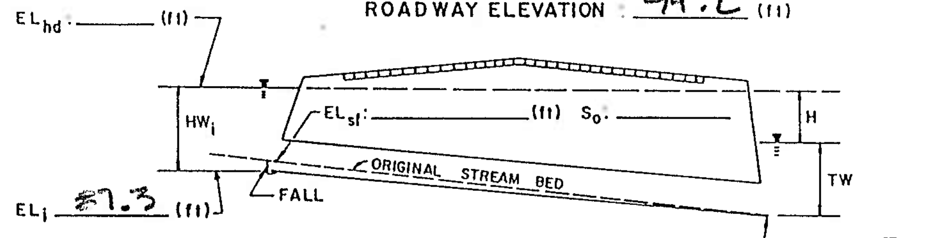
SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.2 (ft)



$S \approx S_o - FALL / L_a$

S = 0.0067 FT/FT

L_a = 15

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 3C8	630	37	1	5.5										92.8		AT CROWN
11 1/8	830	49	1.25	6.9										94.2		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] v^2 / 2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 5.5'H x 17'W
SHAPE: BOX
MATERIAL: CONC n: ____
ENTRANCE: TYPE 1

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SUBJECT: FLAUGHERTY RUN

BY: JTR DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: KAG DATE: 6/13/94 SHEET NO. 6 OF 29

PROJECT: ______

STATION: ______
SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______
REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

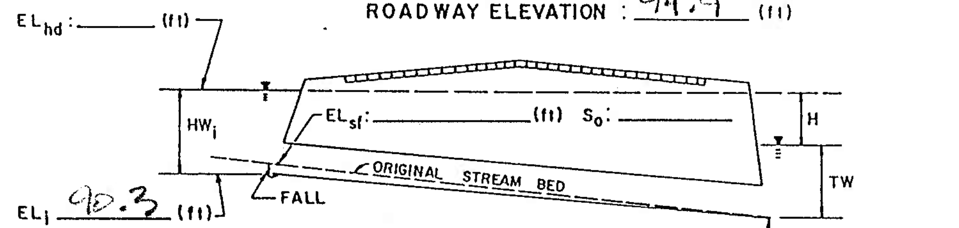
SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.9 (ft)



$S \approx S_o - FALL / L_a$
S = 0.016 FT/FT
L_a = 38'

HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 136																
" "	130	13.9	1	2.8										93.1		AT CROWN
" "	215	23	1.64	4.6										94.9		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i / D = HW / D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8
EXISTING CONDITIONS
ORIGINAL " NOT KNOWN

CULVERT BARREL SELECTED:

SIZE: 2.8'H x 9.3'W
SHAPE: BOX
MATERIAL: CONC n: ______
ENTRANCE: TYPE 1

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 7 OF 29

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PROJECT:	STATION: ______ SHEET ____ OF ____	CULVERT DESIGN FORM DESIGNER / DATE: ______ / ______ REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

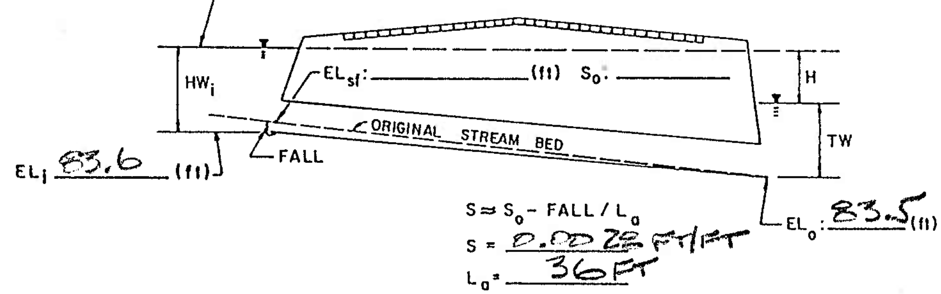
SEE ADD'L SHTS.

- ☐ METHOD:
- ☐ DRAINAGE AREA: ☐ STREAM SLOPE:
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ☐ OTHER:

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.5 (ft)



$S = S_o - FALL / L_a$

S = 0.0028 FT/FT

L_a = 36 FT

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT ~~12~~ 5	1900	80	1	19										92.6		AT CROWN
" "	3600	100	1.21	10.9										94.5		AT ROWN?

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 9' H x 36' W

SHAPE: BRIDGE

MATERIAL: CONC n:

ENTRANCE: TYPE 1

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94

CHKD. BY: RAG DATE: 6/13/94

PROJ. NO.: 91-503-11

SHEET NO. 8 OF 29

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PROJECT: ______

STATION: ______

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

SEE ADD'L SHTS.

☐ METHOD: ______

☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______

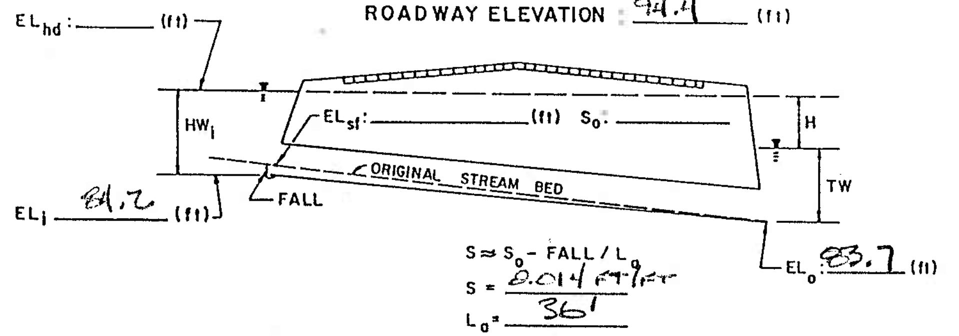
☐ CHANNEL SHAPE: ______

☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.4 (ft)



$S \approx S_o - FALL / L_a$

S = 0.014 FT/FT

L_a = 36'

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT #4	2600	42	1	6.5										90.7		AT CROWN
" "	4300	70	1.57	10.2										94.4		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 6.5' H x 62' W

SHAPE: BRIDGE

MATERIAL: CONC & STEEL n: ______

ENTRANCE: TYPE 3

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO.: 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 9 OF 29

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PROJECT:	STATION: ____ SHEET ____ OF ____	CULVERT DESIGN FORM DESIGNER / DATE: ____ / ____ REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

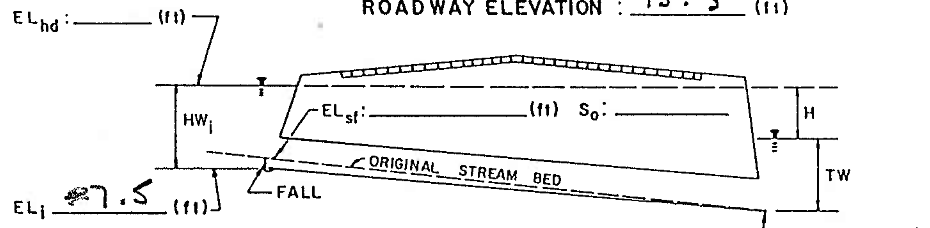
SEE ADD'L SHTS.

- ☐ METHOD:
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE:
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ____ ☐ OTHER:

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 95.3 (ft)



$S \approx S_o - FALL / L_a$

S = 0.046 ft/ft

L_a = 65'

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT ~~10~~ 29	260	215	1	4.2										91.7		AT CROWN
" "	500	42	1.86	7.8										95.3		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 4.24 x 12' W

SHAPE: BOX

MATERIAL: CONC n: ____

ENTRANCE: TYPE. 3

SUBJECT FLAUGHERTY RUN

BY STR DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 10 OF 29

GAI CONSULTANTS, INC.
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Environmental Specialists

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CULVERT DESIGN FORM

PROJECT: ______

STATION: ______
SHEET ______ OF ______

DESIGNER / DATE: ______ / ______
REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

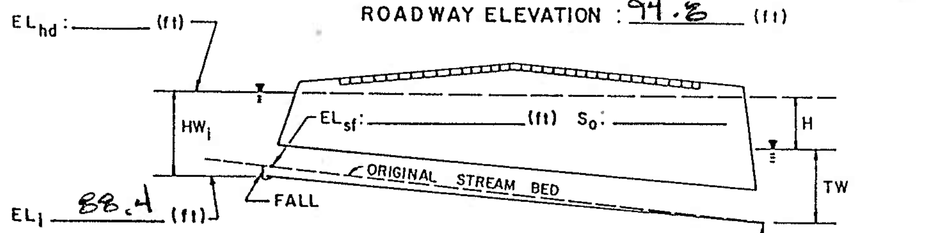
SEE ADD'L. SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.8 (ft)



$S \approx S_o - FALL / L_a$

$S =$ .00077 ft/ft

$L_a =$ 39'

HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 9-25	135	13.5	1	3										91.4		AT CROWN
" "	280	28	2.13	6.4										94.8		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i / D = HW / D$ OR HW_i / D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2 / 2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 3'H x 10'W
SHAPE: BOX
MATERIAL: CONC n: ______
ENTRANCE: TYPE 3

SUBJECT: FLAHERTY RUN

BY: JER DATE: 6/8/94 PROJ. NO.: 91-503-11

CHKD. BY: RLG DATE: 6/13/94 SHEET NO.: 11 OF 29

GAI CONSULTANTS, INC.
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Environmental Specialists

PROJECT: ______

STATION: ______

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

SEE ADD'L SHTS

☐ METHOD: ______

☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______

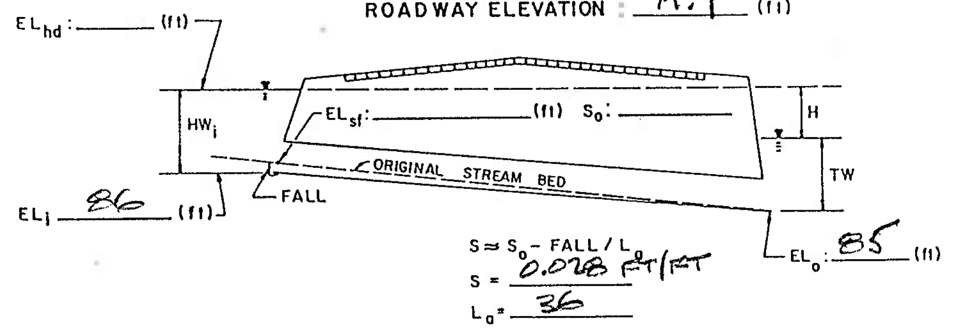
☐ CHANNEL SHAPE: ______

☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.7 (ft)



CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL hi (4)	OUTLET CONTROL TW (5)	d_c	(d_c+D)/2	h_o (6)	k_e	H (7)	EL ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT ~~85~~ 23	370	37	1	6										92		AT CROWN
" "	580	58	1.45	8.7										94.7		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 6' H x 10' W

SHAPE: BOX

MATERIAL: CONC n: ______

ENTRANCE: TYPE 3

SUBJECT FLAUGHERTY RUN

BY SFR DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY BAG DATE 6/13/94 SHEET NO. 12 OF 29

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ROJECT : ____

STATION : ____ SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE : ____ / ____

REVIEWER / DATE : ____ / ____

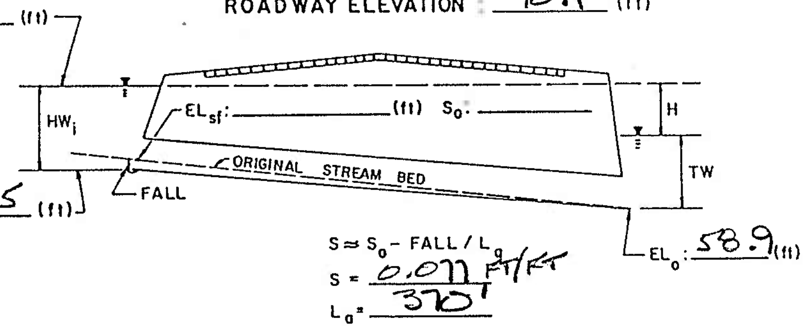
HYDROLOGICAL DATA

☐ METHOD: ____
☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
☐ CHANNEL SHAPE: ____
☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION : 90.1 (ft)



$S \approx S_o - FALL / L_a$
S = 0.077 FT/FT
L_a = 370'

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT # 19	200		1	6										93.5		AT CROWN
" "				2.6		DON'T USE								90.1		AT RDWY

HEADWATER CALCULATIONS

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] v^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

APPROXIMATE
CULVERT FACE
DESIGN HEADWATER
HEADWATER IN INLET CONTROL
HEADWATER IN OUTLET CONTROL
INLET CONTROL SECTION
OUTLET
STREAMBED AT CULVERT FACE
TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 1

CULVERT BARREL SELECTED:

SIZE: 6 FT Φ
SHAPE: CIRC
MATERIAL: CONC. n: ____
ENTRANCE: ~ TYPICAL

SUBJECT: FLAUCHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 13 OF 29

GAI CONSULTANTS, INC.
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CULVERT DESIGN FORM

PROJECT: ____

STATION: ____

SHEET ____ OF ____

DESIGNER / DATE: ____ / ____

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

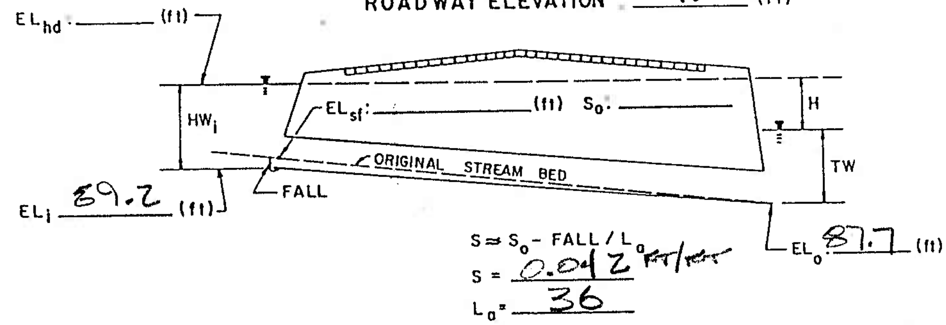
SEE ADD'L. SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.7 (ft)



$S \approx S_o - FALL / L_o$

$S =$ 0.042 FT/FT

$L_o =$ 36

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS — INLET CONTROL: HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL: TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 18 17	70		1	4										93.2		AT CROWN
" "	100		1.38	5.5										94.7		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 1

CULVERT BARREL SELECTED:

SIZE: 4' Φ

SHAPE: CIRC

MATERIAL: CONC n:

ENTRANCE: 4, TYPE 1

SUBJECT FLAUGHERTY RUN

BY STR DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 14 OF 29

GAI CONSULTANTS, INC.
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CULVERT DESIGN FORM

PROJECT: ____________

STATION: ____________

SHEET ____ OF ____

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

☐ METHOD: ____________

☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______

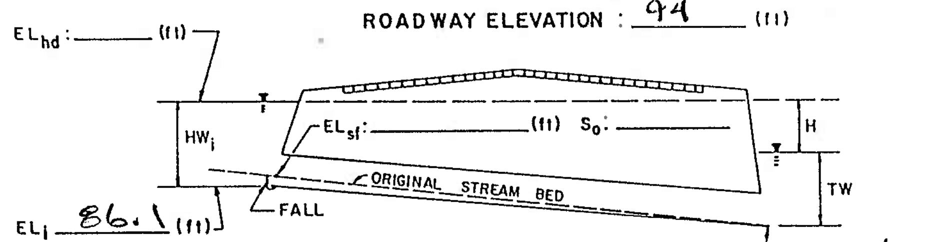
☐ CHANNEL SHAPE: ____________

☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94 (ft)



$S \approx S_o$ - FALL / L_a

S = 0.058 ft/ft

L_a = 36'

HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 2018	65		1	4										90.1		AT CROWN
" "	125		1.98	7.9										94		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 2

CULVERT BARREL SELECTED:

SIZE: 48" ⌀

SHAPE: CIRC

MATERIAL: CMP n: ______

ENTRANCE: TYPE 3

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO.: 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO.: 15 OF 29

GAI CONSULTANTS, INC.
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CULVERT DESIGN FORM

PROJECT: ______

STATION: ______

SHEET ____ OF ____

DESIGNER / DATE: ____ / ____

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

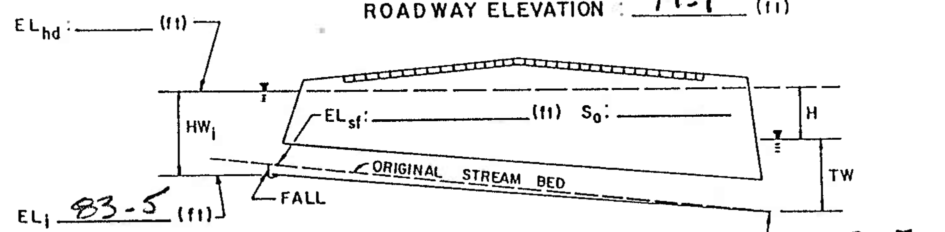
SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.7 (ft)



$S \approx S_o - FALL / L_a$

S = 0.0079 FT/FT

L_a = 38'

CULVERT DESCRIPTION / HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 14 14	1800	87	1	9.5										93		AT CROWN
" "	2100	102	1.18	11.2										94.7		AT RIDGE

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 9.5'H x 21'W

SHAPE: BRIDGE

MATERIAL: CONC. & STEEL n: ______

ENTRANCE: TYPE 1

SUBJECT FLAUGHERTY RUN

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 16 OF 29

GAI CONSULTANTS, INC.
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PROJECT: ______

STATION: ______
SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______
REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

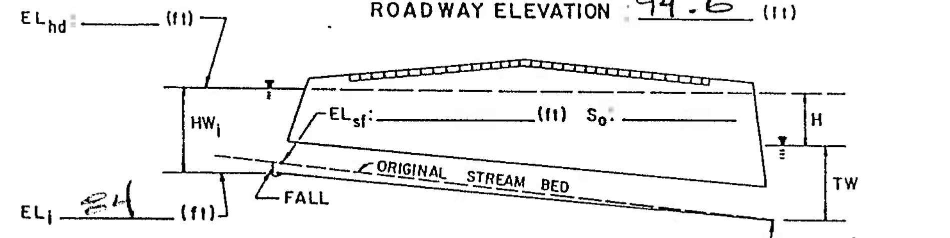
SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.6 (ft)



$S \approx S_o - FALL / L_a$
S = 0.034 ft/ft
L_a = 29

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 257	1752		1	8										92		AT CROWN
" "	2530		1.33	10.6										94.6		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
RISE/SPAN = 0.3
USE CHART 41
ASSUME AREA = 1/2 ELLIPSE

CULVERT BARREL SELECTED:

