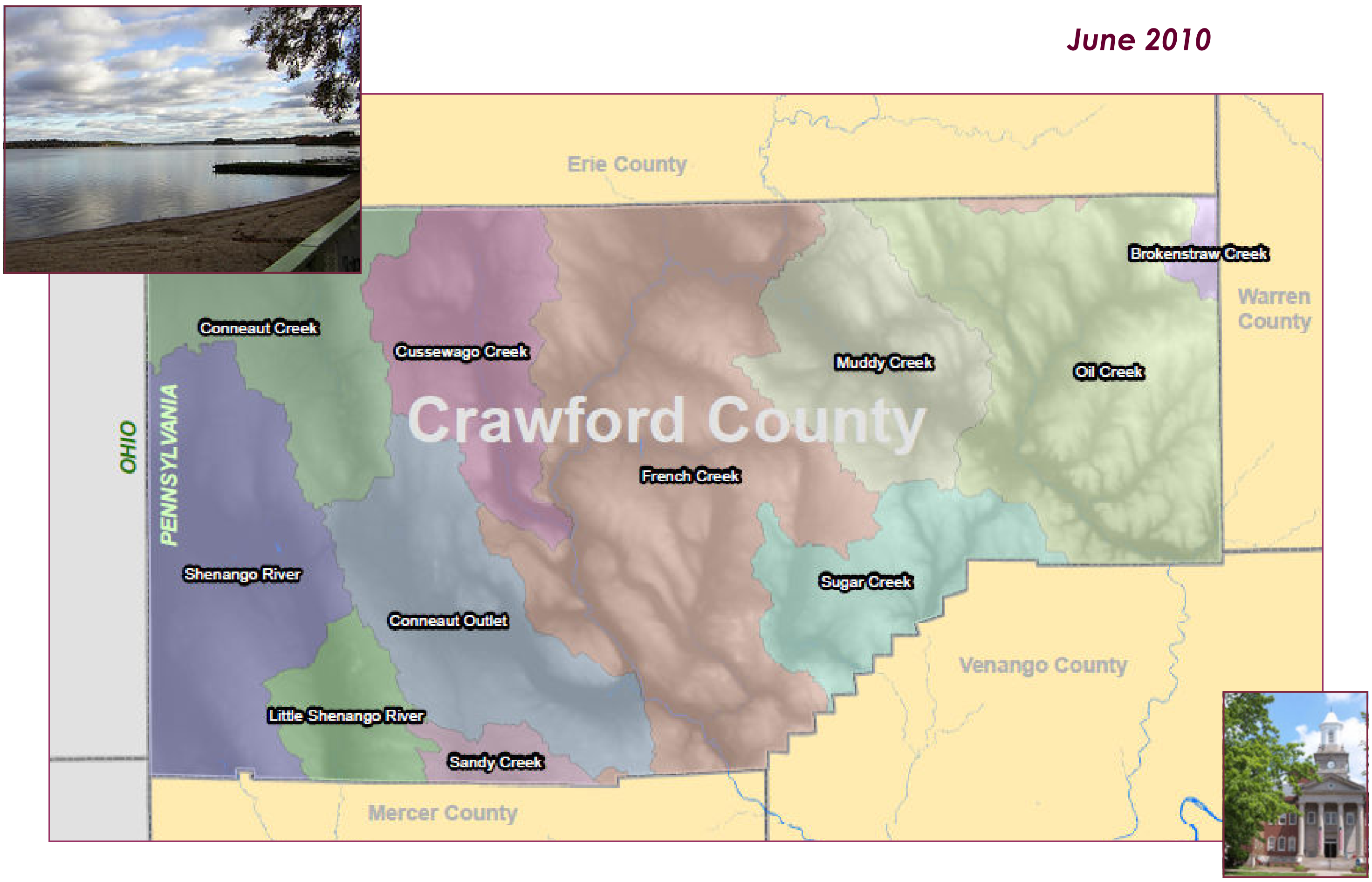
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Crawford County Planning Commission

Act 167 County-Wide Watershed
Stormwater Management Plan for Crawford County
Part 2 of 2
Phase II

June 2010



[BUILDING RELATIONSHIPS.
DESIGNING SOLUTIONS.]

200 West Kensinger Drive• Cranberry Township, Pennsylvania 16066 • 724.779.4777 [phone]

Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Draft Model Stormwater Management Ordinance

Crawford County
Act 167 County-Wide
Stormwater Management Plan

May 15, 2010

474 Windmere Drive• State College, Pennsylvania 16801 • 814.238.7117 [phone]

Using The Model Stormwater Management Ordinance

Municipal Requirements: This Model Stormwater Management Ordinance was developed during the *Crawford County Act 167 Stormwater Management Plan*. The Pennsylvania Stormwater Management Act (Act 167) requires that each municipality adopt a stormwater management ordinance to implement the stormwater management plan. Section 11(b) of Act 167 states:

> "Within six months following the DEP's approval of the this plan, each municipality is required to adopt new and/or amend existing stormwater ordinances or other ordinances, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development in a manner consistent with plan."

Any ordinance(s) adopted or amended by the municipality to comply with the stormwater management standards and criteria of the *Crawford County Act 167 Stormwater Management Plan* must be sent by a municipal official to the DEP with the municipal ordinance number and including the date the ordinance was enacted.

Enacting and Amending Municipal Ordinances: It is recommended that municipalities enact the Model Ordinance as a stand-alone ordinance. In addition, it is recommended that municipalities review existing ordinances (subdivision and land development, zoning, etc.) and consider amending them to refer to and coordinate with the new municipal stormwater management ordinance.

Ordinance Provisions: Ordinances adopted by municipalities are the legal instrument that implements the standards and criteria of this stormwater management plan. Unless otherwise denoted as [OPTIONAL], the provisions of the Ordinance are required.

- The text ***[Municipality]*** in the Model Ordinance should be replaced by the name of the individual municipality.
- Provisions with **[OPTIONAL]** is recommended but may be modified or deleted by the municipality.
- Criteria and standards can be modified to be more restrictive (but not less restrictive), if the municipality wishes.

The final ordinance adopted by the municipality should be developed in conjunction with, reviewed by, and agreed upon by the municipal solicitor, engineer, and governing body.

Crawford County Stormwater Management Facility Design Handbook: Section 601.B of the Model Ordinance references the technical design criteria that are contained in this separate document to allow modification from time to time based on new developments within the stormwater management**.** A committee will be established by the County to review the *Crawford County Stormwater Management Facility Design Handbook* and make recommendations for revisions as appropriate.

STORMWATER MANAGEMENT MODEL ORDINANCE

Implementing the Requirements of the

Crawford County Stormwater Management Plan

ORDINANCE NO. _________ OF_________

____________________, CRAWFORD COUNTY, PENNSYLVANIA

Adopted at a Public Meeting Held on
_________________, 2010

TABLE OF CONTENTS

ARTICLE I - GENERAL PROVISIONS

Section 101. Short Title

This Ordinance shall be known and may be cited as the "***Municipality*** Stormwater Management Ordinance."

Section 102. Statement of Findings

The governing body of ***Municipality*** finds that:

A. Inadequate management of accelerated stormwater runoff resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of existing streams and storm sewers, greatly increases the cost of public facilities to convey and manage stormwater, undermines floodplain management and flood reduction efforts in upstream and downstream communities, reduces groundwater recharge, threatens public health and safety, and increases non-point source pollution of water resources.

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

C. Inadequate planning and management of stormwater runoff resulting from land development and redevelopment throughout a watershed can also harm surface water resources by changing the natural hydrologic patterns; accelerating stream flows (which increase scour and erosion of streambeds and stream banks thereby elevating sedimentation); destroying aquatic habitat; and elevating aquatic pollutant concentrations and loadings such as sediments, nutrients, heavy metals, and pathogens. Groundwater resources are also impacted through loss of recharge.

D. Stormwater is an important water resource which provides groundwater recharge for water supplies and base flow of streams, which also protects and maintains surface water quality.

E. Public education on the control of pollution from stormwater is an essential component in successfully addressing stormwater issues.

F. Federal and state regulations require certain municipalities to implement a program of stormwater controls. These municipalities are required to obtain a permit for stormwater discharges from their separate storm sewer systems under the National Pollutant Discharge Elimination System (NPDES).

Section 103. Purpose

The purpose of this Ordinance is to promote health, safety, and welfare within ***[Municipality]***, Crawford County, by minimizing the harms and maximizing the benefits described in Section 102 of this Ordinance through provisions intended to:

A. Meet legal water quality requirements under state law, including regulations at 25 PA Code Chapter 93 to protect, maintain, reclaim, and restore the existing and designated uses of the Waters of the Commonwealth.

B. Manage accelerated runoff and erosion and sedimentation problems close to their source, by regulating activities that cause these problems.

C. Preserve the natural drainage systems as much as possible.

D. Maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to otherwise protect water resources.

E. Maintain existing flows and quality of streams and watercourses.

F. Preserve and restore the flood-carrying capacity of streams and prevent scour and erosion of stream banks and streambeds.

G. Manage stormwater impacts close to the runoff source, with a minimum of structures and a maximum use of natural processes.

H. Provide procedures, performance standards, and design criteria for stormwater planning and management.

I. Provide proper operations and maintenance of all temporary and permanent stormwater management facilities and Best Management Practices (BMPs) that are constructed and implemented.

J. Provide standards to meet the NPDES permit requirements.

Section 104. Statutory Authority

A. Primary Authority: ***[Municipality]*** is empowered to regulate these activities by the authority of the Act of October 4, 1978, 32 P.S., P.L. 864 (Act 167), 32 P.S. Section 680.1 et seq., as amended, the "Storm Water Management Act", and the ***[applicable Municipal Code]***.

B. Secondary Authority: ***[Municipality]*** also is empowered to regulate land use activities that affect runoff by the authority of the Act of July 31, 1968, P.L. 805, No. 247, The Pennsylvania Municipalities Planning Code, as amended.

Section 105. Applicability

This Ordinance shall apply to all areas of ***[Municipality]***, any Regulated Activity within ***[Municipality]***, and all stormwater runoff entering into ***[Municipality's]*** separate storm sewer system from lands within the boundaries of ***[Municipality]***.

Earth disturbance activities and associated stormwater management controls are also regulated under existing state law and implementing regulations. This Ordinance shall operate in coordination with those parallel requirements; the requirements of this Ordinance shall be no less restrictive in meeting the purposes of this Ordinance than state law.

"Regulated Activities" are any earth disturbance activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff. "Regulated Activities" include, but are not limited to, the following listed items:

A. Earth Disturbance Activities
B. Land Development
C. Subdivision where earth disturbance activities are proposed
D. Construction of new or additional impervious or semi-pervious surfaces
E. Construction of new buildings or additions to existing buildings
F. Diversion or piping of any natural or man-made stream channel
G. Installation of stormwater management facilities or appurtenances thereto
H. Installation of stormwater BMPs

See Section 302 of this Ordinance for Exemption/Modification Criteria.

Section 106. Repealer

Any ordinance, ordinance provision(s), or regulation of ***[Municipality]*** inconsistent with any of the provision(s) of this Ordinance is hereby repealed to the extent of the inconsistency only.

Section 107. Severability

In the event that a court of competent jurisdiction declares any section(s) or provision(s) of this Ordinance invalid, such decision shall not affect the validity of any of the remaining section(s) or provision(s) of this Ordinance.

Section 108. Compatibility with Other Ordinance Requirements

Approvals issued and actions taken pursuant to this Ordinance do not relieve the Applicant of the responsibility to comply with or to secure required permits or approvals for activities regulated by any other applicable codes, laws, rules, statutes, or ordinances. To the extent that this Ordinance imposes more rigorous or stringent requirements for stormwater management, the specific requirements contained in this Ordinance shall be followed.

Section 109. Duty of Persons Engaged in the Development of Land

Notwithstanding any provision(s) of this Ordinance, including exemptions, any landowner or 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. Such measures also shall include actions as are required to manage the rate, volume, direction, and quality of resulting stormwater runoff in a manner which otherwise adequately protects health, property, and water quality.

Section 110. Municipal Liability Disclaimer

A. Neither the granting of any approval under this Ordinance, nor the compliance with the provisions of this Ordinance, or with any condition imposed by a municipal official hereunder, shall relieve any person from any responsibility for damage to persons or property resulting there from, or as otherwise imposed by law nor impose any liability upon the Municipality for damages to persons or property.

B. The granting of a permit which includes any storm water management facilities shall not constitute a representation, guarantee or warranty of any kind by the Municipality, or by an official or employee 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 public body, official or employee for any damage that may result pursuant thereto.

ARTICLE II - DEFINITIONS

For the purpose of this Ordinance, certain terms and words used herein shall be interpreted as follows:

A. Words used in the present tense include the future tense; the singular number includes the plural; and the plural number includes the singular; words of masculine gender include feminine gender; and words of feminine gender include masculine gender.

B. The word "includes" or "including" shall not limit the term to the specific example but is intended to extend its meaning to all other instances of like kind and character.

C. The word "person" includes an individual, firm, association, organization, partnership, trust, company, corporation, or any other similar entity.

D. The words "shall" and "must" are mandatory; the words "may" and "should" are permissive.

E. The words "used or occupied" include the words "intended, designed, maintained, or arranged to be used, occupied or maintained".

Accelerated Erosion - The removal of the surface of the land through the combined action of human activity and natural processes at a rate greater than would occur because of the natural process alone.

Agricultural Activities - Activities associated with agriculture such as agricultural cultivation, agricultural operation, and animal heavy use areas. This includes the work of producing crops, tillage, land clearing, plowing, disking, harrowing, planting, harvesting crops, or pasturing and raising of livestock and installation of conservation measures. Construction of new buildings or impervious area is not considered an Agricultural Activity.

Alteration - As applied to land, a change in topography as a result of the moving of soil and rock from one location or position to another; changing of surface conditions by causing the surface to be more or less impervious; land disturbance.

Applicant - A landowner, developer, or other person who has filed an application for approval to engage in any Regulated Activities at a project site within the municipality.

Best Management Practices (BMPs) - Activities, facilities, designs, measures or procedures used to manage stormwater impacts from Regulated Activities, to meet State Water Quality Requirements, to promote groundwater recharge and to otherwise meet the purposes of this Ordinance. Stormwater BMPs are commonly grouped into one of two broad categories or measures: "non-structural" or "structural". "Non-structural" BMPs are measures referred to as operational and/or behavior-related practices that attempt to minimize the contact of pollutants with stormwater runoff whereas "structural" BMPs are measures that consist of a physical device or practice that is installed to capture and treat stormwater runoff. "Structural" BMPs include, but are not limited to, a wide variety of practices and devices, from large-scale retention ponds and constructed wetlands, to small-scale underground treatment systems, infiltration facilities, filter strips, low impact design, bioretention, wet ponds, permeable paving, grassed swales, riparian or forested buffers, sand filters, detention basins, and manufactured devices. "Structural" stormwater BMPs are permanent appurtenances to the project site.

Channel Erosion - The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to large floods.

Cistern - An underground reservoir or tank used for storing rainwater.

Conservation District - The Crawford County Conservation District. The Crawford County Conservation District has the authority under a delegation agreement executed with the Department of Environmental Protection to administer and enforce all or a portion of the regulations promulgated under 25 PA Code Chapter 102.

Culvert - A structure with appurtenant works that carries a stream and/or stormwater runoff under or through an embankment or fill.

Dam - An artificial barrier, together with its appurtenant works, constructed for the purpose of impounding or storing water or another fluid or semifluid, or a refuse bank, fill or structure for highway, railroad or other purposes which does or may impound water or another fluid or semifluid.

Design Storm - The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., a 25-year storm) and duration (e.g., 24-hours), used in the design and evaluation of stormwater management systems. Also see Return Period.

Designee - The agent of this municipality and/or agent of the governing body involved with the administration, review or enforcement of any provisions of this Ordinance by contract or memorandum of understanding.

Detention Basin - An impoundment structure designed to manage stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate.

Detention Volume - The volume of runoff that is captured and released into Waters of the Commonwealth at a controlled rate.

Developer - A person, partnership, association, corporation, or other entity, or any responsible person therein or agent thereof, that undertakes any Regulated Activity of this Ordinance.

Development Site - **(Site)** - The specific tract of land for which a Regulated Activity is proposed. Also see Project Site.

Disturbed Area - An unstabilized land area where an Earth Disturbance Activity is occurring or has occurred.

Downslope Property Line - That portion of the property line of the lot, tract, or parcels of land being developed located such that all overland or pipe flow from the site would be directed toward it.

Drainage Conveyance Facility - A stormwater management facility designed to convey stormwater runoff and shall include streams, channels, swales, pipes, conduits, culverts, storm sewers, etc.

Drainage Easement - A right granted by a landowner to a grantee, allowing the use of private land for stormwater management, drainage, or conveyance purposes.

Drainageway - Any natural or artificial watercourse, trench, ditch, pipe, swale, channel, or similar depression into which surface water flows.

Earth Disturbance Activity - A construction or other human activity which disturbs the surface of the land, including, but not limited to, clearing and grubbing, grading, excavations, embankments, land development, agricultural plowing or tilling, timber harvesting activities, road maintenance activities, mineral extraction, and the moving, depositing, stockpiling, or storing of soil, rock or earth materials.

Erosion - The movement of soil particles by the action of water, wind, ice, or other natural forces.

Erosion and Sediment Pollution Control Plan - A plan which is designed to minimize accelerated erosion and sedimentation.