SIZE: 8'H X 30'W
SHAPE: ARCH
MATERIAL: CONC. n: ______
ENTRANCE: TYPE 2 ON CHART 41

AREA = 1/2 πab = 1/2 π 8 · 30/2 = 188 FT²

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 17 OF 29

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CULVERT DESIGN FORM

PROJECT: ______

STATION: ______ SHEET ____ OF ____

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

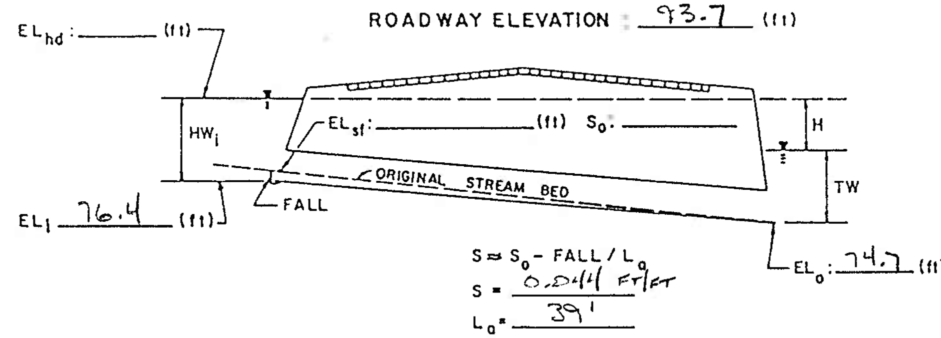
SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 93.7 (ft)



$S \approx S_o - FALL / L_a$

S = 0.044 FT/FT

L_a = 39'

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW$_i$/D (2)	HW$_i$	FALL (3)	EL$_{hi}$ (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL$_{ho}$ (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT X 3	7000		1	16										92.4		@ CROWN
" "	7900		1.08	17.3										93.7		@ RDWY

(HEADWATER CALCULATIONS)

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

SEE NEXT SHEET

CULVERT BARREL SELECTED:

SIZE: 16'H x 49'W

SHAPE: ARCH

MATERIAL: CONC. n:

ENTRANCE: TYPE 1 IN HDS 5

SUBJECT FLAUGHERTY RUN

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 18 OF 29

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CULVERT #3

ASSUME INLET CONTROL

USE FORMULAE IN HDS No 5

UNSUBMERGED

$$HW/D = K\left[\frac{Q}{AD^{0.5}}\right]^M$$

FOR $Q/AD^{0.5} < 3.5$

SUBMERGED

$$HW/D = c\left[\frac{Q}{AD^{0.5}}\right]^2 + Y - 0.5S^2$$

FOR $Q/AD^{0.5} > 4$

USE ARCH CM, BEST CHOICE, TYPE 1 ENTRANCE

K = 0.0083
M = 2.0

c = 0.0379
Y = 0.69
S = 0.044

ASSUME A = 1/2 AREA ELLIPSE

$A = 1/2\,\pi a b = 1/2\,\pi\, 16 \cdot 49/2 = 616\ FT^2$

$AD^{0.5} = 616 \cdot 16^{1/2} = 2464$

$HW/D = 0.0083\left[\frac{Q}{2464}\right]^2$

$HW/D = 0.0379\left[\frac{Q}{2464}\right]^2 + 0.69 - c$

IF $HW/D = 1 = 0.0083\left[\frac{Q}{2464}\right]^2$

$Q = 27{,}000$ CFS ; $Q/AD^{0.5} > 3.5$

IF $HW/D = 1.08 = 0.0083\left[\frac{Q}{2464}\right]^2$

$Q = 28{,}000$ CFS ; $Q/AD^{0.5} > 3.5$

IF $HW/D = 1 = 0.0379\left[\frac{Q}{2464}\right]^2 + 0.69$

$Q = 7000$ CFS ; $Q/AD^{0.5} < 4.0$

IF $HW/D = 1.08$

$Q = 7900$ CFS ; $Q/AD^{0.5} < 4.0$

NEITHER FORMULA IS APPLICABLE HOWEVER SUBMERGED IS CLOSEST USE SUBMERGED NUMBERS

SUBJECT: FLAHERTY RUN

BY: SER   DATE: 6/8/94   PROJ. NO. 91-503-11
CHKD. BY: RAG   DATE: 6/13/94   SHEET NO. D OF 29

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CULVERT DESIGN FORM

PROJECT: ____
STATION: ____
SHEET ____ OF ____
DESIGNER / DATE: ____ / ____
REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

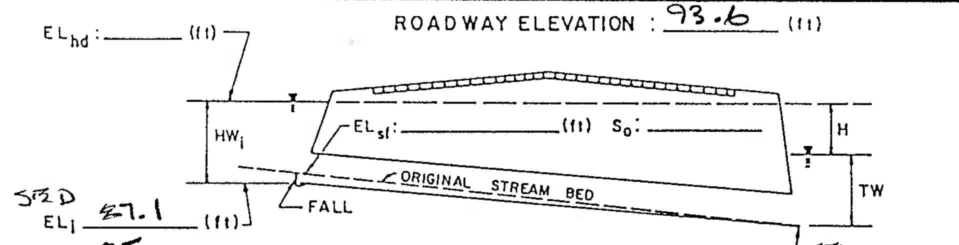
SEE ADD'L. SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 93.6 (ft)



$S = S_o - FALL / L_a$
S = 0.0071 / 0.023
L_a = 70 FT

HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT ~~29~~ 10 ORIGINAL	120		1	4.8										89.8		AT CROWN
" " "	240		1.79	8.6										93.6		AT RDWY
" " EXISTING	51		1	2.7										89.8		AT CROWN
" "	130		2.41	6.5										93.6		AT RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER) $AD^{0.5} = 10.43 \cdot 2.7^{1/2} = 17.14$

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$ USE CIRC. CONC.

(8) $EL_{ho} = EL_o + H + h_o$ SEE NEXT SHEET

SUBSCRIPT DEFINITIONS:

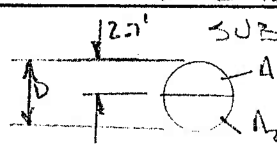
- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 1 FOR
ORIGINAL CONDITIONS
FOR EXISTING USE HDS-5

CULVERT BARREL SELECTED:

SIZE: 4.8' ⌀
SHAPE: CIRC. ?
MATERIAL: CONC n: ____
ENTRANCE: TYPE 2



SUBMERGED INLET CONTROL $y/D = 2.1/4.8 = 0.44$

$A_1 + A_2 = A_T = \pi D^2/4 = 18.10\ FT^2$ $A/D^2 = 0.3328$ FROM CHOW

$y = D - 2.7 = 4.8 - 2.7 = 2.1\ FT$ $A_2 = 7.67\ FT^2$ $A_1 = 10.43\ FT^2$

SUBJECT FLAUGHERTY RUN

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 20 OF 29

GAI CONSULTANTS, INC.
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CULVERT ~~29~~ 10

CONTINUED

UNSUBMERGED

$$\frac{HW}{D} = K\left[\frac{Q}{AD^{0.5}}\right]^M$$

FOR $\frac{Q}{AD^{0.5}} < 3.5$

K = 0.0078
M = 2.0

$$\frac{HW}{D} = 0.0078\left[\frac{Q}{17.14}\right]^2$$

IF HW/D = 1
Q = 190 CFS ; $Q/AD^{0.5} > 3.5$

IF HW/D = 2.41
Q = 300 CFS ; $Q/AD^{0.5} > 3.5$

SUBMERGED

$$\frac{HW}{D} = c\left[\frac{Q}{AD^{0.5}}\right]^2 + Y - 0.5S$$

FOR $\frac{Q}{AD^{0.5}} > 4$

c = 0.0292
Y = 0.74
S = 0.023

$$\frac{HW}{D} = 0.0292\left[\frac{Q}{17.14}\right]^2 + 0.74 - 0$$

IF HW/D = 1
Q = 51 CFS ; $Q/AD^{0.5} = 3 < 4$

IF HW/D = 2.41
Q = 130 CFS ; $Q/AD^{0.5} = 7 > 4$ ∴ OK

USE Q = 51 CFS FOR HW/D = 1
Q = 130 CFS FOR HW/D = 2.41

SUBJECT: Flaugherty Run

BY: SER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 21 OF 29

GAI CONSULTANTS, INC. 52

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PROJECT: ____________

STATION: ____________

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

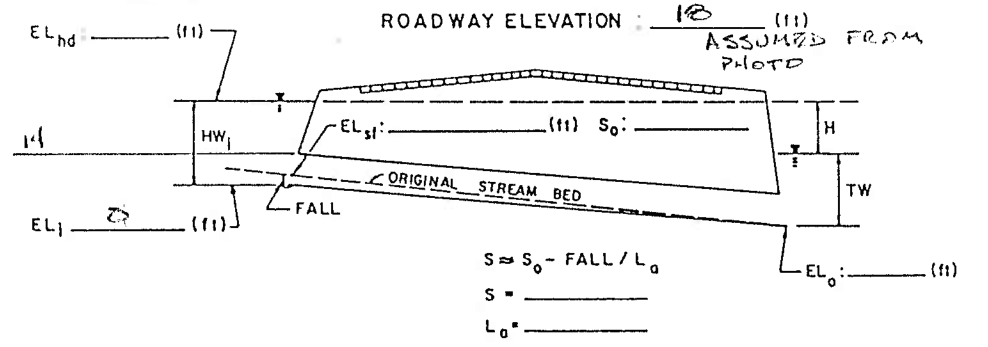
SEE ADD'L. SHTS.

- ☐ METHOD: ____________
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ____________
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 18 (ft) ASSUMED FROM PHOTO



$S \approx S_o - FALL / L_a$

S = ______

L_a = ______

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS — INLET CONTROL: HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL: TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT #1	3100		1	14										14		@ CROWN
" "	3800		1.28	18										18		@ RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 43, USE TYPE 2 ENT.
RISE / SPAN = 14/23 = 0.6
ASSUME SHAPE IS 23' SEMI CIRCLE TOP WITH STRAIGHT SIDES AND BOTTOM
$A = \frac{1}{2}\pi D^2/4 + 2.5' \cdot 23' = 265 \text{ FT}^2$

CULVERT BARREL SELECTED:

SIZE: 14' H x 23' W

SHAPE: ARCH

MATERIAL: CONC. n ______

ENTRANCE: SKEWED 30°

SUBJECT FLAUGHERTY RUN

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 22 OF 29

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PROJECT:	STATION:	CULVERT DESIGN FORM
	SHEET ____ OF ____	DESIGNER / DATE: ____ / ____
		REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

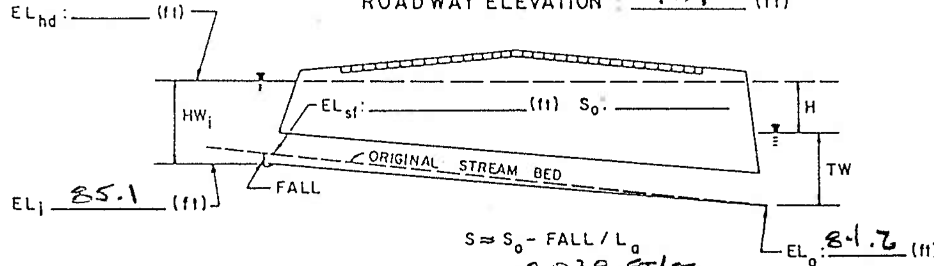
SEE ADD'L SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.7 (ft)



$S \approx S_o - FALL / L_a$

S = 0.028 FT/FT

L_a = 32 FT

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT ~~14~~ 16	1300	61	1	8										93.1		@ CROWN
" "	1700	82	1.2	9.6										94.7		@ RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i / D = HW / D$ OR HW_i / D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2 / 2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 8

CULVERT BARREL SELECTED:

SIZE: 8'H x 21'W

SHAPE: BRIDGE

MATERIAL: CONC. n: ____

ENTRANCE: USE TYPE 1

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO. 91-503-11

CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 23 OF 29

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Environmental Specialists

PROJECT: ______

STATION: ______ SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ____ / ____
REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

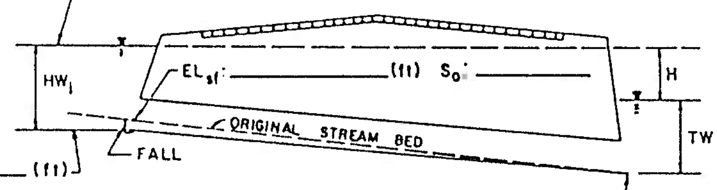
SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94.6 (ft)



$S \approx S_o - FALL / L_o$
S = 0.027 FT/FT
L_o = 33 FT

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT ~~18~~ 15	1600		1	9										91.9		@ CROWN
" "	2000		1.3	11.7										94.6		@ RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 41
RISE/SPAN = 0.4

CULVERT BARREL SELECTED:

SIZE: 9'H x 23'W
SHAPE: ARCH
MATERIAL: CONC n
ENTRANCE: TYPE 2

ASSUME AREA = 1/2 ELLIPSE
$A = 1/2\, \pi a b = 1/2\, \pi\, 9 \cdot 23/2 = 163\ FT^2$

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 6/8/94 PROJ. NO. 91-503-11
CHKD. BY: RAG DATE: 6/13/94 SHEET NO. 24 OF 29

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CULVERT DESIGN FORM

PROJECT: ______

STATION: ______
SHEET ______ OF ______

DESIGNER / DATE: ______ / ______
REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

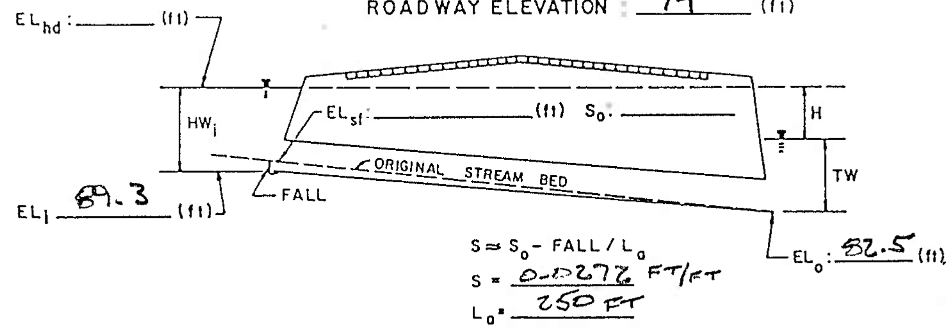
SEE ADD'L. SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: 94 (ft)



$S \approx S_o - FALL / L_o$
S = 0.0272 FT/FT
L_o = 250 FT

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
CULVERT 22 ~~999(Z)~~	132		1	5										94.3		@ CROWN OF RDWY

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME INLET CONTROL
USE CHART 1

CULVERT BARREL SELECTED:

SIZE: 5 FT Φ
SHAPE: CIRC
MATERIAL: CONC. n: ______
ENTRANCE: TYPE 3

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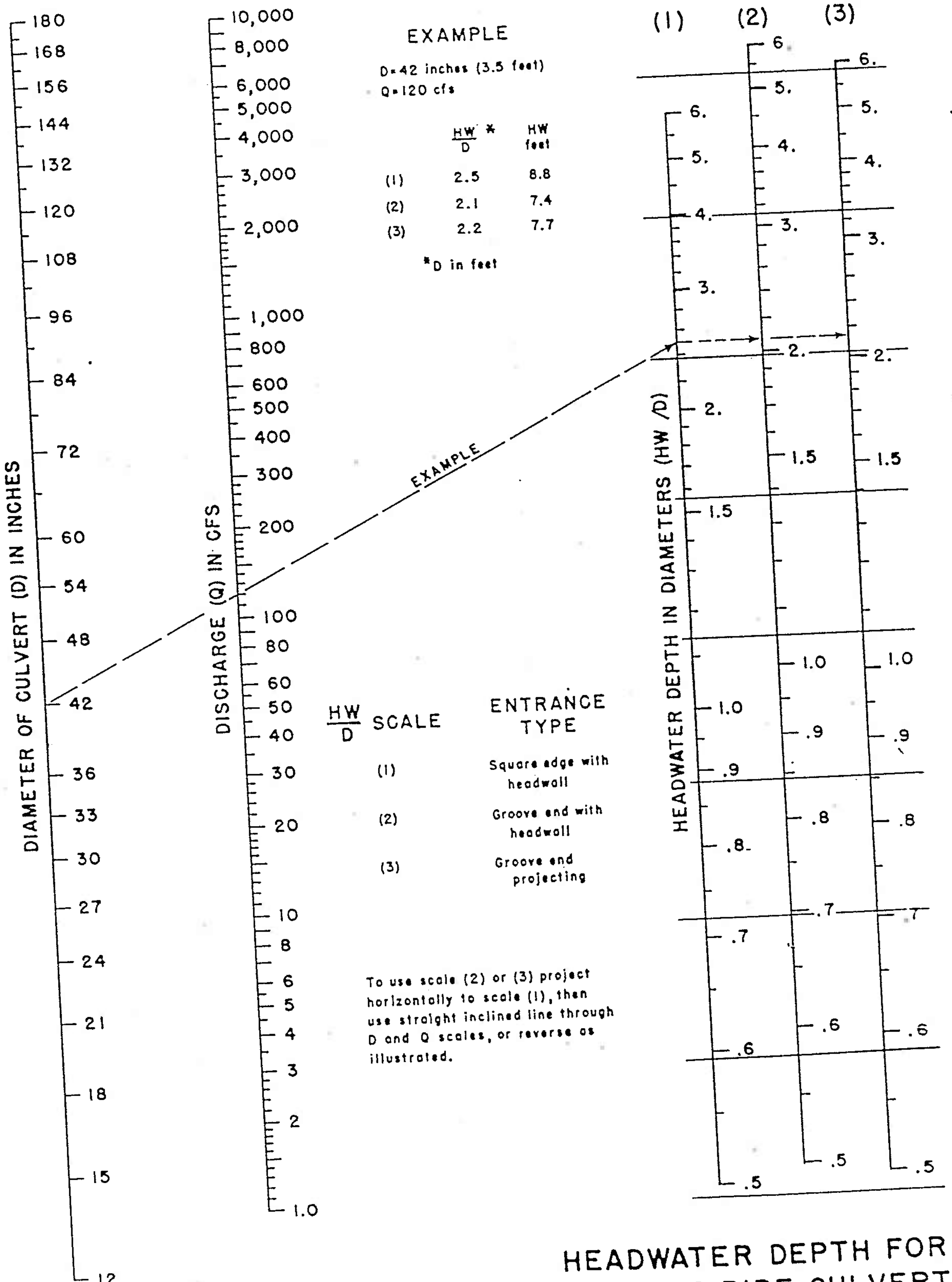
SUBJECT Flaugherty Run

BY STR DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 25 OF 29

CHART 1



Taken from: "Hydraulic Design of Highway Culverts", HDS No 5, FHWA September, 1985

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3

SUBJECT FLAUGHERTY RUN

BY JZR DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 26 OF 29

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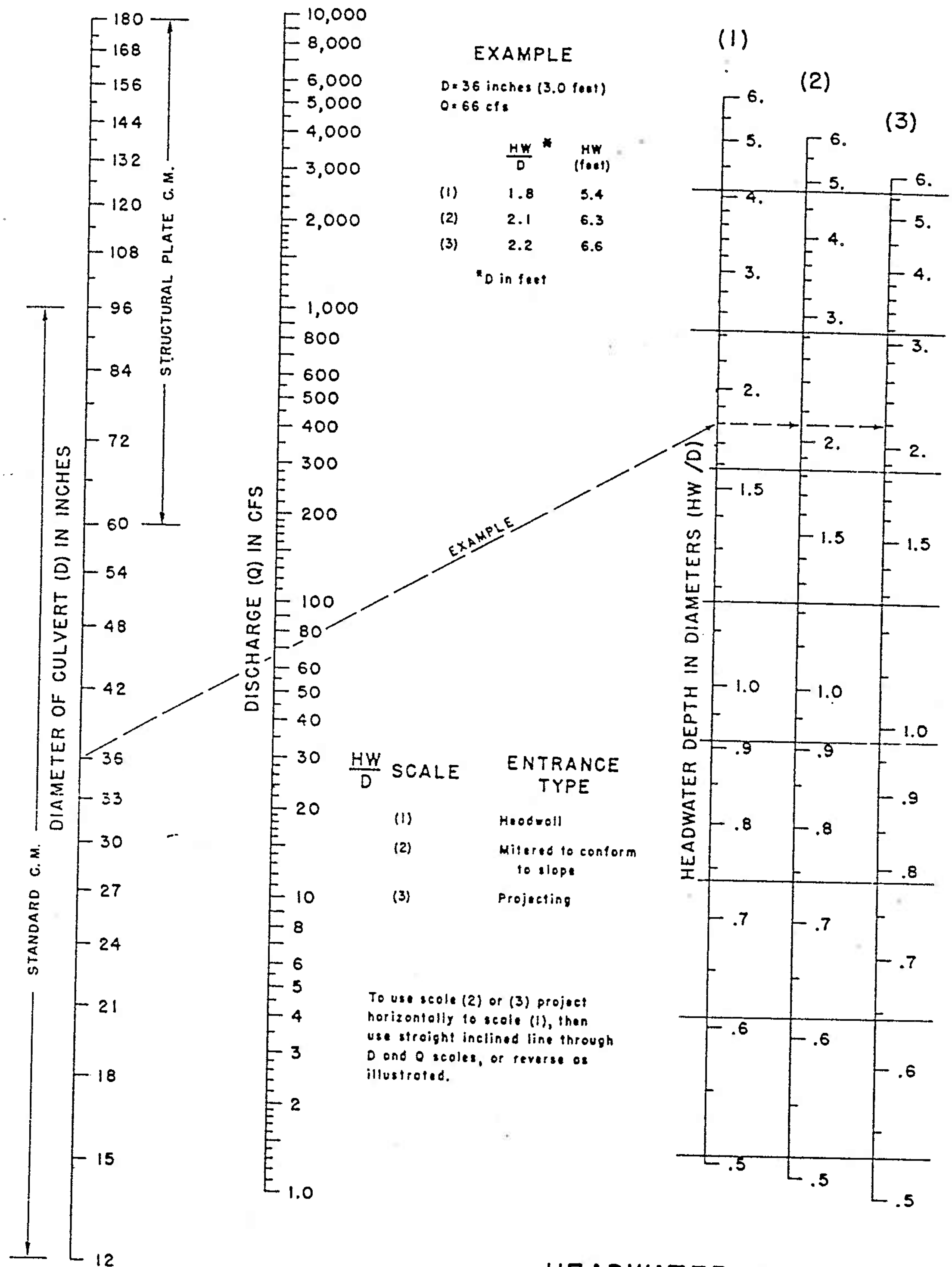
CHART 2



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

SUBJECT FLAHERTY RUN

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 27 OF 29

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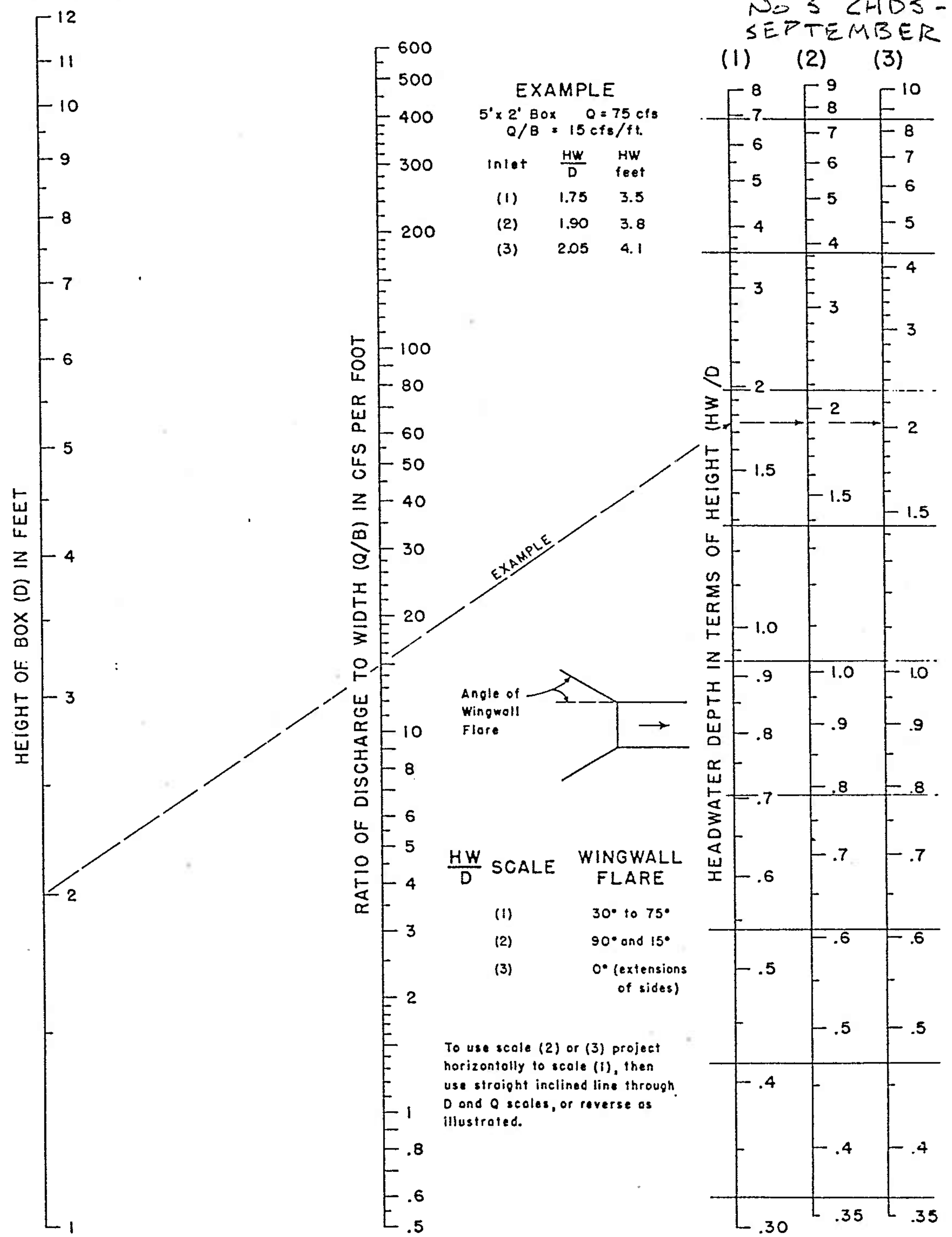
TAKEN FROM: HYDRAULIC DESIGN OF HIGHWAY CULVERTS, HYDRAULIC DESIGN SERIES No 5 (HDS-5) FHWA SEPTEMBER 1985

CHART 8



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

SUBJECT Flaugherty Run

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 28 OF 29

CONSULTANTS, INC.

Engineers • Geologists • Planners
Environmental Specialists

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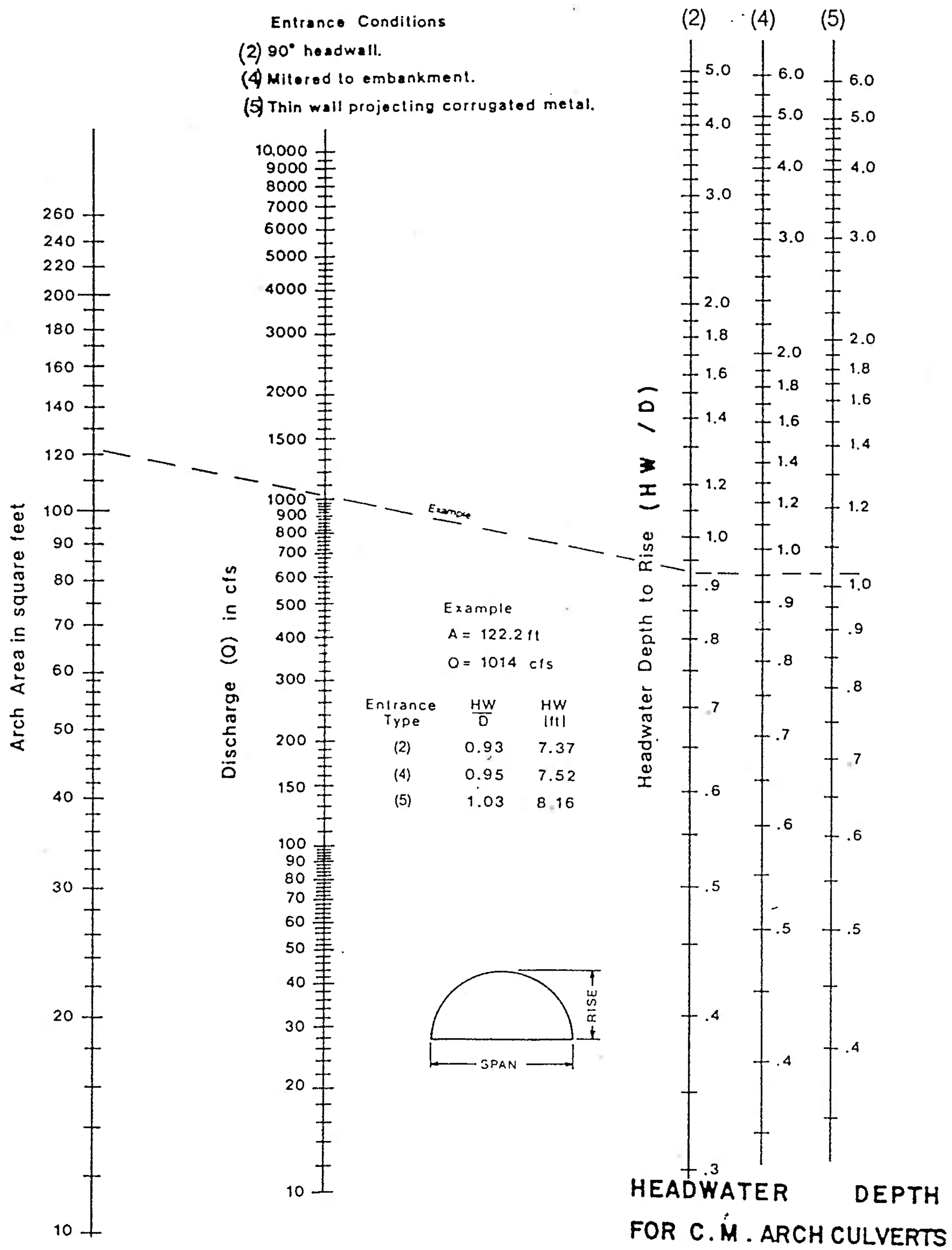
CHART 41



TAKEN FROM "HYDRAULIC DESIGN OF HIGHWAY CULVERTS", HDS No. 5, FHWA, SEPTEMBER, 1985

HEADWATER DEPTH FOR C.M. ARCH CULVERTS $0.3 \leq$ RISE / SPAN < 0.4 WITH INLET CONTROL

Duplication of this nomograph may distort scale

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

SUBJECT FLAUGHERTY RUN

BY SER DATE 6/8/94 PROJ. NO. 91-503-11

CHKD. BY RAG DATE 6/13/94 SHEET NO. 29 OF 29

GAI CONSULTANTS, INC.
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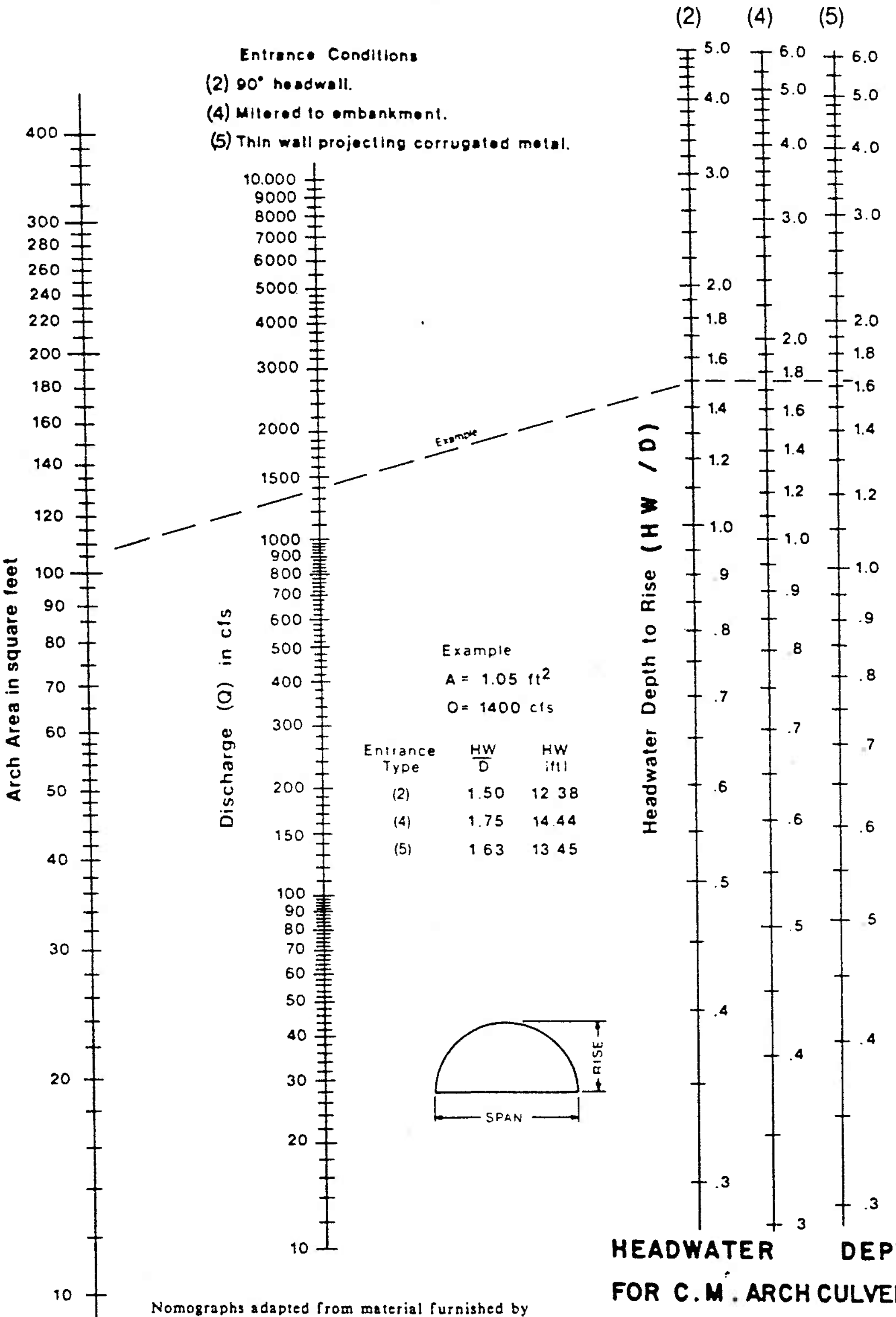
Environmental Specialists

CHART 43

FROM HDS-5 "HYDRAULIC DESIGN OF HIGHWAY CULVERTS" USDOT, FHWA SEPT., 1985



Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

HEADWATER DEPTH FOR C.M. ARCH CULVERTS 0.5 ≤ RISE / SPAN WITH INLET CONTROL

ADDITIONAL OBSTRUCTION CAPACITIES

SUBJECT FLAUGHERTY RUN

BY SER DATE 11/13/95 PROJ. NO. 91-503-11

CHKD. BY ______ DATE ______ SHEET NO. 1 OF 10

GAI CONSULTANTS, INC.
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ADDITIONAL OBSTRUCTION CAPACITIES

ESTIMATE INLET CONTROL CAPACITIES OF OBSTRUCTIONS OBSERVED IN FIELD BY SER/KLF 10/31/95.

NOTES: CAPACITIES FOR OBSTRUCTION NO. ~~102~~ 29, ~~106~~ 25, AND ~~108~~ 23 HAVE PREVIOUSLY BEEN CALCULATED.

REFERENCES: 1) HDS-5, HYDRAULIC DESIGN OF HIGHWAY CULVERTS", FHWA, SEPT. 1985, SEE PREVIOUS CALC BY SER DATED 6/6/94 TITLED "OBSTRUCTION CAPACITIES"
2) STREAM OBSTRUCTION DATA SHEETS FLAUGHERTY RUN WATERSHED

SUBJECT: Flaugherty Run

BY: SER DATE: 11/13/95 PROJ. NO. 91-503-11

CHKD. BY: ____ DATE: ____ SHEET NO. 2 OF 10

GAI CONSULTANTS, INC.
Engineers • Geologists • Planners
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6-2

PROJECT: CULVERT No ~~30~~ 13

STATION: ____
SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ____ / ____
REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

SEE ADD'L SHTS.

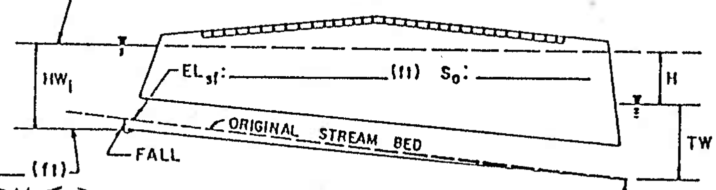
- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

EL_{hd}: 92.2 (ft) ASSUMED

~~ROADWAY~~ ELEVATION: 94.2 (ft) EMB. CREST



EL_i: 89.2 (ft) ASSUMED

$S = S_o - FALL / L_o$

S = 0.02 ASSUMED

L_o = 30'

EL_o: 88.6 (ft)

CULVERT DESCRIPTION / HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW$_i$/D (2)	HW$_i$	FALL (3)	EL$_{hi}$ (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL$_{ho}$ (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
30" ⌀ STEEL	24		1.0	30"												CREST OF PIPE
	50		2.0	5'												CREST OF EMBANKMENT
	30		1.2	3'												NORMAL POOL

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME: PIPE SLOPE = 2% ∴ PIPE INLET INVERT = 88.6 + 30 * .02 = 89.2
ASSUME NORMAL WATER SURFACE IS 2' BELOW EMBANKMENT CREST
USE CONCRETE INLET CONTROL NOMOGRAPHS

CULVERT BARREL SELECTED:

SIZE: 30"
SHAPE: CIRC
MATERIAL: STEEL
ENTRANCE: ASSUME NO HEADWALL

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 11/13/95 PROJ. NO. 91-503-11

CHKD. BY: DATE: SHEET NO. 3 OF 10

GAI CONSULTANTS, INC. 63

Engineers • Geologists • Planners
Environmental Specialists

PROJECT: CULVERT NO ~~[illegible]~~ 30

STATION: SHEET ___ OF ___

CULVERT DESIGN FORM

DESIGNER / DATE: ___ / ___

REVIEWER / DATE: ___ / ___

HYDROLOGICAL DATA

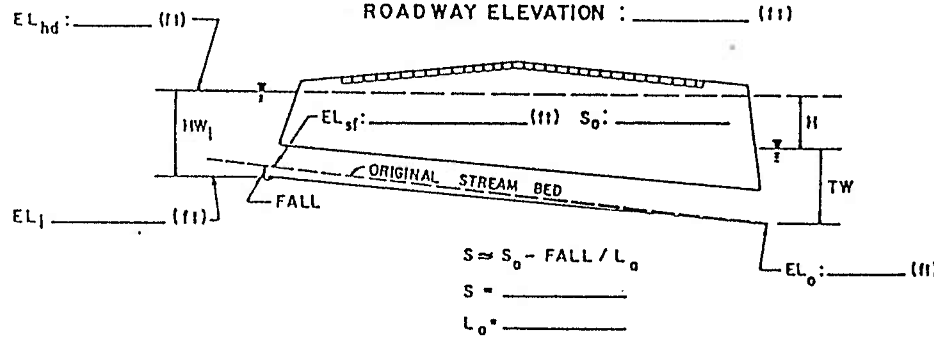
SEE ADD'L SHTS.