Exceptional Value Waters - Surface waters of high quality, which satisfies PA Code Title 25 Environmental Protection, Chapter 93 Water Quality Standards 93.4b(b) (relating to anti-degradation).

Existing Conditions - The initial condition of a project site prior to the proposed construction. If the initial condition of the site is undeveloped land and not forested, the land use shall be considered as "meadow" unless the natural land cover is documented to generate lower Curve Numbers or Rational "C" Coefficient.

FEMA - The Federal Emergency Management Agency.

Flood - A general but temporary condition of partial or complete inundation of normally dry land areas from the overflow of streams, rivers, and other Waters of the Commonwealth.

Flood Fringe - The remaining portions of the 100-year floodplain outside of the floodway boundary.

Floodplain - Any land area susceptible to inundation by water from any natural source or delineated by applicable Department of Housing and Urban Development, Federal Insurance Administration Flood Hazard Boundary - mapped as being a special flood hazard area. Included are lands adjoining a river or stream that have been or may be inundated by a 100-year flood. Also included are areas that comprise Group 13 Soils, as listed in Appendix A of the Pennsylvania Department of Environmental Protection (PADEP) Technical Manual for Sewage Enforcement Officers (as amended or replaced from time to time by PADEP).

Floodway - The channel of the watercourse and those portions of the adjoining floodplains that are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed - absent evidence to the contrary - that the floodway extends from the stream to 50 feet landward from the top of the bank of the stream.

Forest Management/Timber Operations - Planning and activities necessary for the management of forestland. These include timber inventory and preparation of forest management plans, silvicultural treatment, cutting budgets, logging road design and construction, timber harvesting, site preparation and reforestation.

Freeboard - A vertical distance between the elevation of the design high water and the top of a dam, levee, tank, basin, or diversion ridge. The space is required as a safety margin in a pond or basin.

Grade - A slope, usually of a road, channel or natural ground specified in percent and shown on plans as specified herein.

(To) Grade - To finish the surface of a roadbed, top of embankment or bottom of excavation.

Groundwater Recharge - Replenishment of existing natural underground water supplies.

HEC-HMS Model Calibrated - (Hydrologic Engineering Center Hydrologic Modeling System) A computer-based hydrologic modeling technique adapted to the watershed(s) in Crawford County for the Act 167 Plan. The model has been calibrated by adjusting key model input parameters.

High Quality Waters - Surface water having quality, which exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water by satisfying PA Code Title 25 Environmental Protection, Chapter 93 Water Quality Standards 93.4b(a).

Hydrologic Soil Group (HSG) - Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into one of four HSG (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. The Natural Resource Conservation Service (NRCS) of the US Department of Agriculture defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report from the local NRCS office or the County Conservation District.

Impervious Surface (Impervious Area) - A surface that prevents the infiltration of water into the ground. Impervious surface (or areas) include, but is not limited to: roofs, additional indoor living spaces, patios, garages, storage sheds and similar structures, parking or driveway areas, and any new streets and sidewalks. Any surface areas proposed to initially be gravel or crushed stone shall be assumed to be impervious surfaces.

Impoundment - A retention or detention basin designed to retain stormwater runoff and release it at a controlled rate.

Infiltration Structures - A structure designed to direct runoff into the ground (e.g., french drains, seepage pits, seepage trench, etc.).

Inlet - A surface connection to a closed drain. A structure at the diversion end of a conduit. The upstream end of any structure through which water may flow.

Land Development (Development) - (i) The improvement of one lot or two or more contiguous lots, tracts or parcels of land for any purpose involving (a) a group of two or more buildings, or (b) 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; (ii) Any subdivision of land; (iii) Development in accordance with Section 503(1.1) of the PA Municipalities Planning Code.

Low Impact Development (LID) - an approach to land development that uses various land planning and design practices and technologies to simultaneously conserve and protect natural resource systems and reduce infrastructure costs. LID still allows land to be developed, but in a cost-effective manner that helps mitigate potential environmental impacts.

Main Stem (Main Channel) - Any stream segment or other runoff conveyance facility used as a reach in the Crawford County Act 167 watershed hydrologic model(s).

Manning Equation (Manning Formula) - A method for calculation of velocity of flow (e.g., feet per second) and flow rate (e.g., cubic feet per second) in open channels based upon channel shape, roughness, depth of flow and slope. "Open channels" may include closed conduits so long as the flow is not under pressure.

Municipality - ***[Municipality]***, Crawford County, Pennsylvania.

National Pollutant Discharge Elimination System (NPDES) - The federal government's system for issuance of permits under the Clean Water Act, which is delegated to PADEP in Pennsylvania.

NOAA Atlas 14: - Precipitation-Frequency Atlas of the United States, Atlas 14, Volume 2, US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Hydrometeorological Design Studies Center, Silver Spring, Maryland (2004). NOAA's Atlas 14 can be accessed at Internet address http://hdsc.nws.noaa.gov/hdsc/pfds/.

Non-point Source Pollution - Pollution that enters a water body from diffuse origins in the watershed and does not result from discernible, confined, or discrete conveyances.

NRCS - Natural Resource Conservation Service (previously Soil Conservation Service (SCS)).

Open Channel - A drainage element in which stormwater flows with an open surface. Open channels include, but shall not be limited to, natural and man-made drainageways, swales, streams, ditches, canals, and pipes not under pressure.

Outfall - (i) Point where water flows from a conduit, stream, or drain; (ii) "Point Source" as described in 40 CFR § 122.2 at the point where the Municipality's storm sewer system discharges to surface Waters of the Commonwealth.

Outlet - Points of water disposal from a stream, river, lake, tidewater, or artificial drain.

PADEP - The Pennsylvania Department of Environmental Protection.

Parking Lot Storage - Involves the use of impervious parking areas as temporary impoundments with controlled release rates during rainstorms.

Peak Discharge - The maximum rate of stormwater runoff from a specific storm event.

Person - An individual, partnership, public or private association or corporation, or a governmental unit, public utility or any other legal entity whatsoever which is recognized by law as the subject of rights and duties.

Pervious Area - Any area not defined as impervious.

Pipe - A culvert, closed conduit, or similar structure (including appurtenances) that conveys stormwater.

Planning Commission - The Planning Commission of ***[Municipality]***.

Point Source - Any discernible, confined, or discrete conveyance, including, but not limited to: any pipe, ditch, channel, tunnel, or conduit from which stormwater is or may be discharged, as defined in State regulations at 25 Pennsylvania Code § 92.1.

Probable Maximum Flood (PMF) - The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in any area. The PMF is derived from the probable maximum precipitation (PMP) as determined on the basis of data obtained from the National Oceanographic and Atmospheric Administration (NOAA).

Project Site - The specific area of land where any Regulated Activities in the Municipality are planned, conducted, or maintained.

Qualified Professional - Any person licensed by the Pennsylvania Department of State or otherwise qualified by law to perform the work required by the Ordinance.

Rational Formula - A rainfall-runoff relation used to estimate peak flow.

Redevelopment - Earth disturbance activities on land, which has previously been developed.

Regulated Activities - Any earth disturbance activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff.

Regulated Earth Disturbance Activity - Activity involving Earth Disturbance subject to regulation under 25 PA Code Chapter 92, Chapter 102, or the Clean Streams Law.

Release Rate - The percentage of pre-development peak rate of runoff from a site or subwatershed area to which the post-development peak rate of runoff must be reduced to protect downstream areas.

Release Rate District - Those subwatershed areas in which post-development flows must be reduced to a certain percentage of pre-development flows as required to meet the plan requirements and the goals of Act 167.

Retention Basin - An impoundment in which stormwater is stored and not released during the storm event. Stored water may be released from the basin at some time after the end of the storm.

Retention Volume/Removed Runoff - The volume of runoff that is captured and not released directly into the surface Waters of this Commonwealth during or after a storm event.

Return Period - The average interval, in years, within which a storm event of a given magnitude can be expected to recur. For example, the 25-year return period rainfall would be expected to recur on the average once every twenty-five years; or stated in another way, the probability of a 25-year storm occurring in any one given year is 0.04 (i.e. a 4% chance).

Riparian Buffer - A vegetated area bordering perennial and intermittent streams and wetlands, that serves as a protective filter to help protect streams and wetlands from the impacts of adjacent land uses.

Riser - A vertical pipe extending from the bottom of a pond that is used to control the discharge rate from the pond for a specified design storm.

Road Maintenance - Earth disturbance activities within the existing road right-of-way, such as grading and repairing existing unpaved road surfaces, cutting road banks, cleaning or clearing drainage ditches, and other similar activities. Road maintenance activities that do not disturb the subbase of a paved road (such as milling and overlays) are not considered earth disturbance activities.

Rooftop Detention - Temporary ponding and gradual release of stormwater falling directly onto flat roof surfaces by incorporating controlled-flow roof drains into building designs.

Runoff - Any part of precipitation that flows over the land surface.

Runoff Capture Volume - The volume of runoff that is captured (retained) and not released into surface Waters of the Commonwealth during or after a storm event.

Sediment - Soils or other materials transported by surface water as a product of erosion.

Sediment Basin - A barrier, dam, retention or detention basin located and designed to retain rock, sand, gravel, silt, or other material transported by stormwater runoff.

Sediment Pollution - The placement, discharge, or any other introduction of sediment into Waters of the Commonwealth occurring from the failure to properly design, construct, implement or maintain control measures and control facilities in accordance with the requirements of this Ordinance.

Sedimentation - The process by which mineral or organic matter is accumulated or deposited by the movement of water.

Seepage Pit/Seepage Trench - An area of excavated earth filled with loose stone or similar coarse material, into which surface water is directed for infiltration into the ground.

Separate Storm Sewer System - A conveyance or system of conveyances (including roads with drainage systems, Municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) primarily used for collecting and conveying stormwater runoff.

Sheet Flow - Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.

Soil Cover Complex Method - A method of runoff computation developed by the NRCS that is based on relating soil type and land use/cover to a runoff parameter called Curve Number (CN).

Spillway (Emergency) - A depression in the embankment of a pond or basin, or other overflow structure, that is used to pass peak discharges greater than the maximum design storm controlled by the pond or basin.

State Water Quality Requirements - The regulatory requirements to protect, maintain, reclaim, and restore water quality under Title 25 of the Pennsylvania Code and the Clean Streams Law.

Storage Indication Method - A reservoir routing procedure based on solution of the continuity equation (inflow minus outflow equals the change in storage) with outflow defined as a function of storage volume and depth.

Storm Frequency - The number of times that a given storm "event" occurs or is exceeded on the average in a stated period of years. See also Return Period.

Storm Sewer - A system of pipes and/or open channels that convey intercepted runoff and stormwater from other sources, but excludes domestic sewage and industrial wastes.

Stormwater - Drainage runoff from the surface of the land resulting from precipitation, snow, or ice melt.

Stormwater Hotspot - A land use or activity that generates higher pollutants than are found in typical stormwater runoff and have a high potential to endanger local water quality, and could potentially threaten ground water reservoirs.

Stormwater Management Facilities - Any structure, natural or man-made, that, due to its condition, design, or construction, conveys, stores, or otherwise affects stormwater runoff. Typical stormwater management facilities include, but are not limited to: detention and retention basins, open channels, storm sewers, pipes and infiltration facilities.

Stormwater Management Plan - The Crawford County Stormwater Management Plan for managing stormwater runoff in Crawford County as required by the Act of October 4, 1978, P.L. 864, (Act 167) and known as the "Storm Water Management Act".

Stormwater Management Site Plan (SWM Site Plan) - The plan prepared by the Applicant or his representative indicating how stormwater runoff will be managed at the project site in accordance with this Ordinance.

Stream Enclosure - A bridge, culvert, or other structure in excess of 100 feet in length upstream to downstream which encloses a regulated Waters of the Commonwealth.

Subwatershed Area - The smallest drainage unit of a watershed for which stormwater management criteria has been established in the Stormwater Management Plan.

Subdivision - The division or re-division of a lot, tract, or parcel of land by any means, into two or more lots, tracts, parcels or other divisions of land including changes in existing lot lines for the purpose, whether immediate or future, of lease, transfer of ownership, or building or lot development, provided; however, that the subdivision by lease of land for agricultural purposes into parcels of more than ten acres, not involving any new street or easement of access or any residential dwellings, shall be exempt {Pennsylvania Municipalities Planning Code, Act of July 31, 1968, P.L. 805, No. 247}.

Swale - A low-lying stretch of land that gathers or carries surface water runoff.

Timber Operations - See "Forest Management".

Time of Concentration (T_c) - The time for surface runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. This time is the combined total of overland flow time and flow time in pipes or channels, if any.

USDA - The United States Department of Agriculture.

Watercourse - A channel or conveyance of surface water, such as a stream or creek, having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Waters of the Commonwealth - Rivers, streams, creeks, rivulets, impoundments, ditches, watercourses, storm sewers, lakes, dammed water, wetlands, ponds, springs and other bodies or channels of conveyance of surface and underground water, or parts thereof, whether natural or artificial, within or on the boundaries of the Commonwealth of Pennsylvania.

Watershed - Area drained by a river, watercourse, or other surface water, whether natural or artificial.

Wetland - Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas. (The term includes but is not limited to wetland areas listed in the State Water Plan, the United States Forest Service Wetlands Inventory of Pennsylvania, the Pennsylvania Coastal Zone

Management Plan and a wetland area designated by a river basin commission. This definition is used by the United States Environmental Protection Agency and the United States Army Corps of Engineers.)

ARTICLE III - STORMWATER MANAGEMENT STANDARDS

Section 301. General Requirements

A. For all Regulated Activities, unless specifically exempted in Section 302:

   1. Preparation and implementation of an approved SWM Site Plan is required.
   2. No Regulated Activities shall commence until the municipality issues written approval of a SWM Site Plan, which demonstrates compliance with the requirements of this Ordinance.
   3. The SWM Site Plan shall demonstrate that adequate capacity will be provided to meet the Volume and Rate Control Requirements, as described under Sections 304 and 305 of this Ordinance.
   4. The SWM Site Plan approved by the municipality, shall be on-site throughout the duration of the Regulated Activities.

B. For all Regulated Earth Disturbance Activities, erosion and sediment control BMPs shall be designed, implemented, operated, and maintained during the Regulated Earth Disturbance Activities (e.g., during construction) to meet the purposes and requirements of this Ordinance and to meet all requirements under Title 25 of the Pennsylvania Code (including, but not limited to Chapter 102 Erosion and Sediment Control) and the Clean Streams Law. Various BMPs and their design standards are listed in the *Erosion and Sediment Pollution Control Program Manual* (E&S Manual), No. 363-2134-008 (April 15, 2000), as amended and updated.

C. For all Regulated Activities, stormwater BMPs shall be designed, installed, implemented, operated, and maintained to meet the purposes and requirements of this Ordinance and to meet all requirements under Title 25 of the Pennsylvania Code and the Clean Streams Law, conform to the State Water Quality Requirements, meet all requirements under the Storm Water Management Act and any more stringent requirements as determined by the municipality.

D. The municipality may, after consultation with PADEP, approve measures for meeting the State Water Quality Requirements other than those in this Ordinance, provided that they meet the minimum requirements of, and do not conflict with state law, including, but not limited to, the Clean Streams Law.

E. All Regulated Activities shall include, to the maximum extent practicable, measures to:

   1. Protect health, safety, and property.
   2. Meet the water quality goals of this Ordinance by implementing measures to:
      a. Minimize disturbance to floodplains, wetlands, natural slopes, existing native vegetation and woodlands.
      b. Create, maintain, or extend riparian buffers and protect existing forested buffers.
      c. Provide trees and woodlands adjacent to impervious areas whenever feasible.
      d. Minimize the creation of impervious surfaces and the degradation of Waters of the Commonwealth and promote groundwater recharge.
      e. Protect natural systems and processes (drainageways, vegetation, soils, and sensitive areas) and maintain, as much as possible, the natural hydrologic regime.
      f. Incorporate natural site elements (wetlands, stream corridors, mature forests) as design elements.

g. Avoid erosive flow conditions in natural flow pathways.
h. Minimize soil disturbance and soil compaction.
i. Minimize thermal impacts to Waters of the Commonwealth.
j. Disconnect impervious surfaces by directing runoff to pervious areas, wherever possible and decentralize and manage stormwater at its source.

F. Impervious Areas:
1. The measurement of impervious areas shall include all of the impervious areas in the total proposed development, even if development is to take place in stages.
2. For developments taking place in stages, the entire development plan must be used in determining conformance with this Ordinance.
3. **[OPTIONAL]** For projects that add impervious area to a parcel, the total impervious area on the parcel is subject to the requirements of this Ordinance.

G. If diffused flow is proposed to be concentrated and discharged onto adjacent property, the Applicant must document that adequate downstream conveyance facilities exist to safely transport the concentrated discharge, or otherwise prove that no erosion, sedimentation, flooding, or other harm will result from the concentrated discharge.
1. Applicant must provide an easement for proposed concentrated flow across adjacent properties to a drainage way or public right-of-way.
2. Such stormwater flows shall be subject to the requirements of this ordinance.

H. Stormwater drainage systems shall be provided in order to permit unimpeded flow along natural watercourses, except as modified by stormwater management facilities or open channels consistent with this Ordinance.

I. Where watercourses traverse a development site, drainage easements (to encompass the 100-year flood elevation with a minimum width of 20 feet) shall be provided conforming to the line of such watercourses. The terms of the easement shall prohibit excavation, the placing of fill or structures, and any alterations that may adversely affect the flow of stormwater within any portion of the easement. Also, maintenance, including mowing of vegetation within the easement may be required, except as approved by the appropriate governing authority.

J. When it can be shown that, due to topographic conditions, natural drainageways on the site cannot adequately provide for drainage, open channels may be constructed conforming substantially to the line and grade of such natural drainageways. Work within natural drainage ways shall be subject to approval by PADEP under regulations at 25 PA Code Chapter 105 through the Joint Permit Application process, or, where deemed appropriate by PADEP, through the General Permit process.

K. Any stormwater management facilities or any facilities that constitute water obstructions (e.g., culverts, bridges, outfalls, or stream enclosures, etc.) that are regulated by this Ordinance, that will be located in or adjacent to Waters of the Commonwealth (including wetlands), shall be subject to approval by PADEP under regulations at 25 PA Code Chapter 105 through the Joint Permit Application process, or, where deemed appropriate by PADEP, the General Permit process. When there is a question whether wetlands may be involved, it is the responsibility of the Applicant or his agent to show that the land in question cannot be classified as wetlands; otherwise, approval to work in the area must be obtained from PADEP.

L. Should any stormwater management facility require a dam safety permit under PADEP Chapter 105, the facility shall be designed in accordance with Chapter 105 and meet the regulations of Chapter 105 concerning dam safety.

M. Any stormwater management facilities regulated by this Ordinance that will be located on, or discharged onto State highway rights-of-ways shall be subject to approval by the Pennsylvania Department of Transportation (PENNDOT).

N. Minimization of impervious surfaces and infiltration of runoff through seepage beds, infiltration trenches, etc., are encouraged, where soil conditions and geology permit, to reduce the size or eliminate the need for detention facilities.

O. Infiltration BMPs should be dispersed throughout the site, made as shallow as practicable, and located to maximize use of natural on-site infiltration features while still meeting the other requirements of this Ordinance.

P. Roof drains shall not be connected to streets, sanitary or storm sewers, or roadside ditches in order to promote overland flow and infiltration/percolation of stormwater where it is advantageous to do so. When it is more advantageous to connect directly to streets or storm sewers, then the Municipality shall permit it on a case-by-case basis.

Q. Applicants are encouraged to use Low Impact Development Practices to reduce the costs of complying with the requirements of this Ordinance and the State Water Quality Requirements.

R. When stormwater management facilities are proposed within 1,000 feet of a downstream Municipality, the Developer shall notify the downstream Municipality and, upon request, provide the SWM Plan to the downstream Municipality's Engineer for review and comment.

Section 302. Exemptions/Modifications

A. Under no circumstance shall the Applicant be exempt from implementing such measures as necessary to:

1. Meet State Water Quality Standards and Requirements.
2. Protect health, safety, and property.
3. Meet special requirements for High Quality (HQ) and Exceptional Value (EV) watersheds.

B. The Applicant must demonstrate that the following BMPs are being utilized to the maximum extent practicable to receive consideration for the exemptions:

1. Design around and limit disturbance of Floodplains, Wetlands, Natural Slopes over 15%, existing native vegetation, and other sensitive and special value features.
2. Maintain riparian and forested buffers.
3. Limit grading and maintain non-erosive flow conditions in natural flow paths.
4. Maintain existing tree canopies near impervious areas.
5. Minimize soil disturbance and reclaim disturbed areas with topsoil and vegetation.
6. Direct runoff to pervious areas.

C. The Applicant must demonstrate that the proposed development/additional impervious area will not adversely impact the following:

1. Capacities of existing drainageways and storm sewer systems.
2. Velocities and erosion.
3. Quality of runoff if direct discharge is proposed.

4. Existing known problem areas.
5. Safe conveyance of the additional runoff.
6. Downstream property owners.

D. An Applicant proposing Regulated Activities, after demonstrating compliance with Sections 302.A, 302.B, and 302.C, may be exempted from various requirements of this Ordinance according to the following table:

New Impervious Area[1, 2] (square footage)	Applicant Must Provide
0 – 1,000	---
1,000 – 2,500	Documentation of new impervious surface[3]
2,500 – 5,000	Volume Controls & Small Project SWM Application[3]
> 5,000	Rate Controls, Volume Controls & SWM Site Plan

NOTES:
[1] New Impervious Area since the date of Adoption of this Ordinance.
[2] Gravel in existing condition shall be considered pervious and gravel in proposed condition shall be considered impervious. Existing maintained municipal roads are considered impervious.
[3] The Small Project Stormwater Management Application included in Appendix D may be used for projects under 5,000 sf of new impervious surface and single family home construction. The Small Project SWM Application allows documentation of new impervious surface, credits through disconnection of impervious surfaces and tree planting, and sizing of Volume Control BMP's that may be required.

E. An Applicant proposing Regulated Activities, after demonstrating compliance with Sections 302.A, 302.B, and 302.C, may be exempted from various requirements of this Ordinance if documentation can be provided that a downstream man-made water body (i.e., reservoir, lake, or man-made wetlands) has been designed or modified to address the potential stormwater flooding impacts of the proposed development.

F. The purpose this section is to ensure consistency of stormwater management planning between local ordinances and NPDES permitting (when required) and to ensure that the Applicant has a single and clear set of stormwater management standards to which the Applicant is subject. The Municipality may accept alternative stormwater management controls under this section provided that:

1. The Municipality, in consultation with the PADEP, determines that meeting the Volume Control requirements (See Section 304) is not possible or places an undue hardship on the Applicant.
2. The alternative controls are documented to be acceptable to PADEP, for NPDES requirements pertaining to post construction stormwater management requirements.
3. The alternative controls are in compliance with all other sections of this ordinance, including but not limited to Sections 301.D and 302.A-C.

G. Agricultural activities are exempt from requirements of this Ordinance provided the activities are performed according to the requirements of 25 PA Code Chapter 102.

H. Forest management and timber operations are exempt from the Rate and Volume Control requirement and SWM Site Plan preparation requirement of this Ordinance provided the activities are performed according to the requirements of 25 PA Code Chapter 102. It should be noted that temporary roadways are not exempt.

Section 303. Waivers

A. The provisions of this Ordinance are the minimum standards for the protection of the public welfare.

B. All waiver requests must meet the provisions of Section 303.G. and H. Waivers shall not be issued from implementing such measures as necessary to:

   1. Meet State Water Quality Standards and Requirements.
   2. Protect health, safety, and property.
   3. Meet special requirements for High Quality (HQ) and Exceptional Value (EV) watersheds.

   Municipalities will then consider waivers in accordance with Section 301.D.

C. If an Applicant demonstrates to the satisfaction of the governing body of the Municipality that any mandatory provision of this Ordinance is unreasonable or causes unique or undue unreasonableness or hardship as it applies to the proposed Project, or that an alternate design may result in a superior result within the context of Section 102 and 103 of this Ordinance, the governing body of the Municipality upon obtaining the comments and recommendations of the Municipal Engineer may grant a waiver or relief so that substantial justice may be done and the public interest is secured; provided that such waiver will not have the effect of nullifying the intent and purpose of this Ordinance.

D. The Applicant shall submit all requests for waivers in writing and shall include such requests as a part of the plan review and approval process. The Applicant shall state in full the facts of unreasonableness or hardship on which the request is based, the provision or provisions of the Ordinance that are involved, and the minimum waiver or relief that is necessary. The Applicant shall state how the requested waiver and how the Applicant's proposal shall result in an equal or better means of complying with the intent or Purpose and general principles of this Ordinance.

E. The Municipality shall keep a written record of all actions on waiver requests.

F. The Municipality may charge a fee for each waiver request, which shall be used to offset the administrative costs of reviewing the waiver request. The Applicant shall also agree to reimburse the Municipality for reasonable and necessary fees that may be incurred by the Municipal Engineer in any review of a waiver request.

G. In granting waivers, the Municipality may impose reasonable conditions at will, in its judgment, secure substantially the objectives of the standards or requirements that are to be modified.

H. The Municipality may grant applications for waivers when the following findings are made, as relevant:

   1. That the waiver shall result in an equal or better means of complying with the intent of this Ordinance.
   2. That the waiver is the minimum necessary to provide relief.
   3. That the applicant is not requesting a waiver based on cost considerations.
   4. That existing down gradient stormwater problems will not be exacerbated.
   5. That runoff is not being diverted to a different drainage area.
   6. That increased flooding or ponding on off-site properties or roadways will not occur.

7. That potential icing conditions will not occur.
8. That increase of peak flow (design storms up to 100-year) or volume (design storms up to 2-year) from the site will not occur.
9. That erosive conditions due to increased peak flows or volume will not occur.
10. That adverse impact to water quality will not result.
11. That increased 100-Year Floodplain levels will not result.
12. That increased or unusual municipal maintenance expenses will not result from the waiver.
13. That the amount of stormwater generated has been minimized to the greatest extent allowed.
14. That infiltration of runoff throughout the proposed site has been provided where practicable and pre-development ground water recharge protected.
15. That peak flow attenuation of runoff has been provided.
16. That long term operation and maintenance activities are established.
17. That the receiving streams and/or water bodies will not be adversely impacted in flood carrying capacity, aquatic habitat, channel stability and erosion and sedimentation.

Section 304. Volume Controls

A. The Low Impact Development Practices provided in the BMP Manual and in Appendix B of this Ordinance shall be utilized for all Regulated Activities to the maximum extent practicable.

B. Stormwater runoff Volume Controls shall be implemented using the *Design Storm Method* or the *Simplified Method* as defined below. For Regulated Activity areas equal or less than one (1) acre that do not require hydrologic routing to design the stormwater facilities, this Ordinance establishes no preference for either method; therefore, the Applicant may select either method on the basis of economic considerations, the intrinsic limitations on applicability of the analytical procedures associated with each methodology, and other factors.

   1. The *Design Storm Method* (CG-1 in the BMP Manual) is applicable to any sized Regulated Activity. This method requires detailed modeling based on site conditions.

      a. Do not increase the post-development total runoff volume when compared to the pre-development total runoff volume for the 2-year/24-hour storm event.

      b. For hydrologic modeling purposes:

         i. Existing non-forested pervious areas must be considered meadow (good condition) for pre-development hydrologic calculations.
         ii. Twenty (20) percent of existing impervious area, when present within the proposed project site, shall be considered meadow (good condition) for pre-development hydrologic calculations for re-development.

   2. The *Simplified Method* (CG-2 in the BMP Manual) is independent of site conditions and should be used if the *Design Storm Method* is not followed. This method is not applicable to Regulated Activities greater than 1 acre or for projects that require detailed design of stormwater storage facilities. For new impervious surfaces:

      a. Stormwater facilities shall capture at least the first 2 inches of runoff from all new impervious surfaces.

b. At least the first 1 inch of runoff from new impervious surfaces shall be permanently removed from the runoff flow, i.e. it shall not be released into surface Waters of the Commonwealth. Removal options include reuse, evaporation, transpiration, and infiltration.

c. Wherever possible, infiltration facilities should be designed to accommodate infiltration of the entire permanently removed runoff; however, in all cases at least the first 0.5 inch of the permanently removed runoff should be infiltrated.

d. Actual field infiltration tests at the location of the proposed elevation of the stormwater BMPs are required. Infiltration test shall be conducted in accordance with the BMP Manual. Notification of the Municipality shall be provided to allow witnessing of the testing.

3. In cases where it is not possible or desirable to use infiltration-based best management practices to partially fulfill the requirements in either Section 304.B.1 or 304.B.2, the following procedure shall be used:

a. At a minimum, the following documentation shall be provided to justify the decision to not use infiltration BMPs:
   i. Description of and justification for field infiltration/permeability testing with respect to the type of test and test locations).
   ii. An interpretive narrative describing existing site soils and their structure as these relate to the interaction between soils and water occurring on the site. In addition to providing soil and soil profile descriptions, this narrative shall identify depth to seasonal high water tables and depth to bedrock, and provide a description of all subsurface elements (fragipans and other restrictive layers, geology, etc.) that influence the direction and rate of subsurface water movement.
   iii. A qualitative assessment of the site's contribution to annual aquifer recharge shall be made, along with identification of any restrictions or limitations associated with the use of engineered infiltration facilities.
   iv. The provided documentation must be signed and sealed by a professional engineer or geologist.

b. The following water quality pollutant load reductions will be required for all disturbed areas within the proposed development:

Pollutant Load	Units	Required reduction (%)
Total Suspended Solids (TSS)	Pounds	85
Total Phosphorous (TP)	Pounds	85
Total Nitrate (NO_3)	Pounds	50

c. The performance criteria for water quality best management practices shall be determined from the Pennsylvania Stormwater Best Management Practices Manual, most current version.

C. The applicable Worksheets from the BMP Manual must be used in calculations to establish Volume Control. Worksheets documenting Volume Control Credits are also acceptable.

Section 305. Rate Controls

A. Lands contained within Crawford County that have not had release rates established under an approved Act 167 Stormwater Management Plan:

   1. Post-development discharge rates shall not exceed the pre-development discharge rates for the 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year storms.

B. Lands contained within Crawford County that have had release rates established under an approved Act 167 Stormwater Management Plan:

   1. The post-development peak discharge rates shall be in accordance with the approved release rate map for the individual watershed.
      a. Conneaut Outlet Watershed - for the 2-year, 10-year, 25-year and 100-year storms, post-development peak discharge rates shall follow the approved release rate map.

Section 306. Sensitive Areas and Stormwater Hotspots

A. Sensitive areas, as defined below, and Stormwater Hotspots which require special consideration with regard to stormwater management.

   1. Sensitive areas are defined as those areas that, if developed, have the potential to endanger a water supply. These areas consist of the delineated 1-year zone of contribution and direct upslope areas tributary to the water supply wells. Municipalities may update the sensitive area boundaries based on new research or studies as required.
   2. Stormwater Hotspots are land development projects that have a high potential to endanger local water quality, and could potentially threaten ground water reservoirs. The Municipal Engineer will determine what constitutes these classifications on a case-by-case basis. The PADEP wellhead protection contaminant source list shall be used as a guide in these determinations. Industrial manufacturing site and hazardous material storage areas must provide NPDES SIC codes.

B. Performance Standards

   1. The location of the boundaries of sensitive areas is set by drainage areas tributary to any public water supply. The exact location of these boundaries as they apply to a given development site, shall be determined using mapping at a scale which accurately defines the limits of the sensitive area. If the project site is within the sensitive area (in whole or in part), 2-foot contour interval mapping shall be provided to define the limits of the sensitive area. If the project site is adjacent to but within 500 linear feet of a defined Sensitive Area, a 5-foot contour interval map defining the limits of the Sensitive Area shall be included in the Stormwater Management Plan to document the site's location relative to the sensitive area.
   2. Stormwater Hotspot developments may be required to prepare and implement a stormwater pollution prevention plan and file notice of intent as required under the provision of the EPA Industrial Stormwater NPDES Permit Requirements.
   3. Stormwater Hotspot developments must use an acceptable pre-treatment BMP prior to volume control and/or rate control BMPs. Acceptable pre-treatment BMPs for these developments include those based on filtering, settling, or chemical reaction processes such as coagulation.

ARTICLE IV – PROTECTED WATERSHED STANDARDS

Section 401. Protected Watershed Requirements

A. For any Regulated Activity within a protected watershed (High Quality or Exceptional Value), the applicant shall meet requirements as contained in 25 PA Code, Chapters 93 as required and applicable.

B. Existing Resources and Site Analysis Plan. Shall be prepared to provide the developer and the Municipality with a comprehensive analysis of existing conditions, both on the proposed development site and within 500 feet of the site. Conditions beyond the parcel boundaries may be described on the basis of existing published data available from governmental agencies and from aerial photographs. The Municipality shall review the plan to assess its accuracy, conformance with Municipal ordinances, and likely impact upon the natural and cultural resources on the property. The following information shall be required:

   1. Complete current perimeter boundary survey of the property to be subdivided or developed prepared by a registered surveyor, showing all courses, distances, and area and tie-ins to all adjacent intersections.

   2. A vertical aerial photograph enlarged to a scale not less detailed than one inch equals 400 feet, with the site boundaries clearly marked.

   3. Natural features, including:
      a. Contour lines at intervals of not more than two feet. (Ten-foot intervals are permissible beyond the parcel boundaries, interpolated from USGS published maps.) Contour lines shall be based on information derived from a topographic survey for the property, evidence of which shall be submitted, including the date and source of the contours. Datum to which contour elevations refer and references to known, established benchmarks and elevations shall be included on the plan.
      b. Steep slopes in the following ranges: 15% to 25%, 25% and greater. The location of these slopes shall be graphically depicted by category on the plan. Slope shall be measured over three or more two-foot contour intervals.
      c. Areas within the floodway, flood fringe, and approximated floodplain.
      d. Watercourses, either continuous or intermittent and named or unnamed, and lakes, ponds or other water features as depicted on the USGS Quadrangle Map, most current edition.
      e. Wetlands and wetland margins.
      f. Riparian buffers.
      g. Soil types and their boundaries, as mapped by the USDA Natural Resource Conservation Service, including a table listing the soil characteristics pertaining to suitability for construction and, in un-sewered areas, for septic suitability. Alluvial and hydric soils shall specifically be depicted on the plan.
      h. Existing vegetation, denoted by type, including woodlands, hedgerows, tree masses, tree lines, individual freestanding trees over six inches DBH, wetland vegetation, pasture or croplands, orchards, permanent grass land, old fields, and any other notable vegetative features on the site. Vegetative types shall be described by plant community, relative age, and condition.
      i. Any identified Pennsylvania Natural Diversity Inventory (PNDI) site conflicts.

    j. Geologic formations on the tract, including rock outcroppings, cliffs, sinkholes, and fault lines, based on available published information or more detailed data obtained by the applicant.