- ☐ METHOD:
- ☐ DRAINAGE AREA: ☐ STREAM SLOPE:
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ☐ OTHER:

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: ___ (ft)



$S \approx S_o - FALL / L_a$

S = ___

L_a = ___

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
4.5'Ø CONCRETE	100		1.0	4.5												PIPE CREST
PROJECTING	160		1.44	6.5												ROADWAY CREST

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME ROADWAY IS 2' ABOVE CREST

CULVERT BARREL SELECTED:

SIZE:

SHAPE:

MATERIAL: n

ENTRANCE:

SUBJECT FLAUGHERTY RUN

BY SER DATE 11/13/95 PROJ. NO. 91-503-11

CHKD. BY ______ DATE ______ SHEET NO. 4 OF 10

GAI CONSULTANTS, INC.
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Environmental Specialists

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PROJECT: CULVERT 1D328

STATION: ______

SHEET ______ OF ______

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

HYDROLOGICAL DATA

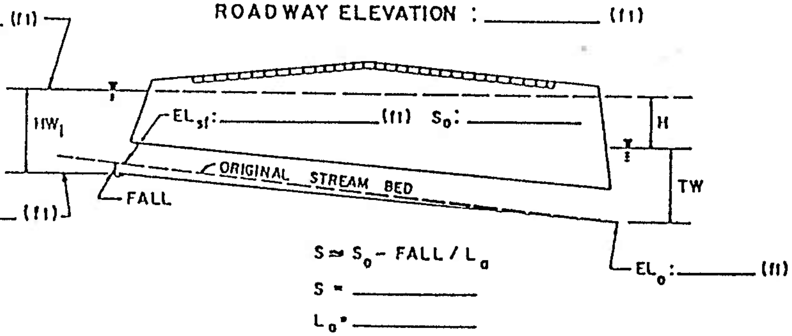
SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: ______ (ft)



$S \approx S_o - FALL / L_a$

S = ______

L_o = ______

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_I/D (2)	HW_I	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c + D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
4' ϕ CMP	67		1.0	4												PIPE CREST
PROJECTING	110		1.6	6.5												ROADWAY CREST

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_I/D = HW/D$ OR HW_I/D FROM DESIGN CHARTS

(3) $FALL = HW_I - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_I + EL_I$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME ROADWAY CREST IS 2.5' ABOVE PIPE CREST

CULVERT BARREL SELECTED:

SIZE: ______

SHAPE: ______

MATERIAL: ______

ENTRANCE: ______

SUBJECT: Flahulerty Run

BY: SER DATE: 11/13/95 PROJ. NO. 91-503-11

CHKD. BY: ____ DATE: ____ SHEET NO. 5 OF 10

CONSULTANTS, INC.
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Environmental Specialists

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CULVERT DESIGN FORM

PROJECT: CULVERT ~~104~~ 27

STATION: ____

SHEET ____ OF ____

DESIGNER / DATE: ____ / ____

REVIEWER / DATE: ____ / ____

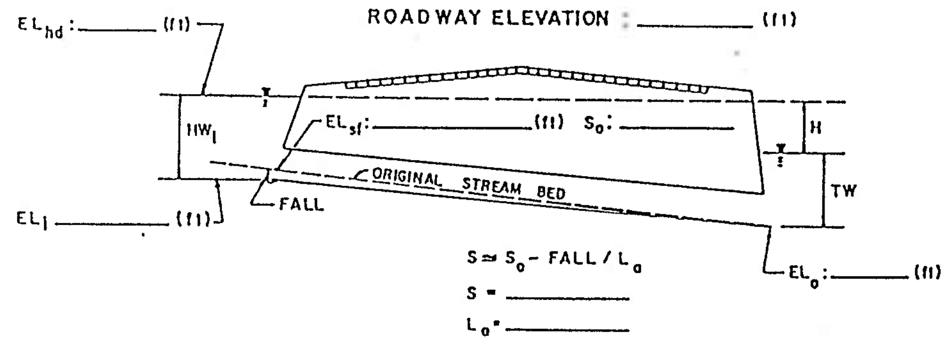
HYDROLOGICAL DATA

SEE ADD'L SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)



CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_I/D (2)	HW_I	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
6' ϕ CMP	90		1	4.5												
w/ 1.5' SEDIMENT	150		1.66	7.5												
PROJECTING																

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_I/D = HW/D$ OR HW_I/D FROM DESIGN CHARTS

(3) $FALL = HW_I - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_I + EL_I$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] v^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME EQUIVALENT D = 4.5'
ASSUME ROADWAY CREST IS 3' ABOVE PIPE CREST

CULVERT BARREL SELECTED:

SIZE: ____

SHAPE: ____

MATERIAL: ____ n ____

ENTRANCE: ____

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 11/13/95 PROJ. NO.: 91-503-11

CHKD. BY: ____ DATE: ____ SHEET NO.: 6 OF 10

CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists

PROJECT: CULVERT 105 26

STATION: ____

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ____ / ____

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

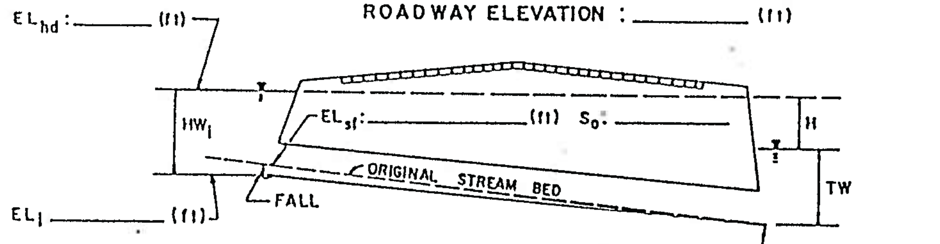
SEE ADD'L SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: ____ (ft)



$S \approx S_o - FALL / L_a$

S = ____

L_a = ____

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_I/D (2)	HW_I	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c + D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
6'ϕ CMP	180		1.0	6												PIPE CREST
USE PROJECTING ENT.	220		1.16	7												ROADWAY CREST

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_I/D = HW/D$ OR HW_I/D FROM DESIGN CHARTS

(3) $FALL = HW_I - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_I + EL_I$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2 / 2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME ROADWAY CREST IS 1 FT ABOVE PIPE CREST

CULVERT BARREL SELECTED:

SIZE: ____

SHAPE: ____

MATERIAL: ____ n ____

ENTRANCE: ____

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 11/13/95 PROJ. NO. 91-503-11

CHKD. BY: DATE: SHEET NO. 7 OF 10

GAI CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists

PROJECT: CULVERT 107-24

STATION: ______ SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ____ / ____
REVIEWER / DATE: ____ / ____

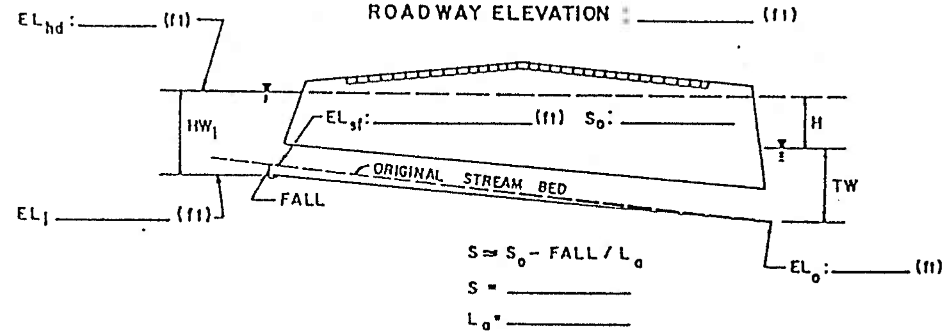
HYDROLOGICAL DATA

SEE ADD'L SHTS.

- ☐ METHOD:
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE:
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ____ ☐ OTHER:

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)



CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS – INLET CONTROL: HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL: TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
6' Ø CMP	180		1.06	6												PIPE CREST
PROJECTING	220		1.16	7												ROADWAY CREST

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME ROADWAY CREST IS 1 FT ABOVE PIPE CREST

CULVERT BARREL SELECTED:

SIZE:
SHAPE:
MATERIAL: ____ n ____
ENTRANCE:

SUBJECT: Flaugherty Run

BY: SER DATE: 11/13/95 PROJ. NO. 91-503-11

CHKD. BY: ____ DATE: ____ SHEET NO. 8 OF 10

GAI CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists

PROJECT: Culvert no 21

STATION: ____

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ____ / ____

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

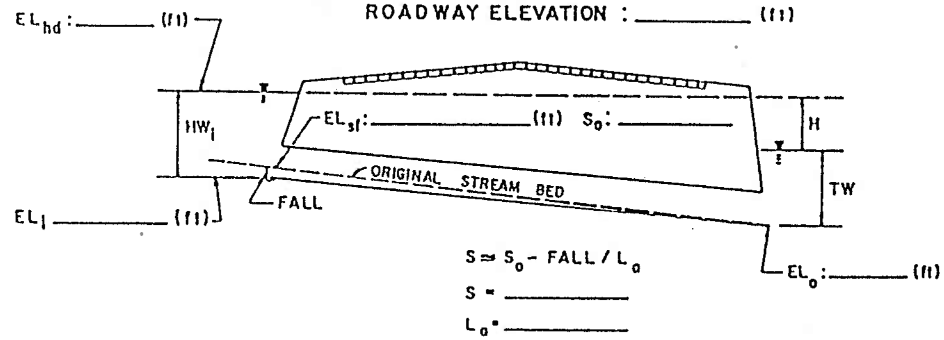
SEE ADD'L SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: ____ (ft)



$S \approx S_o - FALL / L_o$

S = ____

L_o = ____

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
6 1/2' SPAN x 8' RISE	270	42	1.0	8												
USE 0° WINGWALL	290	45	1.06	8.5												
FLARE																

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

USE CONCRETE BOX NOMOGRAPH
ASSUME ROADWAY CREST IS
0.5' ABOVE PIPE CREST

CULVERT BARREL SELECTED:

SIZE: ____

SHAPE: ____

MATERIAL: ____ n ____

ENTRANCE: ____

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 11/13/95 PROJ. NO. 91-503-11

CHKD. BY: ______ DATE: ______ SHEET NO. 9 OF 10

GAI CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists

69

PROJECT: CULVERT #20

STATION: ______

SHEET ______ OF ______

CULVERT DESIGN FORM

DESIGNER / DATE: ______ / ______

REVIEWER / DATE: ______ / ______

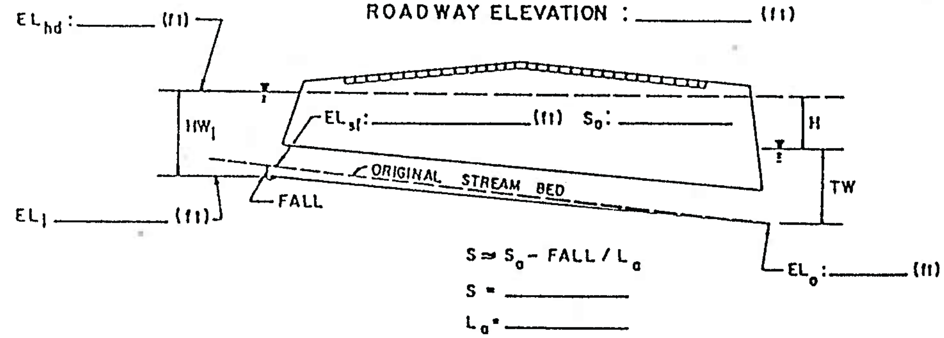
HYDROLOGICAL DATA

SEE ADD'L SHTS.

- ☐ METHOD: ______
- ☐ DRAINAGE AREA: ______ ☐ STREAM SLOPE: ______
- ☐ CHANNEL SHAPE: ______
- ☐ ROUTING: ______ ☐ OTHER: ______

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)



CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
6'Ø CMP	180		1	6												PIPE CREST
PROJECTION	280		1.5	9												ROADWAY CREST

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i / D = HW / D$ OR HW_i / D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2 / 2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME ROADWAY CREST IS 3' ABOVE PIPE CREST

CULVERT BARREL SELECTED:

SIZE: ______

SHAPE: ______

MATERIAL: ______ n ______

ENTRANCE: ______

SUBJECT: FLAUGHERTY RUN

BY: SER DATE: 1/10/96 PROJ. NO. 91-503-11

CHKD. BY: ____ DATE: ____ SHEET NO. 10 OF 10

CONSULTANTS, INC.

Engineers • Geologists • Planners
Environmental Specialists

7D

PROJECT: CULVERT 20

STATION: ____

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: ____ / ____

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

☐ METHOD: ____

☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____

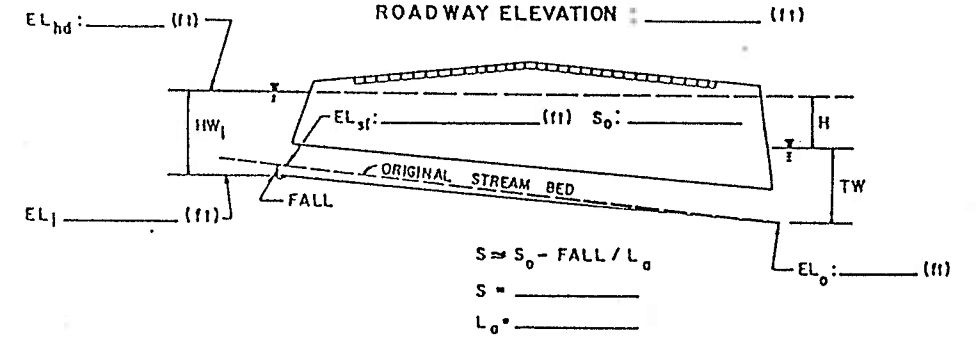
☐ CHANNEL SHAPE: ____

☐ ROUTING: ____ ☐ OTHER: ____

SEE ADD'L SHTS.

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)



HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
6' ⌀ CMP	180		1	6												PIPE CREST
PROJECTION	280		1.5	9												ROADWAY CREST

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

ASSUME ROADWAY CREST IS 3' ABOVE PIPE CREST

CULVERT BARREL SELECTED:

SIZE: ____

SHAPE: ____

MATERIAL: ____

ENTRANCE: ____

APPENDIX C

CORRESPONDENCE WITH AGENCIES

CONSULTANTS

GAI Consultants, Inc

570 Beatty Road
Monroeville, PA 1514[illegible]
412/856-6400
FAX 412/856-4970

October 5, 1994

Project 91-503-11

Mr. Michael Conway
Director, Bureau of Flood Protection Projects
Pennsylvania Department of Environmental Resources
Division of Project Development
P.O. Box 8460
Harrisburg, Pennsylvania 17105-8460

Flaughtery Run Watershed
Department of Environmental Resources Projects

Dear Mr. Conway:

GAI Consultants, Inc., (GAI) is preparing the Act 167 Stormwater Management Plan for the Flaugherty Run watershed. As part of the plan, GAI would appreciate information on any Department of Environmental Resources (DER) projects planned or built on Flaugherty Run or its tributaries. A location map is provided for your use. Specific projects may include stream bank rehabilitation, channel clearing/snagging, or flood control projects. The information should include date constructed, location, and type of project. If the DER has no projects either constructed or planned in the watershed, GAI would appreciate a letter so indicating. If you have any questions, please do not hesitate to call.

Very truly yours,
GAI Consultants, Inc.

Kerry L. Frech, P.E.

KLF:dae
9150311.klf/dae20

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
PO Box 8460
Harrisburg, PA 17105-8460
October 14, 1994

BUREAU OF FLOOD PROTECTION PROJECTS

Kerry L. Frech, P.E.
GAI Consultants
570 Beatty Road
Monroeville PA 15146

DER File No. S2:179

Dear Mr. Frech:

This will acknowledge receipt of your letter dated October 5, 1994 regarding projects planned or constructed in the Flaugherty Run Watershed.

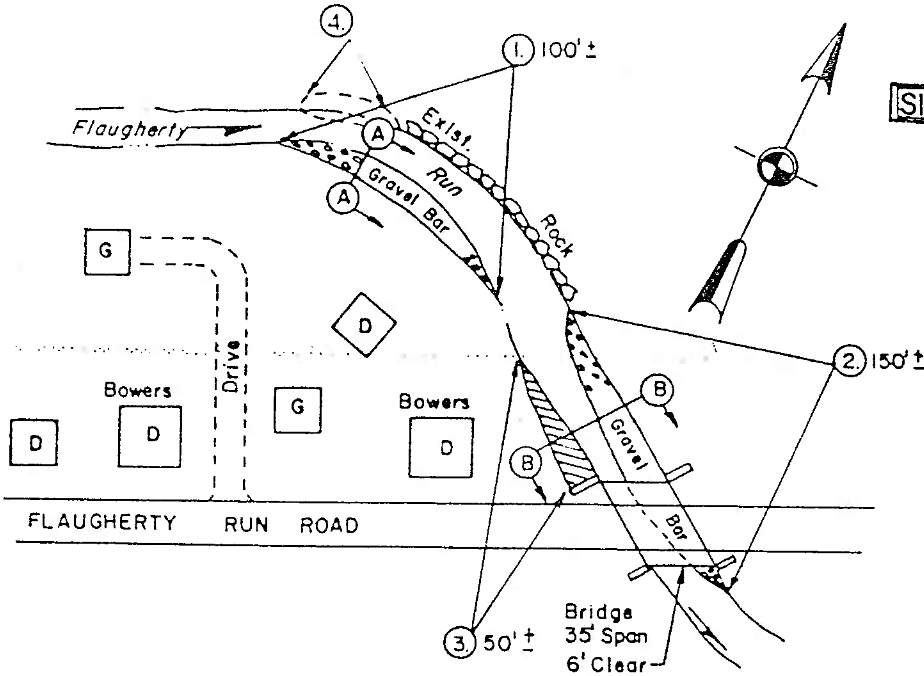
In 1985 we completed the construction of a channel improvement and stabilization project on Flaugherty Run in Moon Township, Allegheny County. I have enclosed a copy of the project plan for your information and use. If you have any questions please contact Larry Oliver, Chief, Division of Stream Improvements at 717-787-7432.