4. Existing man-made features, including:
    a. Location, dimensions, and use of existing buildings and driveways.
    b. Location, names, widths, center line courses, paving widths, identification numbers, and rights-of-way, of existing streets and alleys.
    c. Location of trails that have been in public use (pedestrian, equestrian, bicycle, etc.).
    d. Location and size of existing sanitary sewage facilities.
    e. Location and size of drainage facilities.
    f. Location of water supply facilities, including wellhead protection areas.
    g. Any easements, deed restrictions, rights-of-way, or any other encumbrances upon the land, including location, size, and ownership.
    h. Site features or conditions such as hazardous waste, dumps, underground tanks, active and abandoned wells, quarries, landfills, sandmounds, and artificial land conditions.

5. Total acreage of the tract, the adjusted tract area, where applicable, and the constrained land area with detailed supporting calculations.

C. Stormwater Management System Concept Plan. A written and graphic concept plan of the proposed post-development stormwater management system shall be prepared and include:
    1. Preliminary selection and location of proposed structural stormwater controls;
    2. Location of existing and proposed conveyance systems such as grass channels, swales, and storm drains;
    3. Location of floodplain/floodway limits;
    4. Relationship of site to upstream and downstream properties and drainages.
    5. Preliminary location of proposed stream channel modifications, such as bridge or culvert crossings.

D. Consultation Meeting. Prior to any stormwater management permit application submission, the land owner or developer shall meet with the Municipality for a consultation meeting on a concept plan for the post-development stormwater management system to be utilized in the proposed project. This consultation meeting shall take place at the time of the preliminary plan or other early step in the development process. The purpose of this meeting is to discuss the post-development stormwater management measures necessary for the proposed project, as well as to discuss and assess constraints, opportunities and potential ideas for stormwater management designs before the formal site design engineering is commenced.

E. All proposed Regulated Activities within a protected watershed shall utilize, to the maximum extent possible, Low Impact Development Practices as contained in Appendix B.

    1. SWM Plan and Report shall address the following:
        a. Design using nonstructural BMPs
            i. Lot configuration and clustering.
                (a) Reduced individual lot impacts by concentrated/clustered uses and lots
                (b) Lots/development configured to avoid critical natural areas
                (c) Lots/development configured to take advantage of effective mitigative stormwater practices

(d) Lots/development configured to fit natural topography

ii. Minimum disturbance
   (a) Define disturbance zones (excavation/grading) for the site and individual lots to protect maximum total site area from disturbance
   (b) Barriers/flagging proposed to protect designated non-disturbance areas
   (c) Considered mitigative practices for minimal disturbance areas (e.g., Soil Restoration)
   (d) Considered re-forestation and re-vegetation opportunities

iii. Reduce Impervious coverage
   (a) Reduced road width
   (b) Reduced driveway lengths and widths
   (c) Reduced parking ratios and sizes
   (d) Utilized porous surfaces for applicable features

iv. Stormwater disconnected from impervious area
   (a) Disconnected drives/walkways/small impervious areas to natural areas
   (b) Use rain barrels and/or cisterns for lot irrigation

b. Apply structural BMP selection process that meets runoff quantity and quality needs.
   i. Manage close to source with collection with conveyance minimized
   ii. Consistent with site factors (e.g., soils, slope, available space, amount of sensitive areas, pollutant removal needs)
   iii. Minimize footprint and integrate into already disturbed areas/other building program components (e.g., recharge beneath parking areas, vegetated roofs)
   iv. Consider other benefits such as aesthetic, habitat, recreational and educational benefits
   v. BMP's select based on maintenance needs that fit owner/users
   vi. BMP's sustainable using a long-term maintenance plan

ARTICLE V – RIPARIAN BUFFER STANDARDS

Section 501. Riparian Buffer Requirements

Where a Regulated Activity is proposed, the Riparian Buffer shall be established as follows:

A. The buffer shall be measured perpendicularly from the top of the stream bank landward.
   1. High Quality or Exceptional Value Watersheds - a minimum of 150 feet;
   2. Impaired Watersheds – a minimum of 150 feet;
   3. All other watersheds - a minimum of 50 feet; or
   4. As determined by a stream corridor study approved by PADEP and the Municipality.

B. The riparian buffer shall be located on both sides of all perennial and intermittent streams. The perennial and intermittent streams and the riparian buffer boundaries shall be shown on all applications for Building Permits, subdivision, or land development. Existing uses within the buffer are permitted to continue but not be expanded. Placement of new structures or roadways within the riparian buffer shall be prohibited. Where a wetland exists within the buffer area, the buffer shall be extended landward to provide a minimum buffer of 25 feet, as measured perpendicularly from the wetland boundary.

C. The buffer shall be undisturbed forest consisting of appropriate native species.

D. Where wetlands are located partially or entirely within a buffer, the buffer shall be extended to encompass the wetland and shall be widened by a distance sufficient to provide a 25 foot forested buffer measured perpendicularly from the wetland boundary.

E. The following uses shall be permitted in the buffer:

   1. Footpaths, trails and bike paths provided that:
      a. Width is limited to 5 feet;
      b. Width may be increased provided a corresponding increase in the buffer is provided;
      c. Construction shall have minimal impact to the buffer.
   2. Stream crossings, provided the crossing is designed and constructed in such a manner as to minimize the impact to the buffer. The Riparian Buffer shall be restored to its original condition, to the maximum extent practical, upon completion of construction.
   3. Utility lines, provided that the crossing is designed and constructed in such a manner as to minimize the impact to the inner buffer and provided that there is no practical alternative to locating the utility line within the buffer. The Riparian Buffer shall be restored to its original condition, to the maximum extent practical, upon completion of construction.
   4. Maintenance and restoration of the Riparian Buffer.
   5. Projects conducted with the objective of improvement, stabilization, restoration, or enhancement of the stream bank, stream channel, floodplain, watershed hydrology, riparian buffers, or aquatic habitat and maintenance activities associated with such projects. These projects include, but are not limited to agricultural and stormwater management best management practices. Such projects must receive appropriate permits and approvals from PADEP prior to starting the project.
   6. Minor private recreational uses for the property owner. Such uses include benches, fire rings, and similar uses. Such uses do not include structures such as cabins, sheds, pavilions, garages, dwellings or similar structures.

F. Disturbance of the Riparian Buffer shall be limited to the area necessary to perform an allowable use.

G. Where possible and practical, disturbances shall be phased with each phase restored prior to beginning the next phase.

H. Allowable activities shall not cause stormwater flow to concentrate.

I. Any vegetation removed for an allowable activity shall be replaced immediately upon completion of the activity. Where mature trees are removed, such trees shall be replaced with the largest practical tree of acceptable native species.

J. Erosion and sediment pollution control shall be installed and maintained during construction. Evidence of an approved Erosion and Sediment Control Plan, NPDES Permit or other PADEP permit, where required, shall be submitted prior to issuance of local permits.

K. Riparian buffers shall be maintained in a manner consistent with sound forest management practices. In the absence of a site specific management plan, the following maintenance guidelines apply:

    1. Buffers shall be inspected periodically for evidence of excessive sediment deposition, erosion or concentrated flow channels. Prompt action shall be taken to correct these problems and prevent future occurrence.
    2. Trees presenting an unusual hazard of creating downstream obstructions shall be removed. Such material shall be removed from the floodplain or the riparian buffer (whichever is widest); or cut into sections small enough so as to prevent the possibility of creating obstructions downstream. Wherever possible, large stable debris should be conserved.
    3. Vegetation should be inspected periodically to ensure diverse vegetative cover and vigorous plant growth consistent with buffering objectives.
        a. Remove invasive plant species that may threaten the integrity of the buffer.
        b. Periodic cutting of trees may be necessary to promote vigorous growth and encourage regeneration.
    4. Excessive use of fertilizers, pesticides, herbicides, and other chemicals shall be avoided. These products should be used only when absolutely necessary to maintain buffer vegetation.

Section 502. Riparian Buffer Easement

For all required Riparian Buffers, an easement shall be provided:

A. Easements shall be in accordance with Section 801 and recorded in accordance with Section 1303 of this Ordinance.

ARTICLE VI - DESIGN CRITERIA

Section 601. Design Criteria for Stormwater Management & Drainage Facilities

A. General Design Guidelines:

1. Stormwater shall not be transferred from one watershed to another, unless (1) the watersheds are sub-watersheds of a common watershed which join together within the perimeter of the property; (2) the effect of the transfer does not alter the peak rate discharge onto adjacent lands; or (3) easements from the affected landowner(s) are provided.

2. Consideration shall be given to the relationship of the subject property to the drainage pattern of the watershed. A concentrated discharge of stormwater to an adjacent property shall be within an existing watercourse or confined in an easement or returned to a pre-development flow type condition.

3. Innovative stormwater BMPs and recharge facilities are encouraged (e.g., rooftop storage, drywells, cisterns, recreation area ponding, diversion structures, porous pavements, holding tanks, infiltration systems, in-line storage in storm sewers, and grading patterns). They shall be located, designed, and constructed in accordance with the latest technical guidance published by PADEP, provided they are accompanied by detailed engineering plans and performance capabilities and supporting site specific soils, geology, runoff and groundwater and infiltration rate data to verify proposed designs. Additional guidance from other sources may be accepted at the discretion of the Municipal Engineer (a pre-application meeting is suggested).

4. All existing and natural watercourses, channels, drainage systems and areas of surface water concentration shall be maintained in their existing condition unless an alteration is approved by the appropriate regulatory agency.

5. The design of all stormwater management facilities shall incorporate sound engineering principles and practices. The Municipality shall reserve the right to disapprove any design that would result in the continuation or exacerbation of a documented adverse hydrologic or hydraulic condition within the watershed, as identified in the Plan.

6. The design and construction of multiple use stormwater detention facilities are strongly encouraged. In addition to stormwater management, facilities should, where appropriate, allow for recreational uses including ball fields, play areas, picnic grounds, etc. Consultation with the Municipality, and prior approval are required before design. Provision for permanent wet ponds with stormwater management capabilities may also be appropriate.

   a. Multiple use basins should be constructed so that potentially dangerous conditions are not created.
   b. Water quality basins or recharge basins that are designed for a slow release of water or other extended detention ponds are not permitted for recreational uses, unless the ponded areas are clearly separated and secure.

7. Should any stormwater management facility require a dam safety permit under PADEP Chapter 105, the facility shall be designed in accordance with Chapter 105 and meet the regulations of Chapter 105 concerning dam safety.

B. Stormwater Management Facility Design Considerations: All stormwater management facilities shall meet the requirements contained in the *Crawford County Stormwater Management Facility Design Criteria*.

Section 602. Calculation Methodology

A. All calculations shall be consistent with the guidelines set forth in the BMP Manual, as amended herein.

B. Stormwater runoff from all development sites shall be calculated using either the Rational Method or the NRCS Rainfall-Runoff Methodology. Methods shall be selected by the design professional based on the individual limitations and suitability of each method for a particular site.

C. Rainfall Values:

1. Rational Method – The Pennsylvania Department of Transportation Drainage Manual, Intensity-Duration-Frequency Curves, Publication 584, Chapter 7A, latest edition, shall be used in conjunction with the appropriate time of concentration and return period.
2. NRCS Rainfall-Runoff Method – The Soil Conservation Service Type II, 24-hour rainfall distribution shall be used in conjunction with rainfall depths from NOAA Atlas 14 or be consistent with the following table:

Return Interval (Year)	24-hour Rainfall Total (inches)
1	2.08
2	2.49
10	3.50
25	3.60
50	4.67
100	5.23

D. Runoff Volume:

1. Rational Method – Not to be used to calculate runoff volume.
2. NRCS Rainfall-Runoff Method – This method shall be used to estimate the change in volume due to Regulated Activities. Combining Curve Numbers for land areas proposed for development with Curve Numbers for areas unaffected by the proposed development into a single weighted curve number is NOT acceptable.

E. Peak Flow Rates:

1. Rational Method – This method may be used for design of conveyance facilities only. Extreme caution should be used by the design professional if the watershed has more then one main drainage channel, if the watershed is divided so that hydrologic properties are significantly different in one versus the other, if the time of concentration exceeds 60 minutes, or if stormwater runoff volume is an important factor. The combination of Rational Method hydrographs based on timing shall be prohibited.
2. NRCS Rainfall-Runoff Method – This method is recommended for design of stormwater management facilities and where stormwater runoff volume must be taken into consideration. The following provides guidance on the model applicability:

a. NRCS's TR-55 – limited to 100 acres in size
b. NRCS's TR-20 or HEC-HMS – no size limitations
c. Other models as pre-approved by the Municipal Engineer

The NRCS antecedent runoff condition II (ARC II, previously AMC II) must be used for all simulations. The use of continuous simulation models that vary the ARC are not permitted for stormwater management purposes.

3. For comparison of peak flow rates, flows shall be rounded to a tenth of a cubic foot per second (cfs).

F. Runoff Coefficients:

1. Rational Method – Use Table C-1 (Appendix C).
2. NRCS Rainfall-Runoff Method – Use Table C-2 (Appendix C). Curve Numbers (CN) should be rounded to tenths for use in hydrologic models as they are a design tool with statistical variability. For large sites, CN's should realistically be rounded to the nearest whole number.
3. For the purposes of pre-development peak flow rate and volume determination, existing non-forested pervious areas conditions shall be considered as meadow (good condition).
4. For the purposes of pre-development peak flow rate and volume determination, 20 percent of existing impervious area, when present, shall be considered meadow (good condition).

G. Design Storm:

1. All stormwater management facilities shall be verified by routing the proposed 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year hydrographs through the facility using the storage indication method or modified puls method. The design storm hydrograph shall be computed using a calculation method that produces a full hydrograph.
2. The stormwater management and drainage system shall be designed to safely convey the post development 100-year storm event to stormwater detention facilities, for the purpose of meeting peak rate control.
3. All structures (culvert or bridges) proposed to convey runoff under a Municipal road shall be designed to pass the 50-year design storm with a minimum 1 foot of freeboard measured below the lowest point along the top of the roadway.

H. Time of Concentration:

1. The Time of Concentration is to represent the average condition that best reflects the hydrologic response of the area. The following Time of Concentration (T_c) computational methodologies shall be used unless another method is pre-approved by the Municipal Engineer:

   a. Pre-development – NRCS's Lag Equation:

   Time of Concentration = $T_c = [(T_{lag}/.6) * 60]$ (minutes)

$$T_{lag} = L^{0.8}\frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where:

T_{lag} = Lag time (hours)
L = Hydraulic length of watershed (feet)
Y = Average overland slope of watershed (percent)
S = Maximum retention in watershed as defined by: S = [(1000/CN) – 10]
CN = NRCS Curve Number for watershed

b. Post-development; commercial, industrial, or other areas with large impervious areas (>20% impervious area) – NRCS Segmental Method. The length of sheet flow shall be limited to 100 feet. T_c for channel and pipe flow shall be computed using Manning's equation.

c. Post-development; residential, cluster, or other low impact designs less than or equal to 20% impervious area – NRCS Lag Equation or NRCS Segmental Method.

2. Additionally, the following provisions shall apply to calculations for Time of Concentration:

a. The post-development T_c shall never be greater that the pre-development T_c for any watershed or sub-watershed. This includes when the designer has specifically used swales to reduce flow velocities. In the event that the designer believes that the post-development T_c is greater, it will still be set by default equal to the pre-development T_c for modeling purposes.

b. The minimum T_c for any watershed shall be 5 minutes.

c. The designer may choose to assume a 5 minute T_c for any post development watershed or subwatershed without providing any computations.

d. The designer must provide computations for all pre-development T_c paths. A 5 minute T_c can not be assumed for pre-development.

e. Undetained fringe areas (areas that are not tributary to a stormwater facility but where a reasonable effort has been made to convey runoff from all new impervious coverage to best management practices) may be assumed to represent the pre-development conditions for purpose of T_c calculation.

I. Where uniform flow is anticipated, the Manning's equation shall be used for hydraulic computations and to determine the capacity of open channels, pipes, and storm sewers. The Manning's equation should not be used for analysis of pipes under pressure flow or for analysis of culverts. Manning's "n" values shall be obtained from *PENNDOT's Drainage Manual, Publication 584*. Inlet control shall be checked at all inlet boxes to ensure the headwater depth during the 10-year design event is contained below the top of grate for each inlet box.

J. The Municipality may approve the use of any generally accepted full hydrograph approximation technique that shall use a total runoff volume that is consistent with the volume from a method that produces a full hydrograph.

K. The Municipality has the authority to require that computed existing runoff rates be reconciled with field observations, conditions and site history. If the designer can substantiate, through actual physical calibration, that more appropriate runoff and time of concentration values should be utilized at a particular site, then appropriate variations may be made upon review and recommendation of the Municipality.

ARTICLE VII - SWM SITE PLAN & REPORT REQUIREMENTS

Section 701. General Requirements

For any of the activities regulated by this Ordinance and not eligible for the exemptions provided in Section 302, the final approval of subdivision and/or land development plans, the issuance of any building or occupancy permit, or the commencement of any land disturbance activity, may not proceed until the Applicant has received written approval of a SWM Site Plan from the Municipality.

Section 702. SWM Site Plan & Report Contents

A. The SWM Site Plan & SWM Site Report shall consist of all applicable calculations, maps, and plans. All SWM Site Plan materials shall be submitted to the Municipality in a format that is clear, concise, legible, neat and well organized; otherwise, the SWM Site Plan shall be rejected.

B. The SWM Site Plan & Report shall meet the requirements set forth in the *Crawford County Stormwater Management Facility Design Handbook*

C. Appropriate sections from the Municipal Subdivision and Land Development Ordinance, and other applicable local ordinances, shall be followed in preparing the SWM Site Plan.

Section 703. SWM Site Plan & Report Submission

A. The Applicant shall submit the SWM Site Plan & Report for the Regulated Activity.

B. Three (3) **[OPTION Five (5)]** copies of the SWM Site Plan & Report shall be submitted and be distributed as follows:

    1. Two (2) copies to the Municipality accompanied by the requisite executed Review Fee Reimbursement Agreement, as specified in this Ordinance
    2. One (1) copy to the Municipal Engineer
    3. One (1) copy to the Crawford County Planning and Commission **[OPTIONAL]**
    4. One (1) copy to the Crawford County Conservation District **[OPTIONAL]**

C. Additional copies shall be submitted as requested by the Municipality or PADEP.

Section 704. SWM Site Plan & Report Review

A. The Municipality shall require receipt of a complete SWM Site Plan & Report as specified in this Ordinance. The Municipality shall review the SWM Site Plan & Report for consistency with the purposes, requirements, and intent of this Ordinance.

B. The Municipality shall not approve any SWM Site Plan & Report that is deficient in meeting the requirements of this Ordinance. At its sole discretion and in accordance with this Article, when a SWM Site Plan & Report is found to be deficient, the Municipality may disapprove the submission and require a resubmission, or in the case of minor deficiencies, the Municipality may accept submission of modifications.

C. The Municipality shall notify the Applicant in writing within forty-five (45) calendar days whether the SWM Site Plan & Report is approved or disapproved if the SWM Site Plan & Report is not part of a Subdivision or Land Development Plan. If the SWM Site Plan & Report involves a

Subdivision or Land Development Plan, the timing shall following the Subdivision and Land Development process according to the Municipalities Planning Code.

D. The Municipal Building Permit Office shall not issue a building permit for any Regulated Activity if the SWM Site Plan & Report has been found to be inconsistent with this Ordinance, as determined by the Municipality. All required permits from PADEP must be obtained prior to issuance of a building permit.

Section 705. Modification of Plans

A. A modification to a submitted SWM Site Plan & Report for a development site that involves a change in stormwater management facilities or techniques, or that involves the relocation or re-design of stormwater management facilities, or that is necessary because soil or other conditions are not as stated on the SWM Site Plan as determined by the Municipality, shall require a resubmission of the modified SWM Site Plan in accordance with this Ordinance.

Section 706. Resubmission of Disapproved SWM Site Plan & Report

A. A disapproved SWM Site Plan & Report may be resubmitted with the revisions addressing the Municipality's concerns documented in writing, to the Municipality in accordance with this Ordinance. The applicable Municipal Review Fee must accompany a resubmission of a disapproved SWM Site Plan & Report.

Section 707. Authorization to Construct and Term of Validity

A. The Municipality's approval of a SWM Site Plan & Report authorizes the Regulated Activities contained in the SWM Site Plan for a maximum term of validity of five (5) years following the date of approval. The Municipality may specify a term of validity shorter than five (5) years in the approval for any specific SWM Site Plan. Terms of validity shall commence on the date the Municipality signs the approval for a SWM Site Plan. If stormwater management facilities included in the approved SWM Site Plan have not been constructed, or if an Record Drawing of these facilities has not been approved within this time, then the Municipality may consider the SWM Site Plan disapproved and may revoke any and all permits or approvals.

Section 708. Record Drawings, Completion Certificate and Final Inspection

A. The Applicant shall be responsible for providing Record Drawings of all stormwater BMPs included in the approved SWM Site Plan. The Record Drawing and an explanation of any discrepancies with the approved SWM Site Plan shall be submitted to the Municipality as a prerequisite for the release of the guarantee or issuance of an occupancy permit.

B. The Record Drawing shall include a certification of completion signed by a Qualified Professional verifying that all permanent stormwater BMPs have been constructed according to the approved SWM Site Plan & Report.
    1. Drawings shall show all approved revisions and elevations and inverts to all manholes, inlets, pipes, and stormwater control facilities.
    2. Submission shall include a comparison of the constructed stage-storage (volume vs. elevation) of all above ground and below ground stormwater storage facilities to the approved design.

C. After receipt of the Record Drawing and certification of completion by the Municipality, the Municipality may conduct a final inspection.

ARTICLE VIII - EASEMENTS

Section 801. Easements

A. Easements provided shall be in favor of the Municipality, granting access and maintenance rights to the Municipality.

B. Easements shall be established to accommodate the existence of drainageways.

C. Where a tract is traversed by a watercourse, drainage-way, channel or stream, there shall be provided an easement paralleling the line of such watercourse, drainage-way, channel or stream with a width adequate to preserve the unimpeded flow of natural drainage in the 100-year floodplain.

D. Easements shall be established for all on-site stormwater management or drainage facilities, including but not limited to: detention facilitates (above or below ground), infiltration facilities, all stormwater BMPs, drainage swales, and drainage facilities (inlets, manholes, pipes, etc.).

E. Easements are required for all areas used for off-site stormwater control.

F. All easements shall be a minimum of 20 feet wide and shall encompass the 100-year surface elevation of the proposed stormwater facility.

G. Easements shall provide ingress to, and egress from, a public right-of-way. In lieu of providing an easement to the public right-of-way, a note may be added to the plan granting the Municipality or their designees access to all easements via the nearest public right-of-way able for vehicle ingress and egress on grades of less than 10% for carrying out inspection or maintenance activities.

H. Where possible, easements shall be centered on side and/or rear lot lines.

I. Nothing shall be planted or placed within the easement which would adversely affect the function of the easement, or conflict with any conditions associated with such easement.

J. All easement agreements shall be recorded with a reference to the recorded easement indicated on the site plan. The format and content of the easement agreement shall be reviewed and approved by the Municipal Engineer and Solicitor.

ARTICLE IX - MAINTENANCE RESPONSIBILITIES

Section 901. Financial Guarantee

A. When an approved SWM Site Plan requires the timely installation and proper construction of stormwater management controls, the Applicant shall provide a Financial Guarantee to the Municipality equal to 110% of the full construction cost of the required controls in accordance with the Municipalities Planning Code.

B. At the completion of the project and as a prerequisite for the release of the Financial Guarantee, the Applicant shall:

   1. Provide a certification of completion from an engineer, architect, surveyor or other qualified person, verifying that all permanent facilities have been constructed according to the SWM Site Plan & Report and approved revisions thereto.
   2. Provide a set of Record Drawings.
   3. Request a final inspection from the Municipality to certify compliance with this Ordinance, after receipt of the certification of completion and Record Drawings by the Municipality.

Section 902. Maintenance Responsibilities

A. The SWM Site Plan & Report for the project site shall describe the future operation and maintenance responsibilities. The operation and maintenance description shall outline required routine maintenance actions and schedules necessary to ensure proper operation of the stormwater control facilities.

B. The SWM Site Plan & Report for the project site shall establish responsibilities for the continuing operating and maintenance of all proposed stormwater control facilities, consistent with the following principals:

   1. If a development consists of structures or lots that are to be separately owned and in which streets, sewers, and other public improvements are to be dedicated to the Municipality, stormwater control facilities/BMPs may also be dedicated to and maintained by the Municipality.
   2. If a development site is to be maintained in a single ownership or if sewers and other public improvements are to be privately owned and maintained, then the ownership and maintenance of stormwater control facilities/BMPs shall be the responsibility of the owner or private management entity.
   3. Facilities, areas, or structures used as stormwater BMPs shall be enumerated as permanent real estate appurtenances and recorded as deed restrictions or easements that run with the land.
   4. The SWM Site Plan & Report shall be recorded as a restrictive deed covenant that runs with the land.
   5. The Municipality may take enforcement actions against an Applicant for failure to satisfy any provision of this Ordinance.

C. The Municipality, upon recommendation of the Municipal Engineer, shall make the final determination on the continuing maintenance responsibilities prior to final approval of the SWM Site Plan & Report. The Municipality may require a dedication of such facilities as part of the requirements for approval of the SWM Site Plan. Such a requirement is not an indication that the Municipality will accept the facilities. The Municipality reserves the right to accept or reject the ownership and operating responsibility for any portion of the stormwater management controls.

D. If the Municipality accepts ownership of stormwater BMPs, the Municipality may, at its discretion, require a fee from the Applicant to the Municipality to offset the future cost of inspections, operations, and maintenance.

E. It shall be unlawful to alter or remove any permanent stormwater BMP required by an approved SWM Site Plan, or to allow the property to remain in a condition, which does not conform to an approved SWM Site Plan, unless the Municipality grants an exception in writing.

Section 903. Maintenance Agreement for Privately Owned Stormwater Facilities

A. Prior to final approval of the SWM Site Plan & Report, the Applicant shall sign the Operation and Maintenance (O&M) Agreement (Appendix A) covering all stormwater control facilities that are to be privately owned. The Operation and Maintenance (O&M) Agreement shall be recorded with the SWM Site Plan and made a part hereto.

B. Other items may be included in the Operation and Maintenance (O&M) Agreement where determined necessary to guarantee the satisfactory operation and maintenance of all BMP facilities. The Operation and Maintenance (O&M) Agreement shall be subject to the review and approval of the Municipality and the Municipal Solicitor.

C. The owner is responsible for operation and maintenance of the stormwater BMPs. If the owner fails to adhere to the Operation and Maintenance (O&M) Agreement, the Municipality may perform the services required and charge the owner appropriate fees. Non-payment of fees may result in a lien against the property.

ARTICLE X - INSPECTIONS

Section 1001. Schedule of Inspections

A. PADEP or its designees normally ensure compliance with any permits issued, including those for stormwater management. In addition to PADEP compliance programs, the Municipality or their municipal assignee may inspect all phases of the installation of temporary or permanent stormwater management facilities.

B. During any stage of Earth Disturbance Activities, if the Municipality determines that the stormwater management facilities are not being installed in accordance with the approved SWM Site Plan, the Municipality shall revoke any existing permits or approvals until a revised SWM Site Plan is submitted and approved as specified in this Ordinance.

C. Stormwater BMPs shall be inspected by the landowner, or the landowner's designee according to the inspection schedule described on the SWM Site Plan for each BMP.

   1. The Municipality may require copies of the inspection reports, in a form as stipulated by the Municipality.

   2. If such inspections are not conducted or inspection reports not submitted as scheduled, the Municipality, or their designee, may conduct such inspections and charge the owner appropriate fees. Non-payment of fees may result in a lien against the property.

      a. Prior to conducting such inspections, the Municipality shall inform the owner of its intent to conduct such inspections. The owner shall be given thirty (30) days to conduct required inspections and submit the required inspection reports to the Municipality.

Section 1002. Right-of-Entry

A. Upon presentation of proper credentials, duly authorized representatives of the Municipality may enter at reasonable times, upon any property within the Municipality, to inspect the implementation, condition, or operations and maintenance of the stormwater BMPs in regard to any aspect governed by this Ordinance.

B. Stormwater BMP owners and operators shall allow persons working on behalf of the Municipality ready access to all parts of the premises for the purposes of determining compliance with this Ordinance.

C. Persons working on behalf of the Municipality shall have the right to temporarily locate on any stormwater BMP in the Municipality such devices, as are necessary, to conduct monitoring and/or sampling of the discharges from such stormwater BMP.

D. Unreasonable delay in allowing the Municipality access to a stormwater BMP is a violation of this Ordinance.

ARTICLE XI - ENFORCEMENT AND PENALTIES

Section 1101. Notification

A. In the event that a person fails to comply with the requirements of this Ordinance, an approved SWM Site Plan, or fails to conform to the requirements of any permit or approval issued hereunder, the Municipality shall provide written notification of the violation. Such notification shall set forth the nature of the violation(s) and establish a time limit for correction of these violation(s).

B. Failure to comply within the time specified shall subject such person to the Penalties Provisions of this Ordinance. All such penalties shall be deemed cumulative and shall not prevent the Municipality from pursuing any and all other remedies. It shall be the responsibility of the owner of the real property on which any Regulated Activity is proposed to occur, is occurring, or has occurred, to comply with the terms and conditions of this Ordinance.

Section 1102. Enforcement

A. The municipal governing body is hereby authorized and directed to enforce all of the provisions of this Ordinance. The approved SWM Site Plan shall be on file at the project site throughout the duration of the construction activity. The Municipality or their designee may make periodic inspections during construction.

B. Adherence to Approved SWM Site Plan

    1. It shall be unlawful for any person, firm, or corporation to undertake any Regulated Activity on any property except as provided for by an approved SWM Site Plan and pursuant to the requirements of this Ordinance.
    2. It shall be unlawful to alter or remove any control structure required by the SWM Site Plan pursuant to this Ordinance.
    3. It shall be unlawful to allow a property to remain in a condition that does not conform to an approved SWM Site Plan.

Section 1103. Public Nuisance

A. A violation of any provision of this Ordinance is hereby deemed a Public Nuisance.

B. Each day that a violation continues shall constitute a separate violation.

Section 1104. Suspension and Revocation

A. Any approval or permit issued by the Municipality may be suspended or revoked for:

    1. Non-compliance with or failure to implement any provision of the approved SWM Site Plan or Operation & Maintenance (O&M) Agreement.
    2. A violation of any provision of this Ordinance or any other applicable law, Ordinance, rule or regulation relating to the Regulated Activity.
    3. The creation of any condition or the commission of any act, during the Regulated Activity which constitutes or creates a hazard or nuisance, pollution, or which endangers the life or property of others.

B. A suspended approval or permit may be reinstated by the Municipality when:

1. The Municipality or their designee has inspected and approved the corrections to the violation(s) that caused the suspension.
2. The Municipality is satisfied that the violation(s) has been corrected.

C. An approval that has been revoked by the Municipality cannot be reinstated. The Applicant may apply for a new approval under the provisions of this Ordinance.

Section 1105. Penalties

[Municipalities should ask their solicitors to provide appropriate wording for this section.]

A. Anyone violating the provisions of this Ordinance shall be guilty of a summary offense and upon conviction, shall be subject to a fine of not more than $ ____ for each violation, recoverable with costs. Each day that the violation continues shall be a separate offense and penalties shall be cumulative.

B. In addition, the Municipality, through its solicitor, may institute injunctive, mandamus, or any other appropriate action or proceeding at law or in equity for the enforcement of this Ordinance. Any court of competent jurisdiction shall have the right to issue restraining orders, temporary or permanent injunctions, mandamus, or other appropriate forms of remedy or relief.

Section 1106. Appeals

A. Any person aggrieved by any action of the Municipality or its designee, relevant to the provisions of this Ordinance, may appeal to the Municipality within thirty (30) days of that action.

B. Any person aggrieved by any decision of the Municipality, relevant to the provisions of this Ordinance, may appeal to the Crawford County Court of Common Pleas within thirty (30) days of the Municipality's decision.

ARTICLE XII - PROHIBITIONS

Section 1201. Prohibited Discharges and Connections

A. Any drain (including indoor drains and sinks), or conveyance whether on the surface or underground, that allows any non-stormwater discharge including sewage, process wastewater, and wash water to enter the Municipality's separate storm sewer system or Waters of the Commonwealth is prohibited.

B. Any drain or conveyance connected from a commercial or industrial land use to the Municipality's separate storm sewer system, which has not been documented in plans, maps, or equivalent records, and approved by the Municipality is prohibited.

C. No person shall allow, or cause to allow, discharges into the Municipality's separate storm sewer system or into surface Waters of the Commonwealth, which are not composed entirely of stormwater, except: (1) as provided in subsection 1301.D below, and (2) discharges allowed under a state or federal permit.

D. The following discharges are authorized unless they are determined to be significant contributors to pollution to the Waters of the Commonwealth:

-Discharges from fire fighting activities
-Potable water sources including dechlorinated water and fire hydrant flushings
-Air conditioning condensate
-Springs
-Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spill material has been removed) and where detergents are not used
-Water from crawl space pumps
-Flows from riparian habitats and wetlands
-Uncontaminated water from foundations or from footing drains
-Irrigation or Lawn watering
-Dechlorinated swimming pool discharges
-Water from individual residential car washing
-Routine external building washdown (which does not use detergents or other compounds)

E. In the event that the Municipality or PADEP determines that any of the discharges identified in subsection 1301.D is a significant contributor to pollution to the Waters of the Commonwealth, the responsible person(s) shall be notified to cease the discharge. Upon notice provided by the Municipality or PADEP, the discharger will have a reasonable time, as determined by the Municipality or PADEP, to cease the discharge, consistent with the degree of pollution caused by the discharge.

F. Nothing in this Section shall affect a discharger's responsibilities under Commonwealth Law.

Section 1202. Roof Drains

A. Roof drains and sump pumps shall discharge to infiltration areas, vegetative BMPs, or pervious areas to the maximum extent practicable.

Section 1203. Alteration of BMPs

A. No person shall modify, remove, fill, landscape, or alter any existing stormwater BMP, facilities, areas, or structures unless it is part of an approved maintenance program, without the written approval of the Municipality.