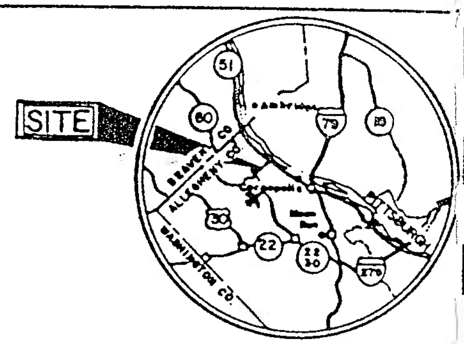
Sincerely,

Michael D. Conway
Director

Enclosure

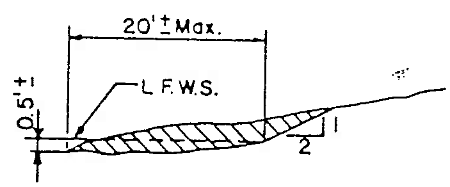
DIVISION OF STREAM IMPROVEMENTS
BUREAU OF WATER PROJECTS
DEPARTMENT OF ENVIRONMENTAL RESOURCES
COMMONWEALTH OF PENNSYLVANIA



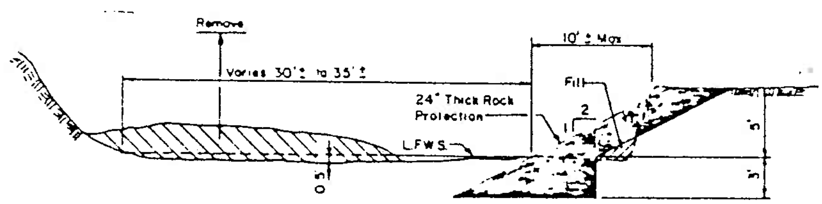


LOCATION MAP

PLAN



TYPICAL SECTION A-A



TYPICAL SECTION B-B

PURPOSE: To increase the channel's flow capacity and stabilize an eroded bank to alleviate flood damages to adjacent residences.

WORKPLAN:

1. 100'±: Remove excess deposits as shown in Typical Section A-A.
2. 150'±: Remove excess deposits as shown in Typical Section B-B.
3. 50'±: Place 24" Thick Rock Protection as shown in Typical Section B-B.
4. At indicated location, remove fallen / undermined trees.

NOTE: Sketch is not to scale.

S2:179

CHANNEL IMPROVEMENT
AND STABILIZATION
IN: FLAUGERTY RUN
AT: MOON TOWNSHIP
ALLEGHENY COUNTY

APPL. BY: DIV. OF STREAM IMPROVEMENTS
BUREAU OF WATER PROJECTS
D. E. R

SHEET 1 of 1

8/14/85

GAI CONSULTANTS

GAI Consultants, Inc.

570 Beatty Road
Monroeville, PA 15146
412/856-6400
FAX 412/856-4970

October 5, 1994

Project 91-503-11

Mr. Robin L. Moyer
District Conservationist
Soil Conservation Service
One Parkway Center, Room 115
875 Greentree Road
Pittsburgh, Pennsylvania 15220

Flaughtery Run Watershed
SCS Projects

Dear Mr. Moyer:

GAI Consultants, Inc., (GAI) is preparing the Act 167 Stormwater Management Plan for the Flaugherty Run watershed. As part of the plan, GAI would appreciate information on any SCS projects planned or built on Flaugherty Run or its tributaries. A location map is provided for your use. Specific projects may include stream bank rehabilitation, channel clearing/snagging, or flood control projects. The information should include date constructed, location, and type of project. If the SCS has no projects either constructed or planned in the watershed, GAI would appreciate a letter so indicating. If you have any questions, please do not hesitate to call.

Very truly yours,
GAI Consultants, Inc.

Kerry L. Frech, P.E.

KLF:dae
9150311.klf/dae20

United States
Department of
Agriculture

Soil
Conservation
Service

Nine Parkway Center, Rm. 180
875 Greentree Road
Pittsburgh, Pa. 15220-3604

RECEIVED
OCT 11 1994
GAI CONSULTANTS, INC.
PROJ NO. 91-503-11

Mr. Kerry L. Frech, P. E.
GAI Consultants, Inc.
570 Beatty Road
Monroeville, Pa. 15146

October 7, 1994

Dear Mr. Frech:

In regards to your request on October 5, 1994 concerning information on SCS projects in the Flaugherty Run Watershed, in Allegheny County. Please be advised that SCS has no projects planned or completed in Allegheny County, in this watershed that I am aware of.

Since a small portion of this watershed is in Beaver County, you may also want to check with the Beaver Field Office (775-6231) for projects that I am not aware of.

Sincerely,

Robin L. Moyer

ROBIN L. MOYER
District Conservationist

KLF

GAI CONSULTANTS

GAI Consultants, Inc.

570 Beatty Road
Monroeville, PA 15146
412/856-6400
FAX 412/856-4970

October 26, 1994

Project 91-503-11

Mr. Jesse Council
District Conservationist
Soil Conservation Service
1000 Third Street, Suite 203
Beaver, Pennsylvania 15009

Flaughtery Run Watershed
SCS Projects

Dear Mr. Council:

GAI Consultants, Inc., (GAI) is preparing the Act 167 Stormwater Management Plan for the Flaugherty Run watershed. As part of the plan, GAI would appreciate information on any SCS projects planned or built on Flaugherty Run or its tributaries. A location map is provided for your use. Specific projects may include stream bank rehabilitation, channel clearing/snagging, or flood control projects. The information should include date constructed, location, and type of project. If the SCS has no projects either constructed or planned in the watershed, GAI would appreciate a letter so indicating. If you have any questions, please do not hesitate to call.

Very truly yours,
GAI Consultants, Inc.

Kerry L. Frech, P.E.

KLF:dae
9150311.klf/dae20

KLF

CONSULTANTS

GAI Consultants, Inc.

570 Beatty Road
Monroeville, PA 15146
412/856-6400
FAX 412/856-4970

October 7, 1994

Project 91-503-11

Mr. John Goga
Acting Chief, Planning Division
Pittsburgh District, Corps of Engineers
Department of the Army
William S. Moorhead Federal Building
1000 Liberty Avenue
Pittsburgh, Pennsylvania 15222-4186

Flaughtery Run Watershed
Corps of Engineers Projects

Dear Mr. Goga:

GAI Consultants, Inc., (GAI) is preparing the Act 167 Stormwater Management Plan for the Flaugherty Run watershed. As part of the plan, GAI would appreciate information on any Corps of Engineers (COE) projects planned or built on Flaugherty Run or its tributaries. A location map is provided for your use. Specific projects may include stream bank rehabilitation, channel clearing/snagging, or flood control projects. The information should include date constructed, location, and type of project. If the Pittsburgh District has no projects either constructed or planned in the watershed, GAI would appreciate a letter so indicating. If you have any questions, please do not hesitate to call.

Very truly yours,
GAI Consultants, Inc.

Kerry Frech

Kerry L. Frech, P.E.

KLF:dae
9150311.klf/dae20

DEPARTMENT OF THE ARMY
PITTSBURGH DISTRICT, CORPS OF ENGINEERS
WILLIAM S. MOORHEAD FEDERAL BUILDING
1000 LIBERTY AVENUE, PITTSBURGH, PA 15222

REPLY TO
ATTENTION OF

November 18, 1994

Special Studies and Flood
Plain Management Branch

Mr. Kerry L. Frech
GAI Consultants, Inc.
570 Beatty Road
Monroeville, Pennsylvania 15146

Dear Mr. Frech:

This is in response to your letter of October 7, 1994, requesting information on any Corps of Engineers projects planned or built on Flaugherty Run or its tributaries. The Corps does not have any projects either constructed or planned in the watershed. If you have any questions regarding this matter, please call Mr. Bill Frechione of my staff at (412) 644-2740.

Sincerely,

John N. Goga
Acting Chief, Planning Division

APPENDIX D

EXAMPLE SWM PLAN

APPENDIX D

EXAMPLE SWM PLAN

- Stormwater Management Plan Procedure Outline
- Introduction to Examples
- Example Plan 1
- Example Plan 2
- Stormwater Management Plan Checklist

Stormwater Management Plan Procedure Outline

A typical stormwater management plan procedure outline is presented herein to give a general guide for the preparation of stormwater management (SWM) plans. The outline should be used in conjunction with the examples given to prepare a plan which fully documents the hydrologic and hydraulic methods and computations. Standard SCS methods (TR-20, TR-55, or software packages utilizing the same) should be used. The modified Rational Method may be acceptable for small sites, contingent upon approval by the municipal engineer.

A typical procedure for preparing a typical SWM plan is presented below. The procedure applies to the recommended SCS methods discussed herein. The use of specific hydrologic and hydraulic methods (software packages, ...) is at the discretion of the plan preparer; however, only standard, generally-accepted engineering practices should be used.

Procedure Outline	Discussion
I. NARRATIVE	A narrative giving a short description of the proposed project should be presented. The narrative should include descriptions of the following: 1. Location, 2. Existing conditions (land use, soils, features), 3. Proposed conditions, 4. Proposed SWM controls,

Procedure Outline	Discussion
2. Area	Document the drainage areas for all areas affected. Upland, off-site, and on-site undisturbed areas which will be collected and conveyed to a SWM facility must be included in the SWM analyses.
3. Curve Number, CN	Document the CN(s).
a. Land Uses	Identify the land uses.
b. Hydrologic Soil Group	Identify the soils and their associated hydrologic soil group.
c. CN Assignment	Assign CNs for each land use considering the basin's hydrologic soil group.
4. Time-of-Concentration, t_c	Calculate the t_c for each drainage basin. Show the flowpath for each basin on the map. Calculations should identify and document sheet flow, shallow concentrated flow, and channel flow (considering bankfull conditions). (The total length of sheet flow should be less than 150 feet in unpaved areas - see SCS Pennsylvania Bulletin No. PA 210-0-5 attached.)
5. Hydrograph Generation	Develop the runoff hydrographs for all areas. Document the method, the peak flow, and the time of peak.
6. Stage-Storage Rating	Document the stage-storage data for the proposed SWM facility, including the source of data and methods.
7. Stage-Discharge Rating	Document the stage-discharge rating for the proposed outlet structure(s).
8. Pond Routing	Route the hydrographs of incoming drainage areas through the proposed SWM facility. (The SCS TR-55 Figure 6-1 is not an acceptable method to design a SWM facility.)
9. Downstream Conditions	Evaluate downstream conditions for erosion, sedimentation, and backwater.

Procedure Outline	Discussion
10. Release Rates	Show the location of the project and the project's discharge point(s) on a copy of the Flaugherty Run Watershed Release Rate Map. The Maximum Allowable Discharge under proposed conditions at each discharge point is computed as the release rate multiplied by the peak flow for existing conditions at each point of interest for each storm. If the proposed condition's peak flow is less than the Maximum Allowable Discharge, the proposed plan meets the SWM release rate criterion.

Introduction to Examples

Two example stormwater management plans are presented in the following plans. These examples are not complete plans with calculations and full documentation, but instead showcase the procedures to be used in stormwater management plan preparation.

The example plans have been chosen to present the most common situational difficulties that occur in stormwater management plan preparation. By following the procedures described herein, potential problems may be avoided.

Example Plan 1

Introduction. A hypothetical recreational facility is to be developed along the top of an existing ridge. A building and parking facilities will be constructed as well as some outdoor fields. The site's assumed location is shown on Figure D-1. The site would fall within Basin 9 of the Flaugherty Run watershed in Allegheny County, Pennsylvania. A stormwater management plan will be devised that will conform to the requirements of the Flaugherty Run Watershed Stormwater Management Plan. (The information presented is not necessarily applicable to the Flaugherty Run watershed, for purposes of simplicity and convenience.)

Design Storms. As required by the Flaugherty Run Plan, the following design storm will be evaluated:

Return Period (years)	Precipitation (inches)
2	2.6
5 (optional)	3.3
10	3.8
25	4.4
50 (optional)	4.7
100	5.0

REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

2000' 0 2000'

SCALE: 1" = 2000'

LOCATION MAP
SPORTS-R-US
SWM PLAN

FIGURE D-1

Site Location in Watershed. The Flaugherty Run watershed basin will be determined and the appropriate release rate documented. See Figure D-2 for a Watershed Location Map. The site is located in Basin 9, with an assigned release rate of 70. Note that a portion of the proposed site will extend into a neighboring basin; the basin and release rate to be used are based on the discharge point for the site. The "Post-Development Hydrology" section will discuss this further.

Point of Interest. A sketch showing the proposed development of the site is shown on Figure D-3. The point of interest, that point where pre-development and post-development flows will be compared, is designated on this figure. In this case, since two different subbasins are impacted after development, an alternative might be to have a point of interest for each subbasin.

Pre-Development Hydrology. The pre-development flows at the point of interest will be calculated.

- Site Description. Figure D-4 shows the existing conditions at the hypothetical site. The area is grassed along the top of the hill with woods beginning on the valley slopes.

- Drainage Area. The drainage area to the point of interest is delineated on Figure D-4.

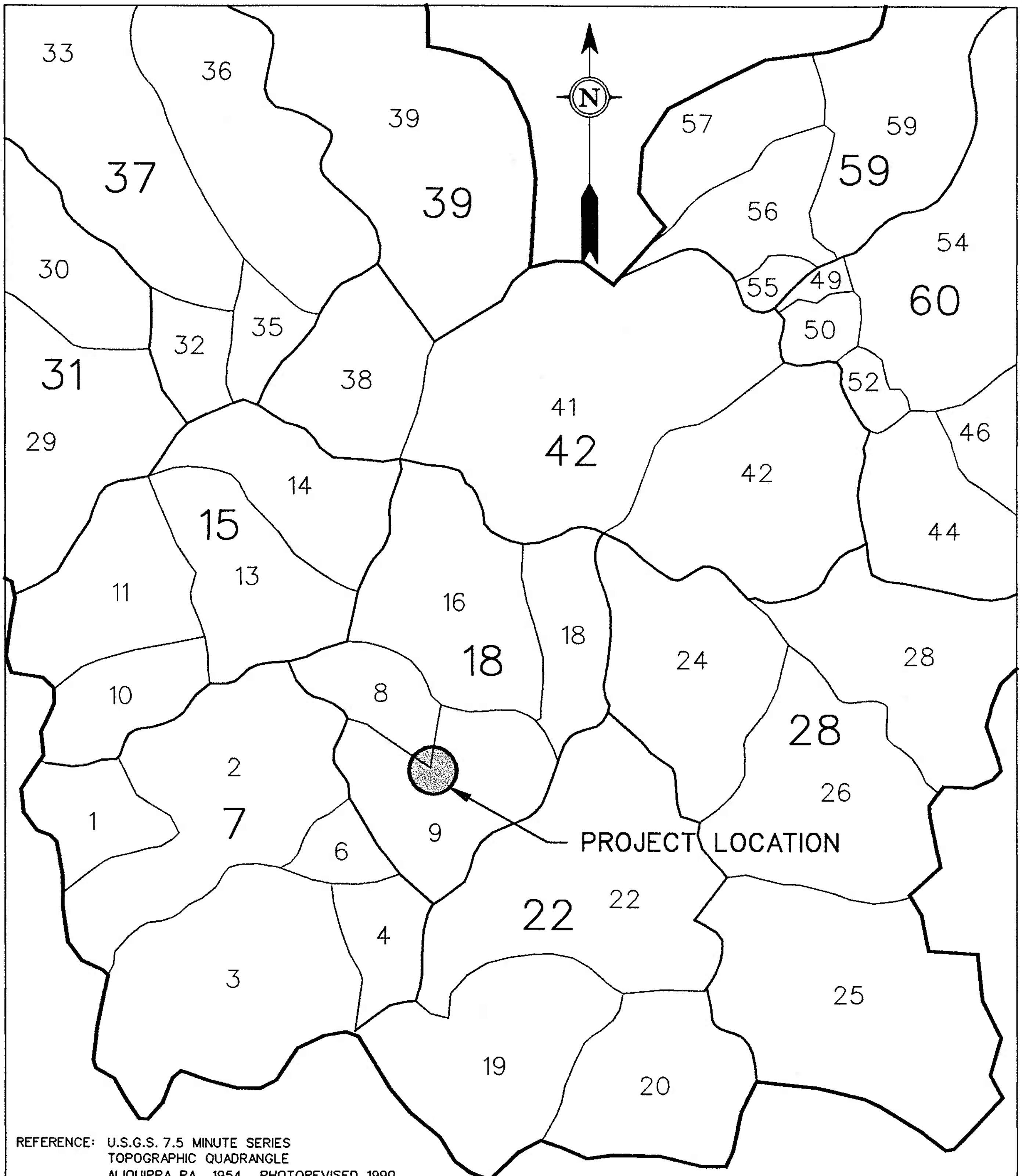
- Runoff CN. Determine the average runoff CN for the site. Figure D-5 shows the soils map for the hypothetical site vicinity. From this, it can be seen that WhB and WhC soils (Wharton silt loams) are present throughout the project area. These soils are classified as Hydrologic Soils Group C.

  From a field visit, the site area consists of approximately 60 percent woodland areas and 40 percent grass. Use an appropriate CN for each terrain type and determine a composite CN for the site.

- Time-of-Concentration. Calculate the time-of-concentration (t_c) for the site. The t_c flow path is shown on Figure D-4. The t_c is calculated according to standard SCS methods, incorporating sheet flow, shallow concentrated flow, and channelized flow. Note that in Pennsylvania, the State Conservationist has recommended using a maximum length of 150 feet for sheet flow over unpaved areas.

- Compute Flows. Calculate the peak flows and runoff hydrographs for the site at the point of interest for the various design storms. This will yield the pre-development peak flows.

Post-Development Hydrology. Calculate post-development flows and hydrographs at the point of interest using the same procedure presented for pre-development hydrology:



REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

LEGEND

REGION BOUNDARY

60 BASIN IDENTIFICATION NUMBER

2000' 0 2000'

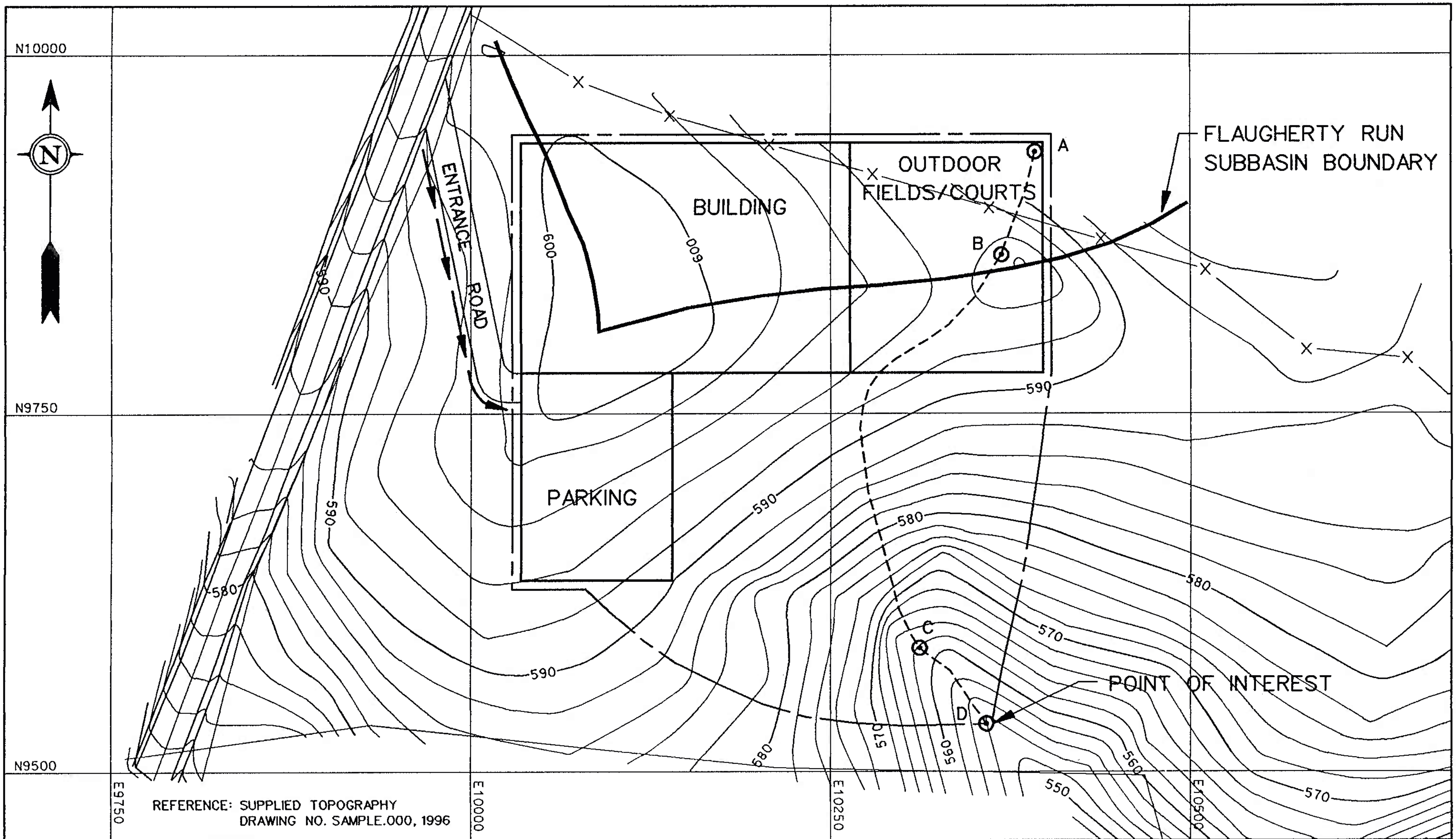
SCALE: 1" = 2000'

WATERSHED SUBBASIN MAP
SPORTS-R-US
SWM PLAN

FIGURE D-2

SOURCE: FLAUGHERTY RUN
SWM PLAN
FIGURE 7-9

GAI DRAWING NO. SAMPL002.DGN



LEGEND

- FLAUGHERTY RUN BASIN BOUNDARY
- DRAINAGE BOUNDARY
- PROPOSED DEVELOPMENT
- TIME-OF-CONCENTRATION FLOW PATH

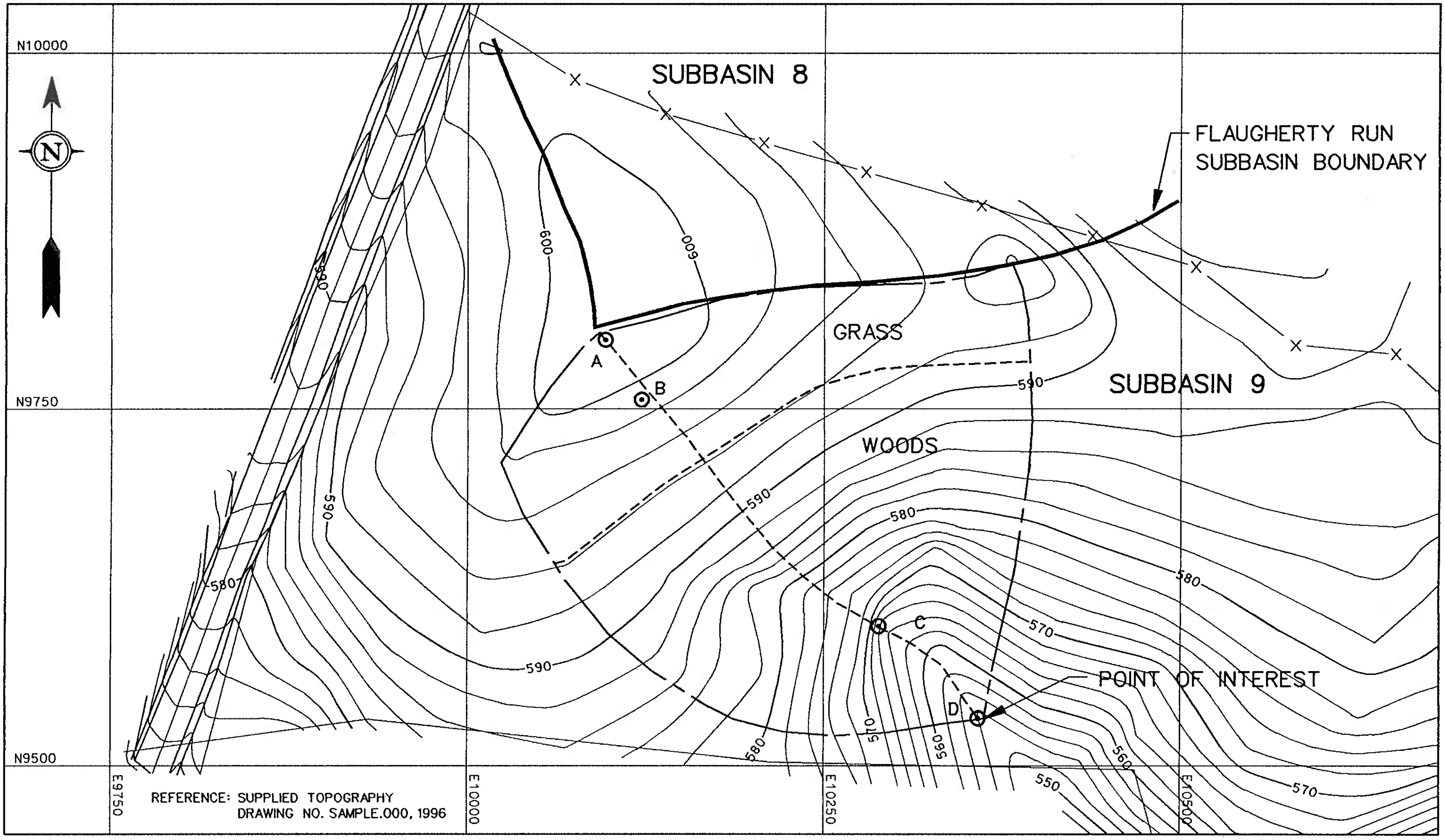
200' 0 200'

SCALE: 1" = 200'

PROPOSED DEVELOPMENT
SPORTS-R-US
SWM PLAN

FIGURE D-3

GAI DRAWING NO. SAM... .DGN



LEGEND

FLAUGHERTY RUN BASIN BOUNDARY

DRAINAGE BOUNDARY

TIME-OF-CONCENTRATION FLOW PATH

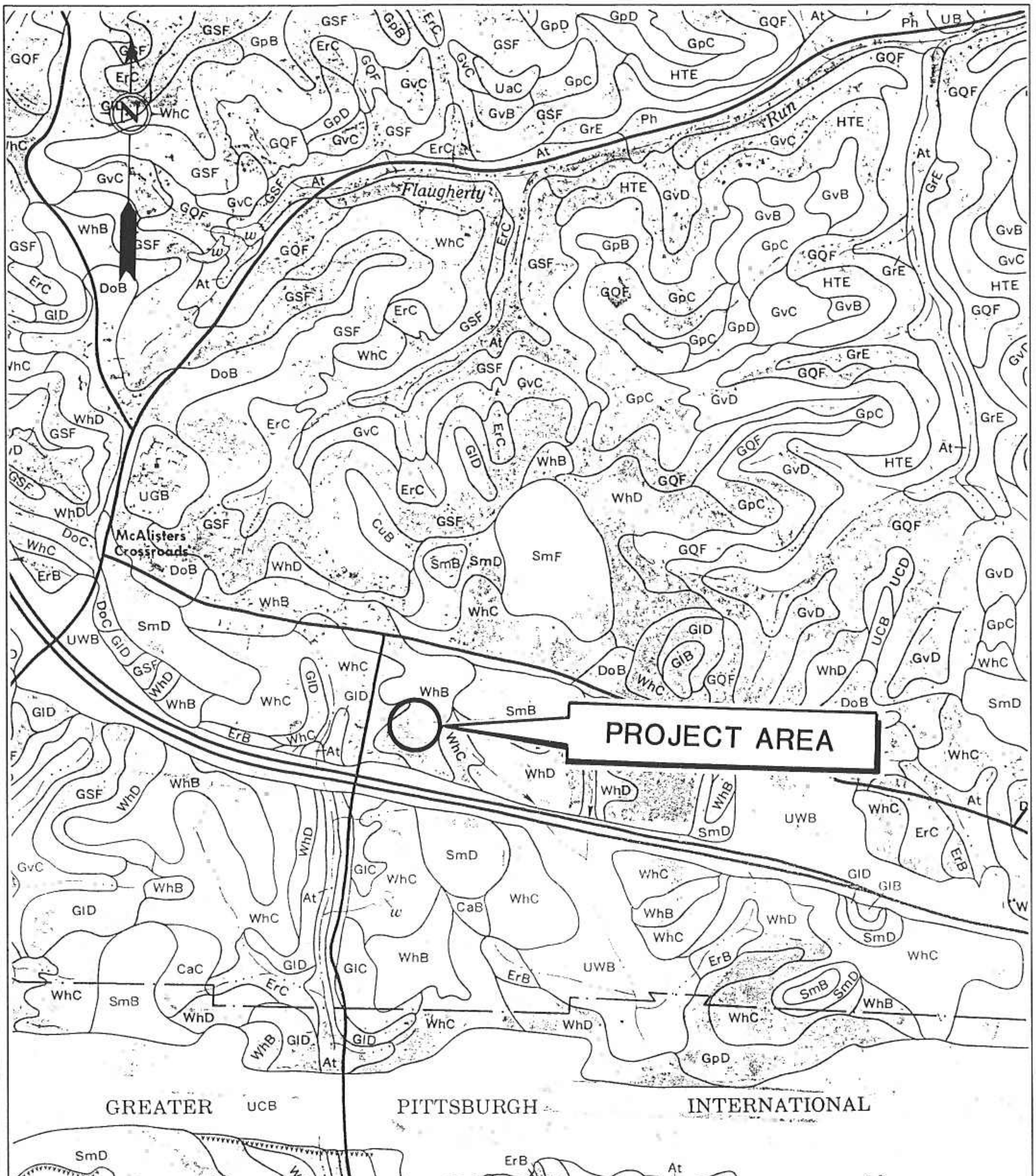
200' 0 200'

SCALE: 1" = 200'

EXISTING CONDITIONS
SPORTS-R-US
SWM PLAN

FIGURE D-4

GAI DRAWING NO. SAMPL004.DGN



REFERENCE: U.S. DEPARTMENT OF AGRICULTURE
SOIL SURVEY OF ALLEGHENY COUNTY
PENNSYLVANIA
AUGUST 1981 - SHEET 31

SOILS MAP
SPORTS-R-US
SWM PLAN

FIGURE D-5

GAI DRAWING NO. SAMPL005.DGN

- Site Description. Figure D-3 shows the proposed development at the site.

- Drainage Area. The proposed drainage area to the point of interest is delineated on Figure D-3. Note that a portion of the drainage area extends into a neighboring watershed basin (8). Since runoff from this area will be redirected to the point of interest, the release rate to be used will be that of the point of interest's basin. This is known as a "watershed transfer" and should be documented and accounted for when it occurs.

- Runoff CN. Determine the CN for the post-development site using the same procedures as outlined for the pre-development site.

- Time-of-Concentration. Figure D-3 shows the t_c flow path for the developed site. Calculate t_c using the same procedure as outlined for the pre-development flow.

- Compute Flows. Calculate the peak flows and runoff hydrographs for the post-development site at the point of interest for the various design storms using the same methodology as in the pre-development calculations. If multiple drainage areas are considered to be tributary to the point of interest, the hydrographs should be added together to determine the flows.

<u>Compare Pre-Development and Post-Development Hydrographs</u>. If the post-development peak flows exceed the pre-development peak flows for any of the design storms, stormwater management must be provided. If the post-development flows are equal to or less than the pre-development flows, then stormwater management, or the application of release rate principles, may still be appropriate. The post-development runoff volume and hydrograph timing should be analyzed to determine development's impact.

For the site considered in this example, the post-development flows exceed pre-development flows at the point of interest for all storms. Stormwater management will be designed.

<u>Calculate the Maximum Allowable Flows</u>. The Maximum Allowable Flow for a given storm is the maximum flow that can be discharged from the site under post-development conditions for that storm, which satisfies the Flaugherty Run Watershed Plan release rate criterion. The Maximum Allowable Flows for discharges from the site, or any other areas as noted above, will be equal to the pre-development peak flows times the release rate for the particular basin. For this example, if the release rate is 70 percent (Figure 7-8) and the pre-development peak flow for the 2-year storm is 14 cubic feet per second (cfs), the allowable release rate for the post-development 2-year storm is:

$$14 \text{ cfs} \times 0.7 = 9.8 \text{ cfs} \; (10 \text{ cfs})$$

Design Stormwater Management Facility. For this example, a detention pond will be proposed along the south edge of the property with a discharge to the point of interest (see Figure D-6). Note that not all of the site will drain to this pond. Only that area tributary to the pond can be considered to be controlled, or have SWM; the remaining area is considered to be uncontrolled. Determine the peak flows and hydrographs resulting from the uncontrolled area and deduct these from the Maximum Allowable Flows from the site to obtain the Maximum Allowable Flows from the pond.

An initial estimate of the required site for a stormwater management structure can be computed by the methods of SCS TR-55 Figure 6-1 (or by using a computer program with a similar technique) considering inflows and allowable releases. Figure 6-1 does **not** substitute for the routing of hydrographs through the structure, but can provide for an initial estimate for the site.

- Stage-Storage. Calculate the storage in the ponds at various elevations in the pond.

- Stage-Discharge. Design a discharge structure for the pond. Using accepted hydraulic methods, prepare a Stage-Discharge rating for the pond.

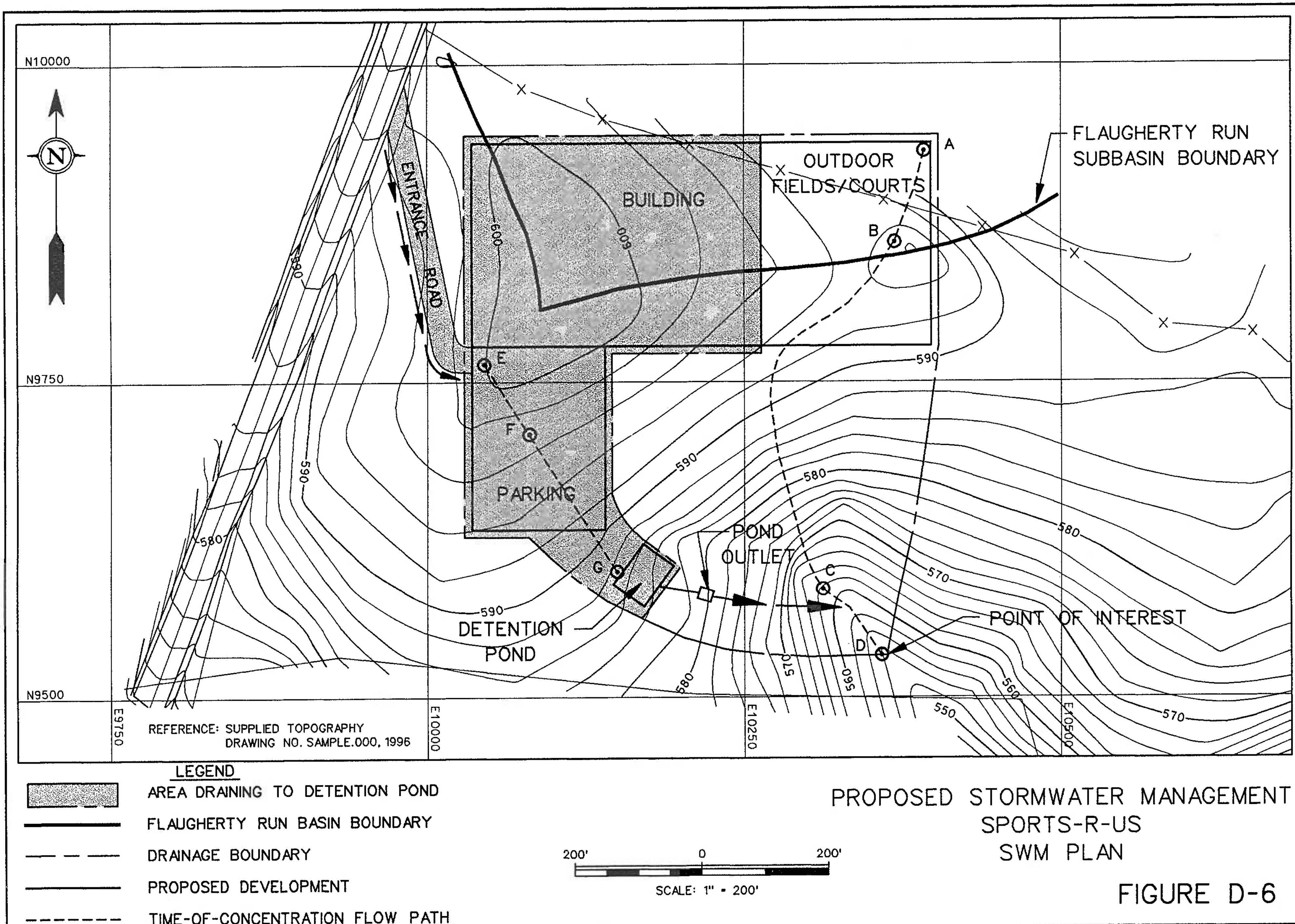
- Route the Inflow Runoff Hydrographs Through the Pond. Using accepted engineering methods, route the inflows to the pond through the pond using the pertinent Stage-Storage and Stage-Discharge data. (Verify that the inflow hydrographs are appropriate to the SWM facility.)

- Evaluate Results. Compare the peak outflows from the pond with the Maximum Allowable Flows. If some flows are exceeded, modify the design(s) of the site, the SWM, and/or other features until acceptable results are obtained.

- Outlet Conditions. First, verify that outlet conditions do not adversely impact discharge flow from the stormwater management structure. For this example, the pipe spillway from the pond discharges into an existing stream. Show that anticipated peak flows in the stream do not cause backwater on the spillway, lessening the flow rates it can pass.

  Second, show that the receiving body (in this case, the stream) has the capacity to handle any flows present in it plus the release from the facility. Normally, this is straightforward unless a point discharge would be created where none existed.

  It is necessary to prevent erosion/sedimentation at the discharge point. For the current example, a point discharge will be created at the point of interest where none existed before. Erosion protection will be designed to protect the stream from the outlet flows from the pond.



PROPOSED STORMWATER MANAGEMENT
SPORTS-R-US
SWM PLAN

FIGURE D-6

GAI DRAWING NO. SAMPL006.DGN

Alternatives. Consider various alternatives to either site design, SWM feature design, etc. The alternatives can be compared on an economic basis. Possible alternatives for the site are:

- reduce runoff volumes by increasing infiltration or reducing impervious area;
- convey uncontrolled areas to a SWM facility for collection, attenuation, etc.;
- direct upland, undeveloped areas from SWM facilities; and
- reduce peak flows by increasing the time-of-concentration for the site by reducing gradient, increasing travel length, etc.

Maintenance. Present a maintenance schedule and the identification and assignment of responsibilities for the stormwater management facility.

Professional Engineer Seal. The plan will be stamped and sealed by a registered Professional Engineer licensed in the State of Pennsylvania.