B. No person shall place any structure, fill, landscaping, or vegetation into a stormwater BMP, facilities, areas, structures, or within a drainage easement which would limit or alter the functioning of the BMP without the written approval of the Municipality.

ARTICLE XIII - FEES AND EXPENSES

Section 1301. General

A. The fee required by this Ordinance is the Municipal Review Fee. The Municipal Review Fee shall be established by the Municipality to defray review costs incurred by the Municipality and the Municipal Engineer. The Applicant shall pay all fees.

Section 1302. Expenses Covered by Fees

A. The fees required by this Ordinance shall, at a minimum, cover:

   1. Administrative and Clerical Costs.
   2. Review of the SWM Site Plan & Report by the Municipality.
   3. Pre-construction meetings.
   4. Inspection of stormwater management facilities/BMPs and drainage improvements during construction.
   5. Final inspection upon completion of the stormwater management facilities/BMPs and drainage improvements presented in the SWM Site Plan.
   6. Any additional work required to enforce any permit provisions regulated by this Ordinance, correct violations, and assure proper completion of stipulated remedial actions.

Section 1303. Recording of Approved SWM Site Plan and Related Agreements

A. The owner of any land upon which permanent BMPs will be placed, constructed, or implemented, as described in the SWM Site Plan, shall record the following documents in the Office of the Recorder of Deeds of Crawford County, within (__) days of approval of the SWM Site Plan by the Municipality:

   1. The SWM Site Plan.
      a. Refer to the requirements of 1.A. of the *Crawford County Stormwater Management Facility Design Criteria*. At a minimum, the items 1.A.1-7, 8-11, 13, 14, 16, 18, and 10 must be included on the recorded SWM Site Plan.
   2. Operations and Maintenance (O&M) Agreement (Appendix A).
   3. Easements under Section 901.
   4. Riparian buffers under Section 602.

B. The Municipality may suspend or revoke any approvals granted for the project site upon discovery of the failure of the owner to comply with this Section.

(ORDINANCE NAME)

(ORDINANCE NUMBER)

ENACTED and ORDAINED at a regular meeting of the

____

on this _________ day of ______________________, 20________.

This Ordinance shall take effect immediately.

____
(Name) (Title)

____
(Name) (Title)

____
(Name) (Title)

ATTEST:

____
Secretary

I hereby certify that the foregoing Ordinance was advertised in the [name of newspaper] on [date], a newspaper of general circulation in the Municipality and was duly enacted and approved as set forth at a regular meeting of the [name of municipal governing body] held on [date].

____
Secretary

APPENDIX A - OPERATION AND MAINTENANCE AGREEMENT

OPERATION AND MAINTENANCE (O&M) AGREEMENT
STORMWATER MANAGEMENT BEST MANAGEMENT PRACTICES (SWM BMPs)

THIS AGREEMENT, made and entered into this ____________ day of _________, 20___, by and between ___________________________________, (hereinafter the "Landowner"), and ______________________________, Crawford County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

WHEREAS, the Landowner is the owner of certain real property in __________________________ (municipality), as recorded by deed in the land records of Crawford County, Pennsylvania, Deed Book ___________ at Page ______, (hereinafter "Property").

WHEREAS, the Landowner is proceeding to build and develop the Property; and

WHEREAS, the SWM Site Plan approved by the Municipality (hereinafter referred to as the "Plan") for the property identified herein, which is attached hereto as Appendix A and made part hereof, as approved by the Municipality, provides for management of stormwater within the confines of the Property through the use of BMPs; and

WHEREAS, the Municipality, and the Landowner, his successors and assigns, agree that the health, safety, and welfare of the residents of the Municipality and the protection and maintenance of water quality require that on-site SWM BMPs be constructed and maintained on the Property; and

WHEREAS, the Municipality requires, through the implementation of the SWM Site Plan, that stormwater BMPs as required by said Plan and the Municipal Stormwater Management Ordinance be constructed and adequately operated and maintained by the Landowner, successors and assigns.

NOW, THEREFORE, in consideration of the foregoing promises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The Landowner shall construct the BMPs in accordance with the plans and specifications identified in the SWM Site Plan.
2. The Landowner shall operate and maintain the BMPs as shown on the Plan in good working order in accordance with the specific maintenance requirements noted on the approved SWM Site Plan.
3. The Landowner hereby grants permission to the Municipality, its authorized agents, and employees, to enter upon the property, at reasonable times and upon presentation of proper credentials, to inspect the BMPs whenever necessary. Whenever possible, the Municipality shall notify the Landowner prior to entering the property.
4. In the event the Landowner fails to operate and maintain the BMPs per paragraph 2, the Municipality or its representatives may enter upon the Property and take whatever action is deemed necessary to maintain said BMPs. It is expressly understood and agreed that the Municipality is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the Municipality.
5. In the event the Municipality, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the Municipality for all expenses (direct and indirect) incurred within ten (10) days of receipt of invoice from the Municipality.
6. The intent and purpose of this Agreement is to ensure the proper maintenance of the onsite BMPs by the Landowner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability of any party for damage alleged to result from or be caused by stormwater runoff.

7. The Landowner, its executors, administrators, assigns, and other successors in interests, shall release the Municipality from all damages, accidents, casualties, occurrences or claims which might arise or be asserted against said employees and representatives from the construction, presence, existence, or maintenance of the BMPs by the Landowner or Municipality.
8. The Municipality may inspect the BMPs at a minimum of once every three years to ensure their continued functioning.

This Agreement shall be recorded at the Office of the Recorder of Deeds of Crawford County, Pennsylvania, and shall constitute a covenant running with the Property and/or equitable servitude, and shall be binding on the Landowner, his administrators, executors, assigns, heirs and any other successors in interests, in perpetuity.

ATTEST:

WITNESS the following signatures and seals:

(SEAL) For the Municipality:

____

For the Landowner:

____

Commonwealth of Pennsylvania
County of Crawford, Pennsylvania } ss:

On this, the __________ day of __________________, 20_____, before me the undersigned officer, personally appeared

____

know to me (or satisfactorily proven) to be the person whose name subscribed to the within instrument, and acknowledges that __________ executed the same for the purpose therein contained.

IN WITNESS WHEREOF, I have hereunto set my hand and seal.

____

My Commission Expires Official Title

APPENDIX B – LOW IMPACT DEVELOPMENT PRACTICES

LOW IMPACT DEVELOPMENT PRACTICES
ALTERNATIVE APPROACHES FOR MANAGING STORMWATER RUNOFF

Natural hydrologic conditions may be altered radically by poorly planned development practices, such as introducing unneeded impervious surfaces, destroying existing drainage swales, constructing unnecessary storm sewers, and changing local topography. A traditional drainage approach of development has been to remove runoff from a site as quickly as possible and capture it in a detention basin. This approach leads ultimately to the degradation of water quality, as well as expenditure of additional resources for detaining and managing concentrated runoff at some downstream location.

The recommended alternative approach is to promote practices that will minimize post-development runoff rates and volumes, which will minimize needs for artificial conveyance and storage facilities. To simulate pre-development hydrologic conditions, forced infiltration is often necessary to offset the loss of infiltration by creation of impervious surfaces. The ability of the ground to infiltrate runoff depends upon the soil types and its conditions.

Preserving natural hydrologic conditions requires careful alternative site design considerations. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, and protecting natural depression storage. A well-designed site will contain a mix of all those features. The following describes various techniques to achieve the alternative approaches:

- **Preserving Natural Drainage Features**. Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in land development. In fact, commonly held drainage philosophy encourages just the opposite pattern - streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. As a result, runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration. Developments designed to fit site topography also minimize the amount of grading on site.

- **Protecting Natural Depression Storage Areas.** Depressional storage areas have no surface outlet, or drain very slowly following a storm event. They can be commonly seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining, thereby obliterating their ability to reduce surface runoff volumes and trap pollutants. The volume and release-rate characteristics of depressions should be protected in the design of the development site. The depressions can be protected by simply avoiding the depression or by incorporating its storage as additional capacity in required detention facilities.

- **Avoiding Introduction of Impervious Areas.** Careful site planning should consider reducing impervious coverage to the maximum extent possible. Building footprints, sidewalks, driveways, and other features producing impervious surfaces should be evaluated to minimize impacts on runoff.

- **Reducing the Hydraulic Connectivity of Impervious Surfaces**. Impervious surfaces are significantly less of a problem if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are: routing of roof runoff over lawns; and reducing the use of storm sewers.

Site grading should promote increasing travel time of stormwater runoff and should help reduce concentration of runoff to a single point in the development.

- **Routing Roof Runoff Over Lawns.** Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. The routing of roof drains and crowning the driveway to allow runoff to discharge to pervious areas is desirable as the pervious area essentially acts as a filter strip.

- **Reducing the Use of Storm Sewers.** By reducing the use of storm sewers for draining streets, parking lots, and back yards, the potential for accelerating runoff from the development can be greatly reduced. The practice requires greater use of swales and may not be practical for some development sites, especially if there are concerns for areas that do not drain in a "reasonable" time. The practice requires educating local citizens and public works officials, who expect runoff to disappear shortly after a rainfall event.

- **Reducing Street Widths.** Street widths can be reduced by either eliminating on-street parking or by reducing cartway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets, which ultimately could lower maintenance and maintenance related costs.

- **Limiting Sidewalks to One Side of the Street.** A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk could be replaced with bicycle/recreational trails that follow back-of-lot lines. Where appropriate, backyard trails should be constructed using pervious materials.

- **Using Permeable Paving Materials.** These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low use surfaces such as driveways, overflow parking lots, and emergency access roads.

- **Reducing Building Setbacks.** Reducing building setbacks reduces driveway and entry walks and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

- **Constructing Cluster Developments.** Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development. Cluster development "clusters" the construction activity onto less-sensitive areas without substantially affecting the gross density of development.

In summary, careful consideration of the existing topography and implementation of a combination of the above mentioned techniques may avoid construction of costly stormwater control measures. Other benefits include: reduced potential of downstream flooding, reduced water quality degradation of receiving streams and water bodies, enhancement of aesthetics, and reduction of development costs. Beneficial results include: more stable baseflows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

APPENDIX C – REVIEW FEE REIMBERSEMENT AGREEMENT

[OPTIONAL]

THIS AGREEMENT MUST BE COMPLETED AND SIGNED BY THE DEVELOPER/APPLICANT PRIOR TO SUBMISSION OF THE SUBDIVISION/LAND DEVELOPMENT APPLICATION AND PLANS, SKETCH PLANS, CONDITIONAL USE APPLICATIONS OR ANY OTHER SUBMISSION WHICH REQUIRES MUNICPAL CONSULTANT REVIEW.

REVIEW FEE REIMBERSEMENT AGREEMENT

THIS AGREEMENT, made and entered into this ____________ day of _________, 20___, by and between ____________________________________, (hereinafter the "Landowner"), and _______________________________, Crawford County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

WHEREAS, the Landowner is the owner of certain real property in ___________________________ (municipality), as recorded by deed in the land records of Crawford County, Pennsylvania, Deed Book ___________ at Page ______, (hereinafter "Property").

WHEREAS, the Landowner is proceeding to build and develop the Property; and

WHEREAS, the Landowner has submitted a SWM Site Plan for review and approval by the Municipality (hereinafter referred to as the "Plan") for the property identified herein; and

WHEREAS, the Developer has requested and/or required the Municipality approval and/or review of its proposed plans, and the Municipality is willing to authorize its professional consultants to review said Plan and/or proposal upon execution of this agreement, and upon deposit of an escrow account according to the current Fee Schedule.

NOW, THEREFORE, in consideration of the foregoing promises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The Landowner and Municipality hereby authorize and direct the Municipality's professional consultants, as defined at Section 107 of the Pennsylvania Municipalities Planning Code to review Landowner's plans or proposals to use its property, and to make such recommendations and specifications as may be necessary with respect to such plans in accordance with all applicable Municipality ordinances, and State and Federal rules and regulations.
2. The Landowner and Municipality acknowledge that the Municipality will incur costs and fees relating to the review of Landowner's plans by its professional consultants, and Landowner agrees to pay and/or reimburse the Municipality for such costs in accordance with this agreement.
3. The Landowner shall pay the professional consultant's charges and fees for the following: (a) review of any and all Stormwater Management Plans, studies, or other correspondence relating to the Landowners submission; (b) attendance at any and all meetings relating to Landowner's planl; (c) preparation of any reports, legal documents, or other correspondence relating to Landowner's plan or proposal; (d) inspection of the improvements during construction and final inspection upon completion; (e) any additional work required to assist the Municipality to enforce any permit provisions regulated by the Stormwater Management Ordinance, correct violations, and assure proper completion of stipulated remedial actions; and (e) administrative cost and incurred expenses relating to the administration of this agreement. It is understood by the execution of this agreement that the Landowner specifically accepts the Fee Schedule currently in effect in the Municipality.

4. The Landowner hereby agrees to deposit with the Municipality the sum of ______________ Dollars ($_____________), payable as cash in U.S. Dollars or check drawn on a Pennsylvania bank, as security for the payment of all costs and expenses, charges and fees as set forth in Paragraph 3 above, upon execution of this agreement, which shall be held in a noninterest- bearing account by the Municipality. In the event that the above deposited escrow fund shall fall below fifty percent (50%) of the original deposit, the Landowner shall immediately, upon receipt of written notice from the Municipality or its agent(s), deposit sums with the Municipality necessary to replenish the account to its original balance. In the event that this is insufficient to pay current Municipality incurred expenses, Landowner agrees to pay the total amount currently due for Municipality incurred expenses without delay in addition to re-establishing the base escrow account balance. The Municipality will use its best efforts to advise the Landowner of the impending likelihood that its costs have exceeded the required escrow account sums as described above.
5. Landowner and Municipality agree that upon completion of the Municipality's review of Landowner's plan or proposal, all unused portions of the escrow account as described above shall be returned to the applicant upon written request to the Municipality.
6. Landowner and Municipality acknowledge that the Ordinance and appropriate fee schedules require Landowner to pay Municipality's professional consultant fees relating to this plan or project, and in the even that Landowner fails to provide sufficient funds in the above-described revolving escrow account upon fifteen (15) days written notice to the Landowner or make the initial deposit payment described above within five (5) days of the date of this agreement, Landowner shall be in default of this agreement and in violation of the above Sections of Ordinance. In the event of Landowner's default as described above, the Municipality may refuse to issue any permit or grant any approval necessary to further improve or develop the subject site until such time as the terms of this Agreement are strictly met by Landowner. Moreover, final approval or further review may be denied or delayed until such time as the terms of this agreement are strictly met by Landowner.
7. Landowner and the Municipality further agree that all fees or costs arising out of this Agreement shall be paid prior to the issuance of any permit, occupancy or otherwise, for the use, improvement or construction of the buildings as proposed on the Landowner's plan. The Landowner agrees and acknowledges that no permit, occupancy or otherwise, or recordable plans, shall be released by the Municipality until all outstanding professional consultant fees and costs are paid to the Municipality, and provided that the Landowner is not in default under this agreement.
8. The Landowner may at any time terminate all further obligations under this Agreement by giving fifteen (15) days written notice to the Municipality that it does not desire to proceed with the development as set forth on the plan and upon receipt of such written notice by the Landowner to the Municipality, the Landowner shall be liable to the Municipality for its costs and expenses incurred to the date and time of its receipt of the notice, plus the applicable administrative costs and expenses as outlined in Paragraph 3 above.
9. The Landowner and the Municipality further agree that the Municipality shall have the right and privilege to sue the Landowner or then property owner in assumpsit for reimbursement or to lien the property or both, in its sole discretion, for any expense in excess of the then current balance of funds on deposit with the Municipality in accordance with this agreement incurred by the Municipality by reason of any review, supervision and inspection of Landowner's project by its professionals including, but not limited to, the Municipality Engineer and Solicitor. The Municipality's election of its remedies under this paragraph shall not constitute a waiver of any other remedies the Municipality may have.
10. The Landowner and the Municipality acknowledge that this agreement represents their full understanding as to the Municipality's reimbursement for professional or consultant services.

11. This agreement shall be binding on and insure to the benefit of the successors and assigns of Landowner. The Municipality shall receive thirty (30) days advance written notice from Landowner of any proposed assignment of Landowner's rights and responsibilities under this Agreement.

ATTEST:

WITNESS the following signatures and seals:

(SEAL)

For the Municipality:

____

For the Landowner:

____

Commonwealth of Pennsylvania
County of Crawford, Pennsylvania } ss:

On this, the __________ day of __________________, 20_____, before me the undersigned officer, personally appeared

____

know to me (or satisfactorily proven) to be the person whose name subscribed to the within instrument, and acknowledges that __________ executed the same for the purpose therein contained.

IN WITNESS WHEREOF, I have hereunto set my hand and seal.

My Commission Expires

____
Official Title

APPENDIX D – SMALL PROJECTS SWM APPLICATION

[OPTIONAL]

Crawford County
Small Project Stormwater Management Application

Per [municipality]'s Act 167 Stormwater Management Ordinance, a stormwater management plan is required whenever more than 2,500 square feet of impervious surface is proposed. Impervious surfaces are areas that prevent the infiltration of water into the ground and shall include, but not be limited to, roofs, patios, garages, storage sheds and similar structures, and any new streets or sidewalks.