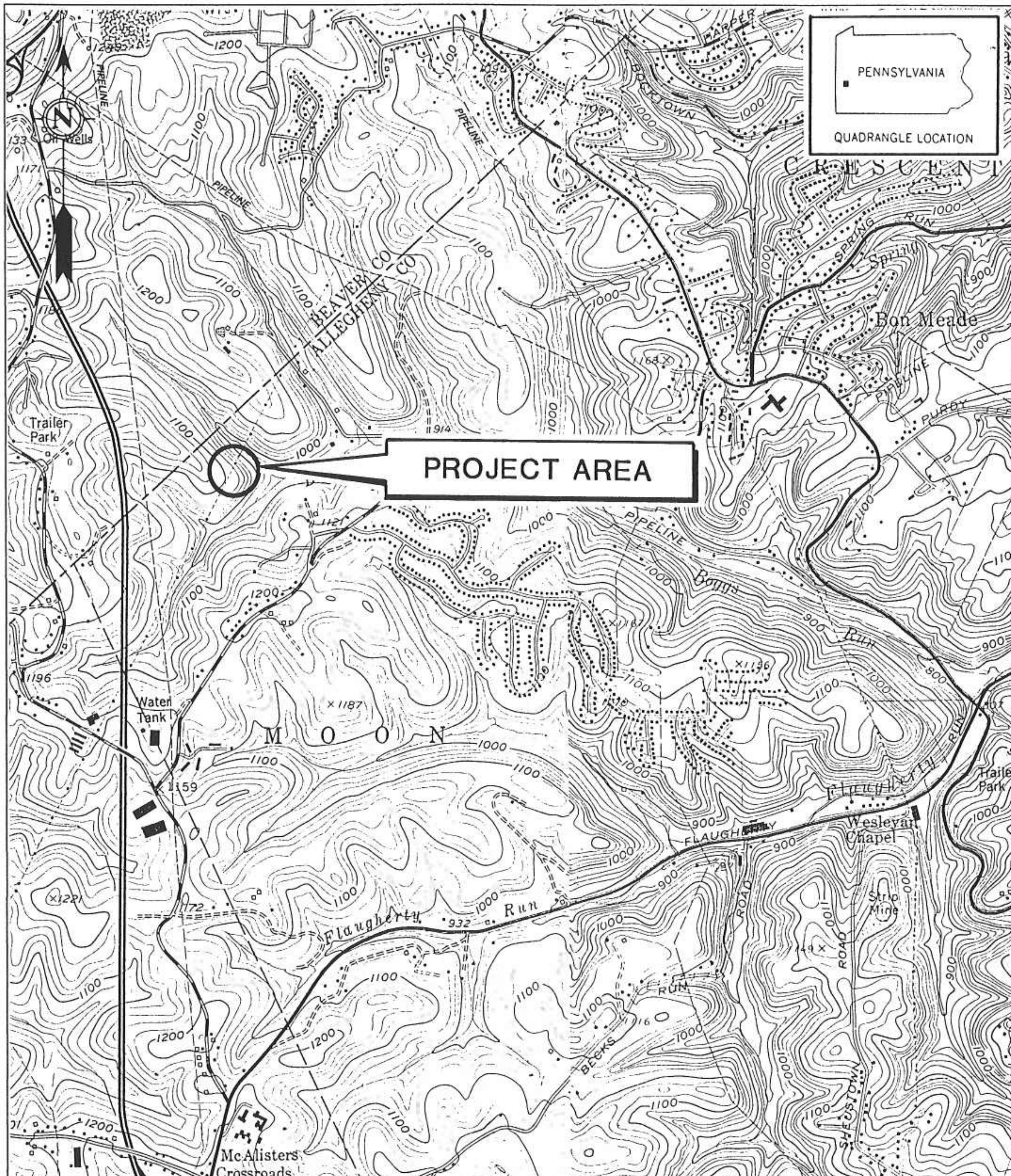
Summary. The goal of the above procedure is to provide a complete stormwater management plan. A checklist of all important steps is provided at the end of this appendix.

Example Plan 2

Introduction. An existing restaurant plans to expand its parking facilities. The new parking lot will be located across the street from the existing restaurant, on a currently wooded hillside. The site's location is shown on Figure D-7. The site is within the Flaugherty Run watershed in Allegheny County, Pennsylvania. A stormwater management plan will be devised that will conform to the requirements of the Flaugherty Run Watershed Stormwater Management Plan.

Design Storms. As required by the Flaugherty Run Plan, the following design storm will be evaluated:

Return Period (years)	Precipitation (inches)
2	2.6
5 (optional)	3.3
10	3.8
25	4.4
50 (optional)	4.7
100	5.0



REFERENCE: U.S.G.S. 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE
ALIQUIPPA, PA 1954 PHOTOREVISED 1990
AMBRIDGE, PA 1960 PHOTOREVISED 1990

2000' 0 2000'

SCALE: 1" = 2000'

LOCATION MAP
PIGEON REEF RESTAURANT
SWM PLAN

FIGURE D-7

GAI DRAWING NO. SAMPL007.DGN

Site Location in Watershed. The Flaugherty Run watershed basin will be determined and the appropriate release rate documented. See Figure D-8 for a Watershed Location Map. The site is located in (assumption) Basin 30, with an assigned release rate of 70.

Point of Interest. A sketch showing the proposed development of the site is shown on Figure D-9. The point of interest, that point where pre-development and post-development flows will be compared, is designated on the figure. The point of interest is located at that point where storm sewers from the existing facility join the main trunk line along the road.

Pre-Development Hydrology. Calculate the pre-development flows at the point of interest.

- Site Description. Figure D-10 shows the existing conditions at the site. The entire area (site and upland) is wooded.

- Drainage Area. The drainage area to the point of interest is delineated on Figure D-10.

- Runoff CN. Determine the average runoff CN for the site. Figure D-11 shows the soils map for the hypothetical site vicinity. From this, it can be seen that GpC (Gilpin-Upshur) and GvB (Guernsey-Vandergrift) soils are present throughout the project area. These soils are Group C soils, except Upshur (Group D). Group C soil conditions with wooded cover is reasonable.

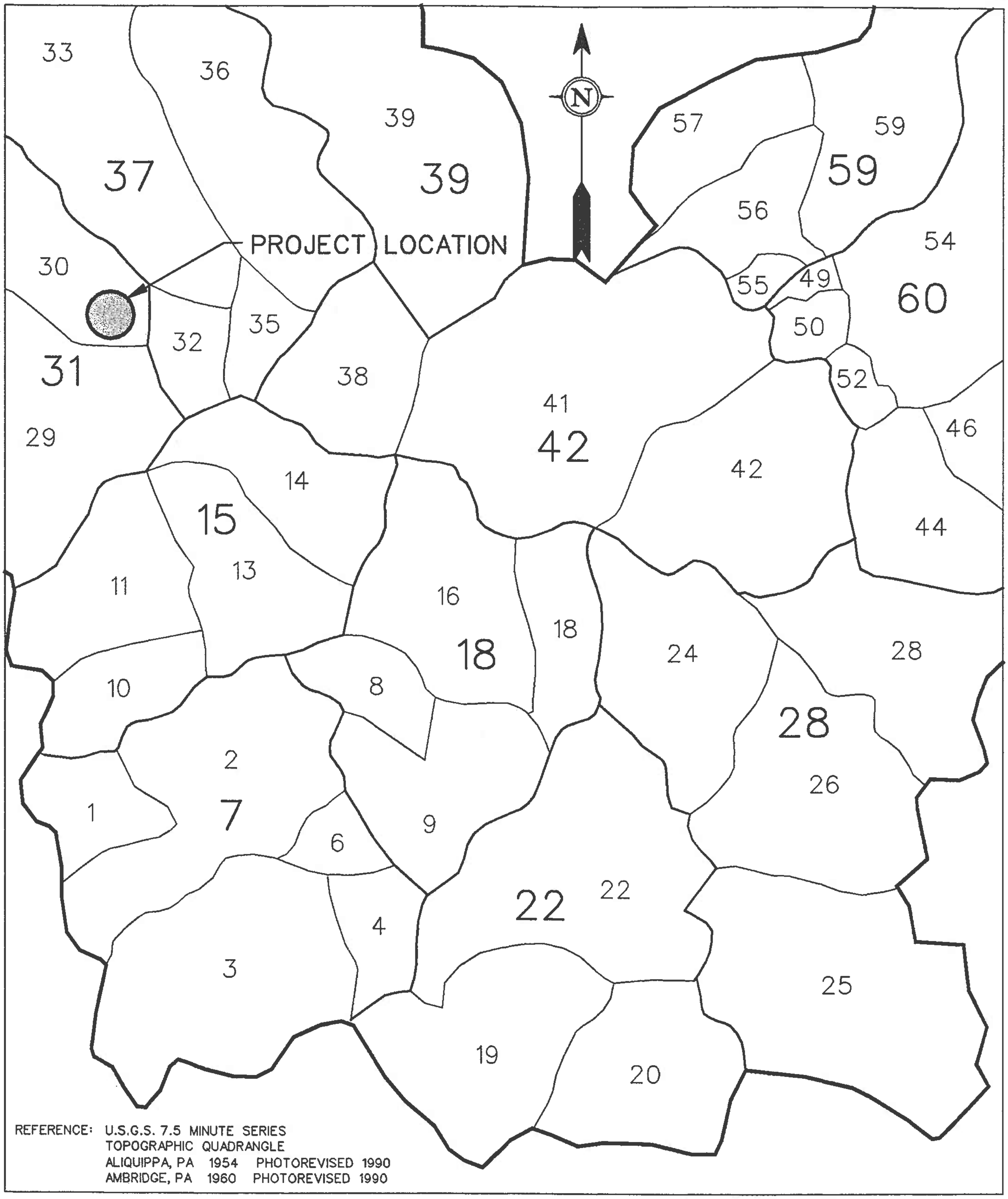
- Time-of-Concentration. Calculate the time-of-concentration (t_c) for the site. The t_c flow path is shown on Figure D-12. The t_c is calculated according to standard SCS methods, incorporating sheet flow, shallow concentrated flow, and channelized flow. Note that in Pennsylvania, the State Conservationist has recommended using a maximum length of 150 feet for sheet flow over unpaved areas.

- Compute Flows. The peak flows and runoff hydrographs for the site at the point of interest for the various design storms will be calculated. This will yield the pre-development peak flows.

Post-Development Hydrology. Calculate post-development peak flows and hydrographs at the point of interest using the same procedure presented for pre-development hydrology.

- Site Description. Figure D-9 shows the proposed development at the site.

- Drainage Area. The proposed drainage area to the point of interest is delineated on Figure D-9. The drainage area as shown does not take into consideration any diversion of upland areas.



LEGEND

REGION BOUNDARY

60 BASIN IDENTIFICATION NUMBER

2000' 0 2000'

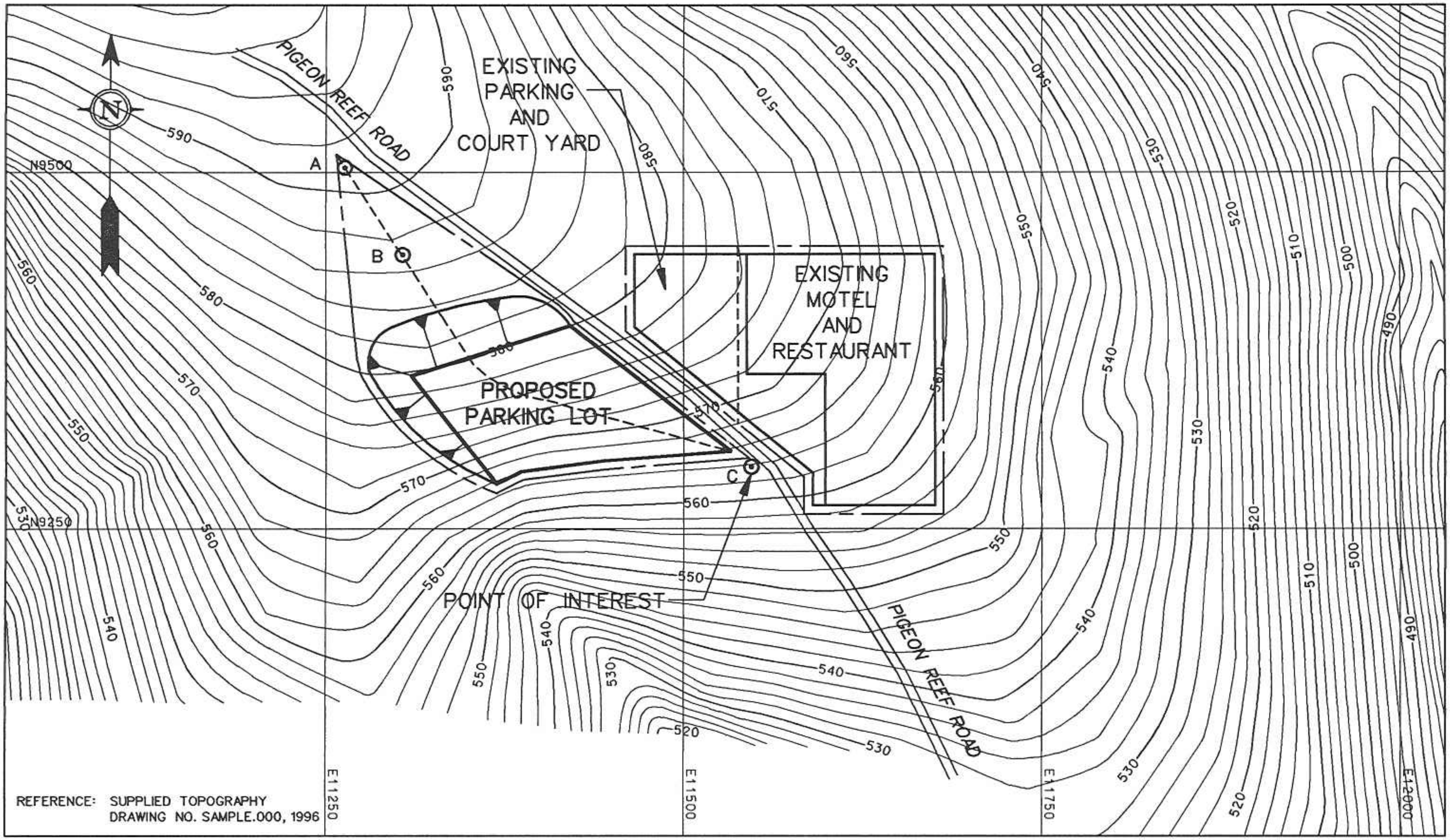
SCALE: 1" = 2000'

SOURCE: FLAUGHERTY RUN
SWM PLAN
FIGURE 7-9

WATERSHED SUBBASIN MAP
PIGEON REEF RESTAURANT
SWM PLAN

FIGURE D-8

GAI DRAWING NO. SAMPL008.DGN



LEGEND

— — — DRAINAGE BOUNDARY

——— PROPOSED DEVELOPMENT

- - - - - - - TIME-OF-CONCENTRATION FLOW PATH

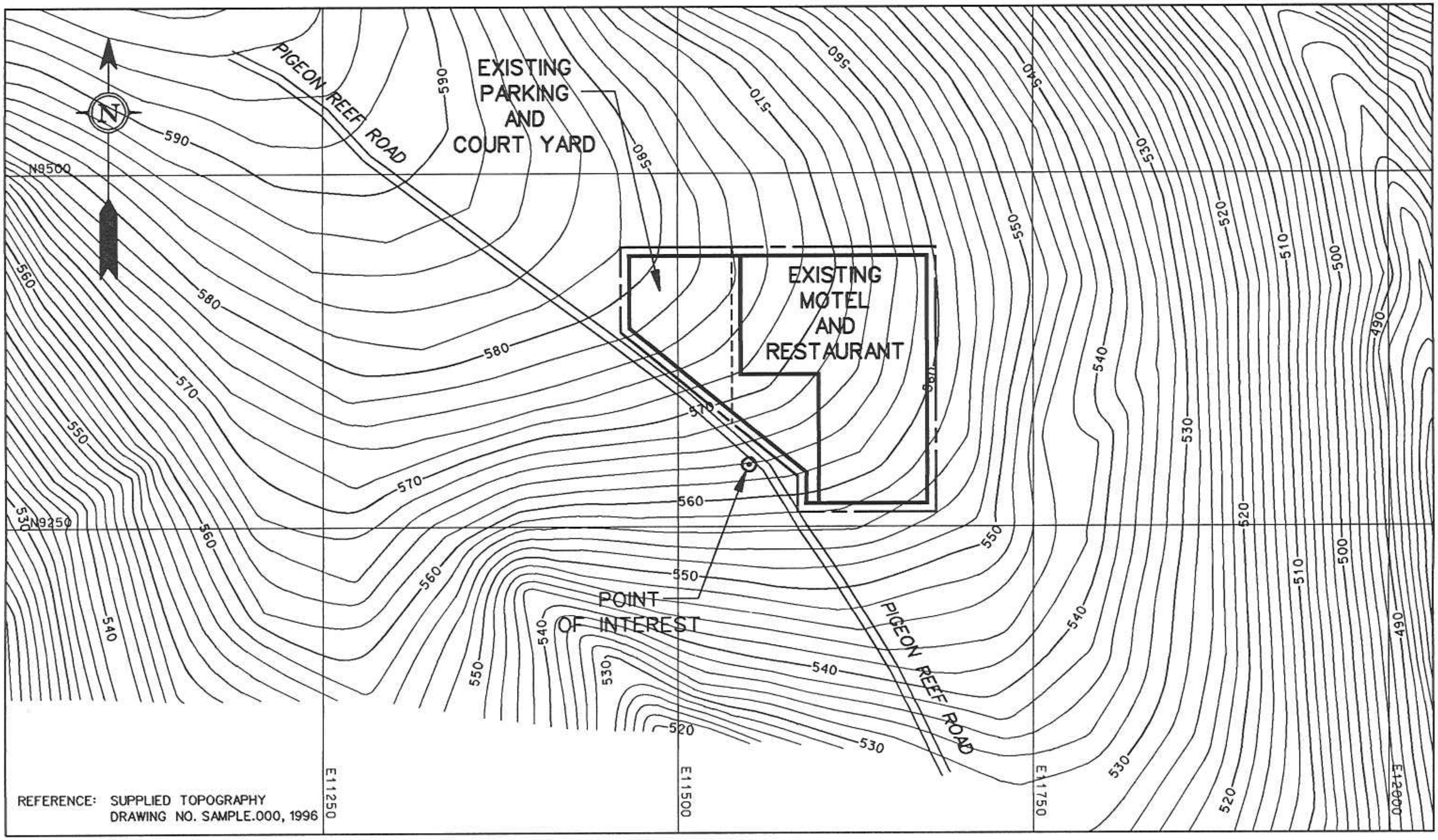
200' 0 200'

SCALE: 1" = 200'