To Calculate Impervious Surfaces Please Complete This Table					
Surface Type	**Length**	**X**	**Width**	**=**	**Proposed Impervious Area**
Building		x		=	
		x		=	
		x		=	
		x		=	
Driveway		x		=	
		x		=	
		x		=	
Parking Areas		x		=	
		x		=	
		x		=	
Patios/Walks		x		=	
		x		=	
		x		=	
		x		=	
Other		x		=	
		x		=	
		x		=	
Total Impervious Surface Area to be managed (sum of all areas)					

If the Total Impervious Surface Area is LESS THAN 2,500 Square Feet, read, acknowledge and sign below.

If the Total Impervious Surface Area is GREATER THAN 2,500 Square Feet, complete the remainder of the Application.

Based Upon the information you have provided a ***Stormwater Management Plan IS NOT required*** for this regulated activity. However, [municipality] may request additional reporting and/or management should public health or safety or property or the environment be threatened.

Property Owner Acknowledges that submission of inaccurate information may result in a stop work order or permit revocation. Acknowledgement of such is by signature below. I declare that I am the owner or owner's legal representative. I further acknowledge that the information provided is accurate and employees of [municipality] are granted access to the above described property for review and inspection as may be required.

______________________________ **Owner** **Date:** ______________

CREDITS

Credit 1: DISCONNECTION OF IMPERVIOUS AREA

When runoff from impervious areas is directed to a pervious area that allows for infiltration, filtration, and increased time of concentration, all or parts of the impervious areas may qualify as Disconnected Impervious Area (DIA). Using the criteria below, determine the portion of the impervious area that can be excluded from the calculation of total impervious area.

Criteria: An impervious area is considered to be completely or partially disconnected if it meets the requirements listed below

- rooftop area draining to a downspout is ≤500 sf
- paved area draining to a discharge is ≤1,000 sf
- flow path of paved impervious area is not more than 75'
- soil at discharge is not designated as hydrologic soil group "D"
- flow path at discharge area has a positive slope of ≤5%
- gravel strip or other spreading device is required at paved discharges.

Length of Pervious Flow Path from discharge point * (ft)	**DIA Credit Factor**
0 – 14	1.0
15 – 29	0.8
30 – 44	0.6
45 – 59	0.4
60 – 74	0.2
75 or more	0

* Flow path cannot include impervious surfaces and must be at least 15 feet from any impervious surfaces.

Calculate DIA Credit & Required Capture Volume									
Surface Type	**Proposed Impervious Area** (from previous sheet)	**X**	**DIA Credit Factor**	**=**	**Impervious Area to be managed**	**÷**		**=**	**Required Capture Volume (ft^3)**
Building (area per downspout)		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Driveway		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Parking Areas		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Patios/Walks		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Other		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
								Total Req'd Capture Volume	

Credit 2: TREE PLANTING

Perhaps the best BMP is a tree as they intercept rainfall, increase evapotranspiration and increase time of concentration. A portion of the required capture volume can be reduced provided the criteria are met.

CREDITS

Deciduous Trees	Evergreen Trees
6 ft^3 per tree planted	10 ft^3 per tree planted

Criteria

To receive credit for planting trees, the following must be met:

- Trees must be native species (see below), minimum 2" caliper and 6 feet tall (min).
- Trees shall be adequately protected during construction.
- Trees shall be maintained until redevelopment occurs.
- No more than 25% of the runoff volume can be mitigated through the use of trees.
- Dead trees shall be replaced within 6 months.
- Non-native species are not applicable.

		Req'd Capture Volume (ft^3)
-		**Tree Planting Credit (ft^3)**
		Capture Volume to be managed (ft^3)

Sizing of BMP

		How much of the Volume will you manage with a Rain Garden?
+		How much of the Volume will you manage with a Sump or Trench?
		Capture Volume to be managed (ft^3)

Enter the volumes into the **Small Project SWM Plan Worksheet** on the next sheet.

Native Species Trees (Common Name)

- Blackgum
- Arrow-wood, southern
- Box-elder
- Maple, (red or silver)
- Birch, (river or gray)
- Ironwood
- Hickory, sweet pignut or shag-bark
- Cedar, (Atlantic white or eastern red)
- Beech, American
- Ash, (white, black or green)
- Holly, American
- Tuliptree
- Sycamore, American
- Cotton-wood, eastern
- Aspen, big-tooth or quaking
- Cherry, black
- Oak, (white, swamp white, scarlet, pin, willow, red)
- Willow, black
- Bald Cypress
- Basswood, American
- Serviceberry, (downy or shadbush)
- Redbud, eastern
- Dogwood, flowering
- Magnolia, sweetbay
- Pine, (pitch or eastern white)

Small Project SWM Plan Worksheet

Based upon the information you have provided a ***Stormwater Plan IS Required*** for this development activity. The Stormwater Management Ordinance developed through the *Crawford County Act 167 Stormwater Management Plan* regulates compliance requirements for Stormwater Management in this jurisdiction. A complete copy of the *Plan* can be found on the Crawford County website.

Regulated activities shall be conducted only after [municipality] approves a stormwater management plan. The *Crawford County Act 167 Stormwater Management Plan* will assist you in preparing the necessary information and plans for [municipality] to review and approve. **This document will constitute an approved plan if all of the relevant details are to be installed in their entirety AND no part of the stormwater system adversely affects any other property, nor adversely affect any septic systems or drinking water wells on this, or any other, parcel.** If an alternative system is to be used a plan will need to be submitted to [municipality] for approval. A design by a qualified professional may be required for more complex sites.

PLEASE INITIAL BELOW TO INDICATE THE STORMWATER MANAGEMENT PLAN FOR THIS SITE

☐ Minimum Control #1 Erosion & Sediment Pollution Control (Elements 1-10)
Minimum Control #2: Source Control of Pollution
Minimum Control #3: Preservation of Natural Drainage Systems and Outfalls

☐ The relevant details from *Crawford County Act 167 Stormwater Management Plan* will be installed in their entirety AND the system will be located as not to adversely affect other property, nor any septic systems or drinking water wells on this, or any other, parcel.

To meet this requirement, the following will be installed and maintained:

Capture Volume to be managed (ft³)			Conversion	Surface Area of BMPs (ft²)
	By Rain Garden 6" ponding; 2' soil depth	x	1.20	
	Dry Well or Infiltration Trench 2½' aggregate depth	x	1.25	
	Total		Total	

☐ In lieu of meeting the above, an alternative and/or professional design is attached for approval AND the system will be located as not to adversely affect other property, any septic systems or drinking water wells on this, or any other, parcel.

☐ **Site Sketch Plan showing:**

- Property lines with dimensions
- Proposed buildings with dimensions
- Proposed impervious surfaces with dimensions
- Proposed septic system, if applicable
- Proposed well site, if applicable
- Proposed stormwater management system(s)

☐ **Operation and Maintenance Agreement**

Condition on approval - The stormwater management plan must be fully implemented prior to a request for final inspection of the building or zoning permit.

Acknowledgement - By executing below, the Owner acknowledges the following:

- I declare that I am the owner of the property.
- The information provided is accurate.
- I further acknowledge that municipal representatives are granted access to the above described property for review and inspection as may be required.

Owner ______________________________ **Date:** ______________

Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Draft Stormwater Management Facility Design Criteria

Crawford County
Act 167 County-Wide
Stormwater Management Plan

May 2010

474 Windmere Drive• State College, Pennsylvania 16801 • 814.238.7117 [phone]

Using The Crawford County Stormwater Management Facility Design Criteria

Municipal Requirements: This Stormwater Management Facility Design Criteria was developed during the *Crawford County Act 167 Stormwater Management Plan*. It is intended that this document work as a resource and technical guide for the *Crawford County Model Stormwater Management Ordinance* as refrenced in Section 601.B. The technical design criteria that are contained in this document is to allow modification from time to time based on new developments within the stormwater management**.** A committee will be established by the County to review the *Crawford County Stormwater Management Facility Design Criteria* and make recommendations for revisions as appropriate.

I. STORMWATER MANAGEMENT SITE PLANS & REPORTS

A. SWM Site Plan shall include, but not be limited to:

1. Plans shall be no greater than 24" by 36" and be of one size and in a form that meets the requirements for recording in the Office of the Recorder of Deeds of Crawford County.
   a. Scale:
      i. Plans for tracts of less than 20 acres: 1" = 50' or less;
      ii. Plans for tracts of 20 acres or more: no greater than 1" = 100';
   b. All lettering and details shall be drawn to a size to be legible if the plans are reduced to half size.

2. The name of the development; name and location address of the property site; name, address, and telephone number of the Applicant/Owner of the property; and name, address, telephone number, email address, and engineering seal of the individual preparing the SWM Site Plan.

3. The date of submission and dates of all revisions.

4. A graphical and written scale on all drawings and maps.

5. A north arrow on all drawings and maps.

6. A location map at a minimum scale of one (1) inch equals two-thousand (2,000) feet and illustrates the project relative to highways, municipalities or other identifiable landmarks.

7. Metes and bounds description of the entire tract perimeter.

8. Existing and final contours at intervals:

   a. Slopes less than 5%: no greater than one (1) foot;
   b. Slopes between 5 and 15%: no greater than two (2) feet;
   c. Steep slopes (greater than 15%), 5-foot contour intervals may be used.

9. Perimeters of existing waterbodies within the project area including stream banks, lakes, ponds, springs, field delineated wetlands or other bodies of water, sinkholes, flood hazard boundaries (FEMA delineated floodplains and floodways), areas of natural vegetation to be preserved, the total extent of the upstream area draining through the site, and overland drainage paths. In Addition, any areas necessary to determine downstream impacts, where required for proposed stormwater management facilities must be shown.

10. The location of all existing and proposed utilities, on-lot wastewater facilities, water supply wells, sanitary sewers, and water lines on and within fifty (50) feet of property lines including inlets, manholes, valves, meters, poles, chambers, junction boxes, and other utility system components.

11. A key map showing all existing man-made features beyond the property boundary that may be affected by the project.

12. Soil names and boundaries with identification of the Hydraulic Soil Group classification including rock outcroppings.

13. Proposed impervious surfaces (structures, roads, paved areas, and buildings), including plans and profiles of roads and paved areas and floor elevations of buildings.

14. Existing and proposed land use(s).

15. Horizontal alignment, vertical profiles, and cross sections of all open channels, pipes, swales and other BMPs.

16. The location and clear identification of the nature of permanent stormwater BMPs.
    a. Where infiltration BMP's are utilized, construction sequence shall be shown on the Plans.

17. The location of all erosion and sedimentation control facilities, shown on a separate from the SWM Site Plan (typically an E&S Plan).

18. A minimum twenty (20) foot wide access easement around all stormwater management facilities that would provide ingress to and egress from a public right-of-way. In lieu of providing an easement to the public right-of-way, a note may be added to the plan granting the Municipality or their designees access to all easements via the nearest public right-of-way.

19. Construction details for all drainage and stormwater BMPs.

20. Identification of short-term and long-term ownership, operations, and maintenance responsibilities.

21. Notes and Statements:
    a. A statement referencing the Operation and Maintenance (O&M) Agreement and stating that the O&M Agreement is part of the SWM Site Plan.
    b. A note indicating that Record Drawings will be provided for all stormwater facilities prior to occupancy, or the release of the surety bond.
    c. The following signature block for the Land Owner:

       "I, ______________________________, the Land Owner, Heirs and assigns acknowledge the Stormwater Management Plan is the be maintained in accordance with the Operation and Maintenance Agreement and shall remain a permanent fixture which cannot be altered or removed without approval by ***[Municipality]***."

    d. The following signature block for the registered professional preparing the Stormwater Management Plan:

       "I, ____________________________, hereby certify that the Stormwater Management Plan meets all design standards and criteria of the ***[Municipality's]*** Stormwater Management Ordinance."

    e. The following signature block for the Municipal Engineer reviewing the Stormwater Management Plan:

"I, ______________________________, have reviewed this Stormwater Management Plan in accordance with the Design Standards and Criteria of the ***[Municipality's]*** Stormwater Management Ordinance."

B. SWM Site Report shall include (but not limited to):

1. General data including:
   a. Project Name
   b. Project location - address of the property site
   c. Name, address, and telephone number of the Applicant/Owner of the property;
   d. Name, address, telephone number, email address, and engineering seal of the individual preparing the SWM Site Report;
   e. Date of submission and revisions.

2. Project description narrative that clearly discusses the project and provides the following information:
   a. Narrative
      - Statement of the regulated activity describing what is being proposed. Overall stormwater management concept with description of permanent stormwater management techniques, including construction specifications and materials to be used for stormwater management facilities.
      - Expected project schedule
      - Location map showing the project site and its location relative to release rate districts.
      - Detailed description of the existing site conditions including a site evaluation completed for projects proposed in areas of carbonate geology or karst topography, and other environmentally sensitive areas such as brownfields.
      - Total site area – pre and post, which must be equal or have an explanation as to why it is not
      - Total site impervious area
      - Total off-site areas
      - Number and description of stormwater management facilities
      - Type of development
      - Pre-development land use
      - Whether site is a Stormwater Hotspot development
      - Whether site is in a defined sensitive area
      - Types of water quality and recharge systems used, if applicable
      - Complete hydrologic, hydraulic, and structural computations for all stormwater management facilities.
      - A written maintenance plan for all stormwater features including detention facilities and other stormwater management elements.
      - Identification of ownership and maintenance responsibility for all permanent stormwater management facilities.
      - Other pertinent information, as required

   b. Summary Tables
      - Pre-development Hydrologic soil group (HSG) assumptions, curve numbers (CN), Computation of average slope, hydraulic length, computed time of concentration
      - Existing conditions runoff volume & peak rate of runoff
      - Post-development runoff volume & peak rate of runoff
      - Undetained areas, areas to ponds

- Land use for each subarea
- Hydrologic soil group (HSG) assumptions, curve numbers (CN)
- Time of concentration computed for each subarea
- Post-development peak rate of runoff routed to ponds and out
- Pond maximum return period design data including: maximum water surface elevation, berm elevation, and emergency spillway elevation
- Water quality depth and volume requirements

c. Calculations
   - Complete hydrologic, hydraulic and structural computations, calculations, assumptions, and criteria for the design of all stormwater BMPs.
   - Details of the berm embankment and outlet structure indicating the embankment top elevation, embankment side slopes, top width of embankment, emergency spillway elevation, perforated riser dimensions, pipe barrel dimensions and dimensions and spacing of antiseep collars.
   - Design computations for the control structures (pipe barrel and riser, etc).
   - A plot or table of the stage-storage (volume vs. elevation) and all supporting computations.
   - Routing computations.

d. Drawings
   - Drainage area maps for all watersheds and inlets depicting the time of concentration path for both existing conditions and post developed condition.
   - All stormwater management facilities must be located on a plan and described in detail including easements and buffers boundaries.

3. Reports that do not clearly indicate the above information may be rejected for review by the Municipality and will be returned to the applicant.

4. Description of, justification, and actual field results for infiltration testing with respect to the type of test and test location for the design of infiltration BMPs.

5. The effect of the project (in terms of runoff volumes, water quality, and peak flows) on surrounding properties and aquatic features and on any existing municipal stormwater collection system that may receive runoff from the project site.

6. Description of the proposed changes to the land surface and vegetative cover including the type and amount of impervious area to be added.

7. Identification of short-term and long-term ownership, operation, and maintenance responsibilities as well as schedules and costs for inspection and maintenance activities for each permanent stormwater or drainage BMP, including provisions for permanent access or maintenance easements.

C. Supplemental information to be provided prior to recording of the SWM Site Plan, as applicable:

1. Signed and executed Operations and Maintenance Agreement.
2. Signed and executed easements, as required for all on-site and off-site work.
3. An Erosion and Sedimentation Control Plan & approval letter from the Crawford County Conservation District.
4. A NPDES Permit.
5. Permits from PADEP and ACOE.

6. Geologic Assessment.
7. Soils investigation report, including boring logs, compaction requirements, and recommendations for construction of detention basins.
8. A Highway Occupancy Permit from PENNDOT when utilization of a PENNDOT storm drainage system is proposed or when proposed facilities would encroach onto a PENNDOT right-of-way.

II. FACILITY DESIGN CONSIDERATIONS

A. All stormwater management facilities shall meet the following design requirements:

1. No outlet structure from a stormwater management facility, or swale, shall discharge directly onto a Municipal or State roadway without approval.

2. The top, or toe, of any slope shall be located a minimum of 10 feet from any property line.

3. The minimum horizontal distance between any structure and any stormwater facility shall be 10 feet; this distance shall be increased to 25 feet for stormwater storage facilities. The lowest floor elevation of any structure constructed immediately adjacent to a detention basin or other stormwater facility shall be a minimum of 2 feet above the 100-year water surface elevation.

4. Stormwater management facility bottom (or surface of permanent pool) elevations must be greater than adjacent floodplain elevations (FEMA or HEC-RAS analysis). If no floodplain is defined, bottom elevations must be greater than existing ground elevations 50 feet from top of stream bank in the facilities' vicinity.

5. Basin outflow culverts discharging into floodplains must account for tailwater. Tailwater corresponding to the 100-year floodplain elevation must be used for all design storms, or the Applicant may elect to determine flood elevations of the adjacent watercourse for each design storm. The floodway is assumed to be 50 feet from top of stream bank in areas where a floodplain is not designated, or no other evidence is provided.

6. The invert of all stormwater management facilities and underground infiltration/storage facilities shall be located a minimum of 2 feet above the seasonal high groundwater table. The invert of stormwater facilities may be lowered if adequate sub-surface drainage is provided.