PROPOSED DEVELOPMENT
PIGEON REEF RESTAURANT
SWM PLAN

FIGURE D-9

AI DRA J. SAMI GN



LEGEND

— — — DRAINAGE BOUNDARY

——— EXISTING DEVELOPMENT

- - - - - - - TIME-OF-CONCENTRATION FLOW PATH

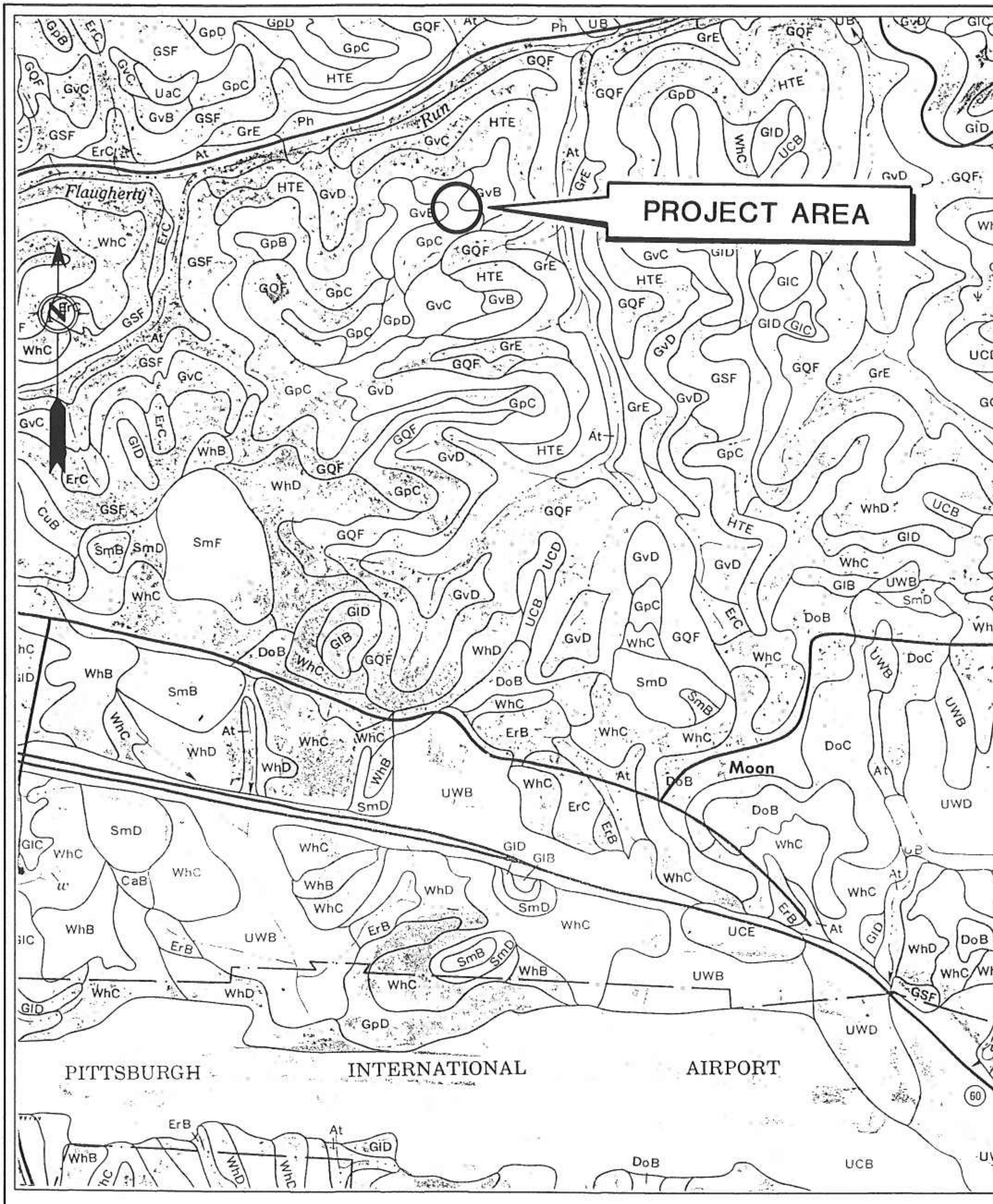
200' 0 200'

SCALE: 1" = 200'

EXISTING CONDITIONS
PIGEON REEF RESTAURANT
SWM PLAN

FIGURE D-10

GAI DRAWING NO. SAMPL010.DGN



REFERENCE: U.S. DEPARTMENT OF AGRICULTURE
SOIL SURVEY OF ALLEGHENY COUNTY
PENNSYLVANIA
AUGUST 1981 - SHEET 31

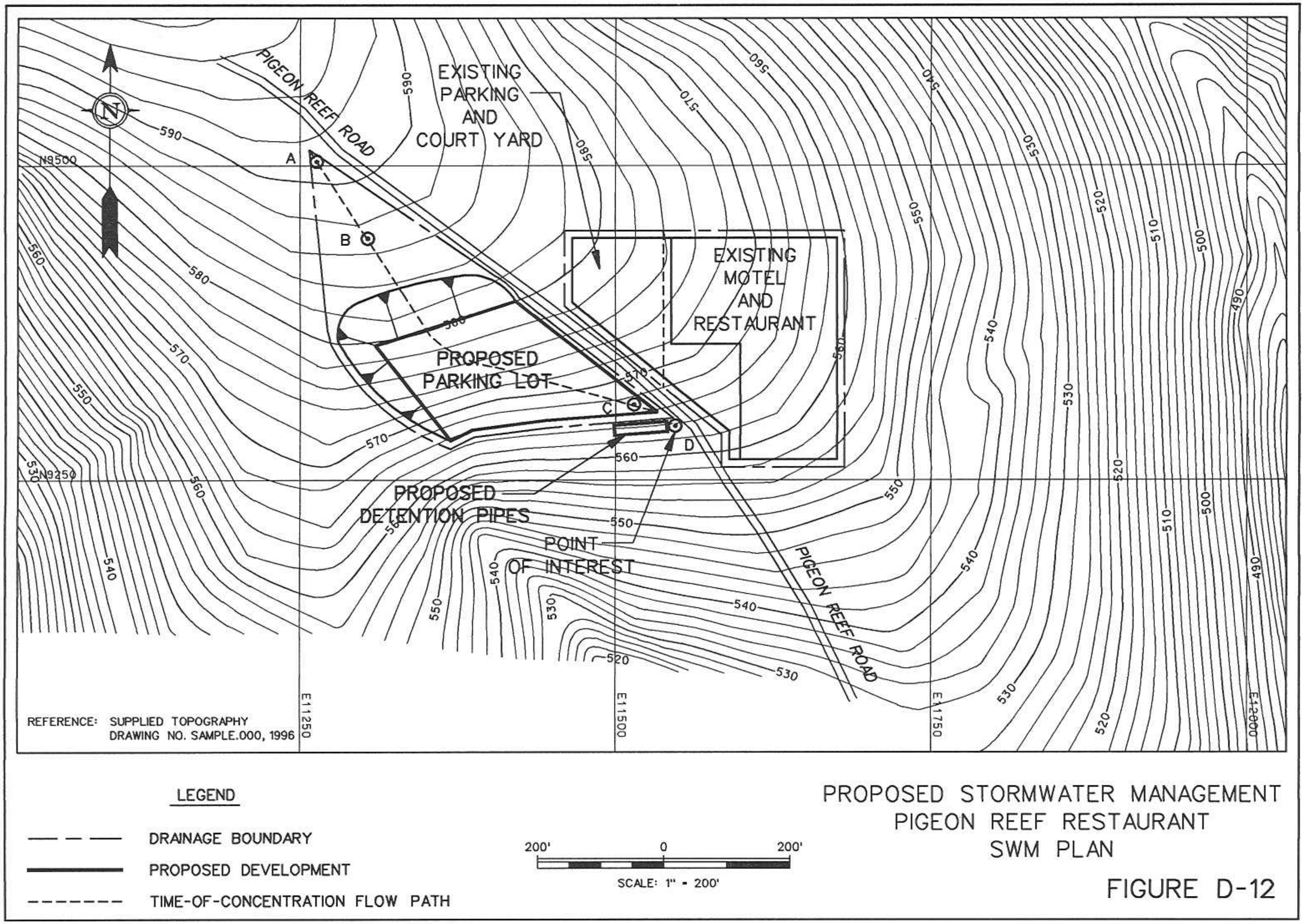
0 1/4 MILE 1/2 MILE

SCALE: 1" = 1/4 MILE

SOILS MAP
PIGEON REEF RESTAURANT
SWM PLAN

FIGURE D-11

GAI DRAWING NO. SAMPL011.DGN



PROPOSED STORMWATER MANAGEMENT
PIGEON REEF RESTAURANT
SWM PLAN

FIGURE D-12

GAI DRAWING NO. SAMPL012.DGN

- Runoff CN. Determine the CN for the post-development site using the same procedures as outlined for the pre-development site.

- Time-of-Concentration. Figure D-9 shows the t_c flow path for the developed site. Calculate t_c using the same procedure as outlined for the pre-development flow.

- Compute Flows. The peak flows and runoff hydrographs for the post-development site at the point of interest for the various design storms will be calculated using the same methodology as in the pre-development calculations. If multiple drainage areas are considered to be tributary to the point of interest, the hydrographs should be added together to determine the flows.

<u>Compare Pre-Development and Post-Development Hydrographs</u>. If the post-development peak flows exceed the pre-development peak flows for any of the design storms, stormwater management must be provided. If the post-development flows are equal to or less than the pre-development flows, then stormwater management, or the application of release rate principles, may still be appropriate. The post-development runoff volume and hydrograph timing should be analyzed to determine development's impact.

For the site considered in this example, the post-development flows exceed pre-development flows at the point of interest for all storms. Stormwater management will be designed.

<u>Calculate the Maximum Allowable Flows</u>. The Maximum Allowable Flow for a given storm is the maximum flow that can be discharged from the site under post-development conditions for that storm, which satisfies the Flaugherty Run Watershed Plan release rate criterion. The Maximum Allowable Flows for discharges from the site, or any other areas as noted above, will be equal to the pre-development peak flows times the release rate for the particular basin. For this example, if the release rate is 70 percent (Figure 7-8) and the pre-development peak flow for the 2-year storm is 10 cubic feet per second (cfs), the allowable release rate for the post-development 2-year storm is:

$$10 \text{ cfs} \times 0.7 = 7 \text{ cfs}$$

<u>Design Stormwater Management Facility</u>. For this example, an underground detention tank will be constructed with the storm sewers draining to it. A plate will be placed on the outlet with orifice openings as discharge structures. The tank outlet will be to an existing storm sewer located along the road (see Figure D-12). The entire developed area will be controlled; some upland area will also enter the stormwater management system.

An initial estimate of the required site for a stormwater management structure can be computed by the methods of SCS TR-55 Figure 6-1 (or by using a computer program with a similar technique) considering inflows and allowable releases. Figure 6-1 does **<u>not</u>**

substitute for the routing of hydrographs through the structure, but can provide for an initial estimate for the site.

- Stage-Storage. Calculate the storage in the tank for various water depths.

- Stage-Discharge. Design a discharge mechanism for the tank. Using accepted hydraulic methods, prepare a Stage-Discharge rating curve for the tank.

- Route Flows. Using accepted engineering methods, route the inflows to the tank through the tank using pertinent Stage-Storage and Stage-Discharge data.

- Evaluate Results. Compare the outflows from the tank with the Maximum Allowable Flows. If some releases are exceeded, modify the site design or SWM facility, until acceptable results are obtained.

- Outlet Conditions. First, verify that outlet conditions do not adversely impact discharges from the stormwater management structure. For this example, show that anticipated peak flows in the existing storm sewer pipes, or the outlet pipe from the detention tank, do not cause backwater on the outlet orifices.

  Second, show that the receiving body (in this case, the storm sewer system) has the capacity to handle any flows present in it plus the release from the tank.

Alternatives. Consider various alternatives to either site design, SWM feature design, etc. The alternatives can be compared on an economic basis. Possible alternatives for the site are:

- divert upland areas around site;

- provide separate SWM for both the existing facility and the new facility;

- reduce peak flows by increasing the time-of-concentration for the site by increasing travel length, reducing gradient, etc.;

- reduce runoff volume by increasing infiltration or reducing impervious area; and

- analyze the new parking lot as an independent entity separate from the existing facility. A detention pond is an option, discharging to a surface point of interest.

If the new parking lot was anticipated during the original restaurant construction, the future development can be incorporated into the original SWM. This can be documented and later referenced.

Maintenance. Present a maintenance schedule and the identification and assignment of responsibilities for the stormwater management facility.

Professional Engineer Seal. The plan will be stamped and sealed by a registered Professional Engineer licensed in the State of Pennsylvania.

Summary. The goal of the above procedure is to provide a complete stormwater management plan. A checklist of all important steps is provided at the end of this appendix.

Stormwater Management Plan Checklist

The attached checklist (Table D.1) can be used to assess the completeness of a stormwater management plan. The figure can be reproduced directly and filled out. Each item can have a response of "Y" (yes) , "N" (no), or "N/A" (not applicable).

Table D.1

FLAUGHERTY RUN STORMWATER MANAGEMENT PLAN CHECKLIST

Project: ______________________________
Name of Preparer: ______________________________
Date: ______________________________

Item	Completed and Included
NARRATIVE	________
PRE-DEVELOPMENT FLOWS	
Site Description	________
Site Map	________
Drainage Area Delineation	________
Runoff Coefficients	________
Time-of-Concentration	________
Design Storms	________
Flow Computation	________
POST-DEVELOPMENT FLOWS	
Site Description	________
Site Map	________
Drainage Area Delineation	________
Runoff Coefficients	________
Time-of-Concentration	________
Design Storms	________
Flow Computation	________
RELEASE RATE APPLICATION	
Basin	________
Release Rate	________
Maximum Allowable Flows	________
STORMWATER MANAGEMENT	
Stage-Storage Data	________
Stage-Discharge Data	________
Routing	________
EVALUATE PROPOSED SWM	________
OUTLET CONDITIONS ANALYZED	________
COMPLIANCE WITH SWM PLAN	________
MAINTENANCE PLAN	________
PROFESSIONAL ENGINEER'S SEAL	________

APPENDIX E

NO-HARM OPTION

APPENDIX E

NO-HARM OPTION

The release rates assigned to the stormwater management regions in the Flaugherty Run Watershed have been established to prevent additional flood damages downstream of future development sites. In certain limited circumstances, the release rates may be "unreasonably restrictive" or inappropriate when applied to a specific site. The No-Harm option can then be used to demonstrate if the proposed development will not increase flooding downstream; that is, the development will cause no adverse effects on downstream areas. The burden of proof rests with the developer to clearly and conclusively demonstrate "no-harm". Qualitative judgments do not constitute adequate proof.

A developer who wishes to use the no-harm option should use hydrologic and hydraulic methods consistent with the Penn State Runoff Model and with the site conditions. All no-harm option users must demonstrate the following:

- That the maximum rate of stormwater runoff from the site is no greater after development than prior to development activities, both at the outlet of the site and at all downstream areas; and
- That the quantity, velocity, and direction of resulting stormwater runoff does not increase erosion or sedimentation problems or conditions downstream, and adequately protects health and property from possible injury.

To successfully demonstrate no-harm, the user must demonstrate that outflows from each PSRM basin downstream of the development site, and including the basin containing the site, would not be increased by the development. Both an "On-site SWM" analysis and a "Downstream SWM" analysis must be performed to demonstrate no harm. It is noted that the no-harm evaluation must be performed considering the stormwater management basins as established in the PSRM models, and not the regions. Table E.1 summarizes the downstream PSRM basins which must be analyzed for each upstream basin for the downstream SWM analysis in the no-harm option. A development which is located in multiple basins must consider all discharge points and all downstream basins as required in Table E.1.

Table E.1

SUMMARY OF DOWNSTREAM BASINS WHICH MUST BE ANALYZED FOR A NO-HARM OPTION FOR A GIVEN UPSTREAM BASIN

For a Development Site in Basin	Downstream Basins to be Analyzed	For a Development Site in Basin	Downstream Basins to be Analyzed
1	1, 2, 7, 9	25	25, 26, 27, 28
2	2, 7, 9, 17, 18, 23, 24, 27	26	26
3	3, 5, 6, 7, 9, 17, 18, 23, 24	29	29, 31, 32, 34, 35, 37, 38, 40, 41, 42
4	4, 5, 6	30	30, 31, 32, 34, 35, 37, 38
6	6	33	33, 34, 35, 37, 38, 40, 41, 42
8	8	36	36, 37, 38, 40, 41, 42
9	9	39	39, 40, 41, 42
10	10, 12, 13, 15, 16	41	41, 42
11	11, 12, 13, 15, 16, 17, 18	49	49, 51, 53
13	13, 15, 16	50	50, 51, 53
14	15, 16	52	52, 53
16	16	55	55, 56, 58, 59
19	19, 21, 22, 23, 24, 27	56	56, 58, 59
20	20, 21, 22	57	57, 58, 59
22	22	59	59

The No-Harm procedure is provided below. A no-harm evaluation which demonstrates no harm and which also satisfies other, non-release rate criteria in the Flaugherty Run Watershed Stormwater Management Plan will be considered to meet the Plan requirements. Should another procedure be used, it will be evaluated on a case-by-case basis and can only be accepted if it demonstrates no harm, meets all plan requirements, and uses standard accepted engineering practices.

General Procedure

1. Perform an on-site SWM analysis using PSRM or the SCS Soil Cover Complex Method ("TR-55") for discharges from the development. Demonstrate that the existing conditions flows are not increased by the development at all points of interest (see Appendix D) of the development.

2. Perform the downstream SWM analysis. Obtain a copy of the Flaugherty Run PSRM basin's existing conditions model or recreate the model using the data given in this document or use another accepted model. PSRM-93 was used for the Flaugherty Run Watershed Plan.

3. Incorporate the proposed site conditions into the model ("Proposed Development Model").

4. Run the "Proposed Development Model" for the required design storms and obtain predicted flows at the downstream basins which are required to be analyzed as listed in Table E.1.

5. Perform appropriate hydraulic analyses for flood levels, erosion/sedimentation potential, ...downstream of the development site. The no-harm evaluation must include analyses for the 2-year, 10-year, 25-year, and 100-year events.

The no-harm option user should demonstrate that the developed conditions hydrograph is less than the existing conditions hydrology at all points in time except at the extreme ends (climbing limb and recession limb) of the hydrograph. This demonstration must be done for all design storms and all points of interest.

Special Circumstances

Certain special circumstances can occur which may allow a simpler analysis to demonstrate no-harm. Examples include:

1. A development which significantly reduces the runoff volume or runoff hydrograph at the point of interest. The development of an existing parcel which has a large impervious area into a parcel which has significantly less impervious area would most likely reduce both the runoff volume and runoff hydrograph at the point(s) of interest.

2. A development with stormwater controls which store runoff for the duration of a storm and which release the stored water at a minimal rate. This type of stormwater control could require as large a facility as that designed for a release rate.

Required Submittals

The following documentation must be submitted to allow review of the no-harm evaluation.

- a narrative which describes the site, existing conditions and proposed development, stormwater runoff and management

- graphics (maps, USGS quadrangles, . . .) as may be needed to clearly present site and watershed conditions affecting stormwater runoff

- graphics (maps, USGS quadrangles, . . .) as may be needed to clearly present site and watershed conditions affecting stormwater runoff

- calculations, including data and output of computer models

- summaries of stormwater conditions and the results of stormwater analyses

- certification statement, signed and sealed by a licensed Professional Engineer experienced in hydrology and hydraulics.

A listing of existing condition peak flows versus developed condition peak flows for each required basin and point of interest and each design storm should be provided to document the no-harm option flows. Hydraulic analyses predicting flood levels and the potential for increased erosion/sedimentation should provide similar documentation.