7. Whenever possible the side slopes and basin shape shall be amenable to the natural topography. Vertical side slopes and rectangular basins shall be avoided whenever possible.

8. Exterior slopes of compacted soil shall not exceed 3:1, and may be further reduced if the soil has unstable characteristics.

9. Interior slopes of the basin shall not exceed 3:1.

10. Unless specifically designed as a volume control facility, all stormwater management facilities shall have a minimum slope of 2% extending radially out from the principal outlet structure. Facilities designed as water quality / infiltration BMPs may have a bottom slope of zero.

11. Impervious low-flow channels are not permitted within stormwater management facilities.

12. Unless specifically designed as a Volume Control or water quality facility, all stormwater management facilities must empty over a period of time not less than 24 hours and not

more than 72 hours from the end of the facility's inflow hydrograph. Infiltration tests performed at the facility locations and proposed basin bottom depths, in accordance with the BMP Manual, must support time-to-empty calculations if infiltration is a factor.

13. Energy dissipators and/or level spreaders shall be installed at points where pipes or drainageways discharge to or from basins. Discharges to drainage swales shall be dissipated, or piped, to an acceptable point.

14. Landscaping and planting specifications must be provided for all stormwater management basins and be specific for each type of basin.

    a. Minimal maintenance, saturation tolerant vegetation must be provided in basins designed as water quality / infiltration BMPs.

15. A safety fence may be required, at the discretion of the Municipality, for any stormwater management facility. The fence shall be a minimum of 4 feet high, and of a material acceptable to the Municipality. A gate with a minimum opening of 10 feet shall be provided for maintenance access.

16. <u>Principal Outlet Structures</u>: The primary outlet structure shall be designed to pass all design storms (up to and including the 100-year event) without discharging through the emergency spillway. All principal outlet structures shall:
    a. Be constructed of reinforced concrete or an alternative material approved by the Municipal Engineer. When approved for use, all metal risers shall:
        i. Be suitably coated to prevent corrosion.
        ii. Have a concrete base attached with a watertight connection. The base shall be sufficient weight to prevent flotation of the riser.
        iii. Provide a trash rack or similar appurtenance to prevent debris from entering the riser.
        iv. Provide an anti-vortex device, consisting of a thin vertical plate normal to the basin berm.
    b. Provide trash racks to prevent clogging of primary outflow structure stages for all orifices equivalent to 12 inches or smaller in diameter.
    c. Provide outlet aprons and shall extend to the toe of the basin slope at a minimum.
    d. Where spillways will be used to control peak discharges in excess of the 10-year storm, the control weirs shall be constructed to withstand the pressures of impounded waters and convey flows at computed outlet velocities without erosion.

17. <u>Emergency Spillways</u>: Any stormwater management facility designed to store runoff shall provide an emergency spillway designed to convey the 100-year post-development peak rate flow with a blocked primary outlet structure. The emergency spillway shall be designed per the following requirements:
    a. The top of embankment elevation shall provide a minimum 1 foot of freeboard above the maximum water surface elevation. This is to be calculated when the spillway functions for the 100-year post-development inflow, with a blocked outlet structure.
    b. Avoid locating on fill areas, whenever possible.
    c. The spillway shall be armored to prevent erosion during the 100-year post-development flow, with a blocked primary outlet structure.
        i. Synthetic liners or riprap may be used, and calculations sufficient to support proposed armor must be provided. An earthen plug must be used to accurately control the spillway invert if riprap is the proposed

armoring material. Emergency spillway armor must extend up the sides of the spillway, and continue at full width to a minimum of 10 feet past the toe of slope.

d. Municipal Engineer may require the use of additional protection when slopes exceed 4:1 and spillway velocities might exceed NRCS standards for the particular soils involved.
e. Any underground stormwater management facility (pipe storage systems) must have a method to bypass flows higher than the required design (up to a 100-year post-development inflow) without structural failure, or causing downstream harm or safety risks.

18. Stormwater Management Basins: Design of stormwater management facilities having 3 feet or more of water depth (measured vertically from the lowest elevation in the facility to the crest of the emergency spillway) shall meet the following additional requirements:

    a. The maximum water depth within any stormwater management facility shall be no greater than 8 feet when functioning through the primary outlet structure.
    b. The top of embankment width shall be:
        i. For embankments up to 4', width shall be at least 6 feet;
        ii. For embankments between 4 and 6 feet, width shall be at least 8 feet;
        iii. For embankments over 6 feet, width shall be at least 10 feet.
    c. A 10 foot wide access to the basin bottom must be provided with a maximum longitudinal slope of 10%.
    d. Berms shall be constructed using soils that conform to the unified soil classification of CH, MH, CL or ML. Soils used shall be tested to determine its density analysis per ASTM 698. The embankments will be constructed in a maximum of 6 inch lifts. The lifts will each be compacted to a density at least 98% of it's the maximum dry density. Each layer of compacted fill shall be tested to determine its density per ASTM 2922 or ASTM 3017. One test per 50 cubic yards of material placed (at least one per layer) shall be performed by an Independent Testing Agency.
    e. A cutoff and key trench of impervious material shall be provided under all embankments 4 feet or greater in height. The cutoff trench shall run the entire length of the embankment and tie into undisturbed natural ground.
    f. Anti-seep collars, or a PADEP approved alternative, must be provided on all outflow culverts in accordance with the methodology contained in the latest edition of the PADEP E&S Manual. An increase in seepage length of 15 percent must be used in accordance with the requirements for permanent anti-seep collars.

19. Construction of Stormwater Management Facilities:

    a. Basins used for rate control only shall be installed prior to or concurrent with any earthmoving or land disturbances, which they will serve. The phasing of their construction shall be noted in the narrative and on the plan.
    b. Basins that include water quality or recharge components shall have those components installed in such a manner as to not disturb or diminish their effectiveness.
    c. Compaction test reports shall be kept on file at the site and be subject to review at all times with copies being forwarded to the Municipal Engineer upon request.
    d. Temporary and permanent grasses or stabilization measures shall be established on the sides and base of all earthen basins within 15 days of construction.

20. Exceptions to these requirements may be made at the discretion of the Municipality for BMPs that retain or detain water, but are of a much smaller scale than traditional stormwater management facilities.

B. Stormwater Carrying Facilities:

1. All storm sewer pipes, grass waterways, open channels, swales and other stormwater carrying facilities that service drainage areas within the site must be able to convey post-development runoff from the 10-year design storm.

2. Stormwater management facilities that convey off-site water through the site shall be designed to convey the 25-year storm event (or larger events, as determined by the Municipal Engineer).

3. All developments shall include provisions that allow for the overland conveyance and flow of the post-development 100-year storm event without damage to public or private property.

4. Storm Sewers:

   a. Storm sewers must be able to convey post-development runoff without surcharging inlets for the 10-year storm event.

   b. When connecting to an existing storm sewer system, the Applicant must demonstrate that the proposed system will not exacerbate any existing stormwater problems and that adequate downstream capacity exists.

   c. Inlets, manholes, pipes, and culverts shall be constructed in accordance with the specifications set forth in PENNDOT's Publication 408, and as detailed in the PENNDOT's Publication 72M - Standards for Roadway Construction (RC) or other detail approved by the Municipal Engineer. All material and construction details (inlets, manholes, pipe trenches, etc.), must be shown on the SWM Site Plan, and a note added that all construction must be in accordance with PENNDOT's Publication 408 and PENNDOT's Publication 72M, latest edition. A note shall be added to the plan stating that all frames, concrete top units, and grade adjustment rings shall be set in a bed of full mortar according to Publication 408.

   d. A minimum pipe size of eighteen (18) inches in diameter shall be used in all roadway systems (public or private) proposed for construction in the Municipality. Pipes shall be designed to provide a minimum velocity of 2-1/2 feet per second when flowing full, but in all cases, the slope shall be no less then 0.5%. Arch pipe of equivalent cross-sectional area may be substituted in lieu of circular pipe where cover or utility conflict conditions exist.

   e. All storm sewer pipes shall be laid to a minimum depth of 1 foot from subgrade to the crown of pipe.

   f. In curbed roadway sections, the maximum encroachment of water on the roadway pavement shall not exceed half of a through travel lane or one (1) inch less than the depth of curb during the ten (10) year design storm of five (5) minute duration. Gutter depth shall be verified by inlet capture/capacity calculations that account for road slope and opening area.

i. Inlets shall be placed at a maximum of 400 feet apart.

ii. Inlets shall be placed so drainage cannot cross intersections or street centerlines.

g. Standard Type "C" inlets with 8 inch hoods shall be used along curbed roadway networks. Type "C" inlets with 10 inch hoods that provide a 2 inch sump condition may be used with approval of the Municipal Engineer when roadway longitudinal slopes are 1.0% or less.

h. For inlets containing a change in pipe size, the elevation for the crown of the pipes shall be the same or the smaller pipe's crown shall be at a higher elevation.

i. All inlets shall provide a minimum 2 inch drop between the lowest inlet pipe invert elevation and the outlet pipe invert elevation.

j. On curbed sections, a double inlet shall be placed at the low point of sag vertical curves, or an inlet shall be placed on each side of the low point at a distance not to exceed 100 feet, or at an elevation not to exceed 0.2 feet above the low point.

k. At all roadway low points, swales and easements shall be provided behind the curb or swale and through adjacent properties to channelize and direct any overflow of stormwater runoff away from dwellings and structures.

l. All inlets in paved areas shall have heavy duty bicycle safe grating. A note to this effect shall be added to the SWM Site Plan or inlet details therein.

m. Inlets must be sized to accept the specified pipe sizes without knocking out any of the inlet corners. All pipes entering or exiting inlets shall be cut flush with the inside wall of the inlet. A note to this effect shall be added to the SWM Site Plan or inlet details therein.

n. Inlets shall have weep holes covered with geotextile fabric placed at appropriate elevations to completely drain the sub grade prior to placing the base and surface course on roadways.

o. Inlets, junction boxes, or manholes greater then five (5) feet in depth shall be equipped with ladder rungs and shall be detailed on the SWM Site Plan.

p. Accessible drainage structures shall be located on continuous storm sewer system at all vertical dislocations, at all locations where a transition in storm sewer pipe sizing is required, at all vertical and horizontal angle points exceeding 5 degrees, and at all points of convergence of 2 or more storm sewer pipes.

q. All storm drainage piping shall be provided with either end sections or reinforced concrete headwalls compatible with the pipe size involved at its entrance and discharge.

r. Outlet protection and energy dissipaters shall be provided at all surface discharge points in order to minimize erosion consistent with the E&S Manual.

i. Flow velocities and volumes from any storm sewer shall not result in a degradation of the receiving channel.

s. Stormwater roof drains and pipes shall not be connected to storm sewers or discharge onto impervious areas without approval by the Municipal Engineer.

5. Swale Conveyance Facilities:
   a. Swales must be able to convey post-development runoff from a 10-year design storm with 6 inches of freeboard to top of the swale.

   b. Swales shall have side slopes no steeper than 3:1.

   c. All swales shall be designed, labeled on the SWM Site Plan, and details provided to adequately construct and maintain the design dimension of the swales.

   d. Swales shall be designed for stability using velocity or shear criteria. Velocity criteria may be used for channels with less than 10% slope. Shear criteria may be used for all swales. Documentation must be provided to support velocity and/or shear limitations used in calculations.

   e. Where swale bends occur, the computed velocities or shear stresses shall be multiplied by the following factor for the purpose of designing swale erosion protection:

      i. 1.75 – When swale bend is 30 to 60 degrees
      ii. 2.00 – When swale bend is 60 to 90 degrees
      iii. 2.50 – When swale bend is 90 degrees or greater

   f. Manning's "n" values used for swale capacity design must reflect the permanent condition.

III. RECOMMENDED BEST MANAGEMENT PRACTICES

A. The preferred strategy for achieving Stormwater Management Goals is to reduce, or eliminate, the sources of non-point source pollution. "The treatment of runoff is not as effective as the removal of runoff needing treatment" (Reese, 2009). The following practices should be used where applicable to decrease the need for less cost effective structural BMP's. Refer to the Pennsylvania BMP Manual.

Non-Structural BMPs	**Stormwater Functions**			
	Peak Rate Control	**Volume Reduction**	**Recharge**	**Water Quality**
Protect Sensitive/Special Value Features	V. High	V. High	V. High	V. High
Protect/Conserve/Enhance Riparian Areas	Low/Med.	Medium	Medium	V. High
Protect/Utilize Natural Flow Pathways	Med./High	Low/Med.	Low	Medium
Cluster Uses – build on the smallest area possible	V. High	V. High	V. High	V. High
Concentrate Uses through Smart Growth	V. High	V. High	V. High	V. High
Minimize Disturbed Area	High	High	High	High
Minimize Soil Compaction in Disturbed Areas	High	V. High	V. High	V. High
Re-Vegetate and Re-Forest Disturbed Areas	Low/Med.	Low/Med.	Low/Med.	V. High
Reduce Street Imperviousness	V. High	V. High	V. High	Medium
Reduce Parking Imperviousness	V. High	V. High	V. High	High
Rooftop Disconnection	High	High	High	Low
Disconnection from Storm Sewers	High	High	High	Low
Streetsweeping	Low/None	Low/None	Low/None	High

B. When non-structural practices are unable to achieve the required standards, it may be necessary to employ structural practices. Structural BMPs are chosen to address specific stormwater functions as each Structural BMPs effectiveness varies. Refer to the Pennsylvania BMP Manual.

Structural BMPs	**Stormwater Functions**			
	Peak Rate Control	**Volume Reduction**	**Recharge**	**Water Quality**
Pervious Pavement with Infiltration Bed	Medium	Medium	Medium	Medium
Infiltration Basin	Med./High	High	High	High
Subsurface Infiltration Bed	Med./High	High	High	High
Infiltration Trench	Medium	Medium	High	High
Rain Garden / Bioretention	Low/Med.	Medium	Med./High	Med./High
Drywell / Seepage Pit	Medium	Medium	High	Medium
Constructed Filter	Low-High*	Low-High*	Low-High*	High
Vegetated Swale	Med./High	Low/Med.	Low/Med.	Med./High
Vegetated Filter Strip	Low	Low/Med.	Low/Med.	High
Infiltration Berm & Retentive Grading	Medium	Low/Med.	None	Medium
Vegetated Roof	Low	Med./High	None	Medium
Rooftop Runoff – Capture & Reuse	Low	Med./High	Low	Medium
Constructed Wetland	High	Low	Low	High
Wet Pond / Retention Basin	High	Low	Low	Medium
Dry Extended Detention Basin	High	Low	None	Low
Water Quality Filter	None	None	None	Medium
Riparian Buffer Restoration	Low/Med.	Medium	Medium	Med./High
Landscape Restoration	Low/Med.	Low/Med.	Low/Med.	V. High
Soil Amendment & Restoration	Medium	Low/Med.	Low/Med.	Medium

TABLE IV-1 - RATIONAL METHOD RUNOFF COEFFICIENTS

Hydraulic Soil Group	Storm	A			B			C			D		
Slope Range		0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%
Cultivated	<25yr	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
Land	≥25yr	0.14	0.08	0.22	0.16	0.21	0.28	0.2	0.25	0.34	0.24	0.29	0.41
Pasture	<25yr	0.12	0.2	0.3	0.18	0.28	0.37	0.24	0.34	0.44	0.3	0.4	0.5
	≥25yr	0.15	0.25	0.37	0.23	0.34	0.45	0.3	0.42	0.52	0.37	0.5	0.62
Meadow	<25yr	0.10	0.16	0.25	0.14	0.22	0.3	0.2	0.28	0.36	0.24	0.3	0.4
	≥25yr	0.14	0.22	0.3	0.2	0.28	0.37	0.26	0.35	0.44	0.3	0.4	0.5
Forest	<25yr	0.05	0.08	0.11	0.08	0.11	0.14	0.1	0.13	0.16	0.12	0.16	0.2
	≥25yr	0.08	0.11	0.14	0.1	0.14	0.18	0.12	0.16	0.2	0.15	0.2	0.25
Residential													
1/8 Acre	<25yr	0.25	0.28	0.31	0.27	0.3	0.35	0.3	0.33	0.38	0.33	0.36	0.42
	≥25yr	0.33	0.37	0.4	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
1/4 Acre	<25yr	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.3	0.34	0.4
	≥25yr	0.3	0.34	0.37	0.33	0.37	0.42	0.36	0.4	0.47	0.38	0.42	0.52
1/3 Acre	<25yr	0.19	0.23	0.26	0.22	0.26	0.3	0.25	0.29	0.34	0.28	0.32	0.39
	≥25yr	0.28	0.32	0.35	0.3	0.35	0.39	0.33	0.38	0.45	0.36	0.4	0.5
1/2 Acre	<25yr	0.16	0.2	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.3	0.37
	≥25yr	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
1 Acre	<25yr	0.14	0.19	0.22	0.17	0.21	0.26	0.2	0.25	0.31	0.24	0.29	0.35
	≥25yr	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.4	0.31	0.35	0.46
Industrial	<25yr	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.7
	≥25yr	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	<25yr	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	≥25yr	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.9	0.89	0.89	0.9
Streets	<25yr	0.7	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	≥25yr	0.76	0.77	0.79	0.8	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open Space	<25yr	0.05	0.1	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
	≥25yr	0.11	0.16	0.2	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking or	<25yr	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
Impervious	≥25yr	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

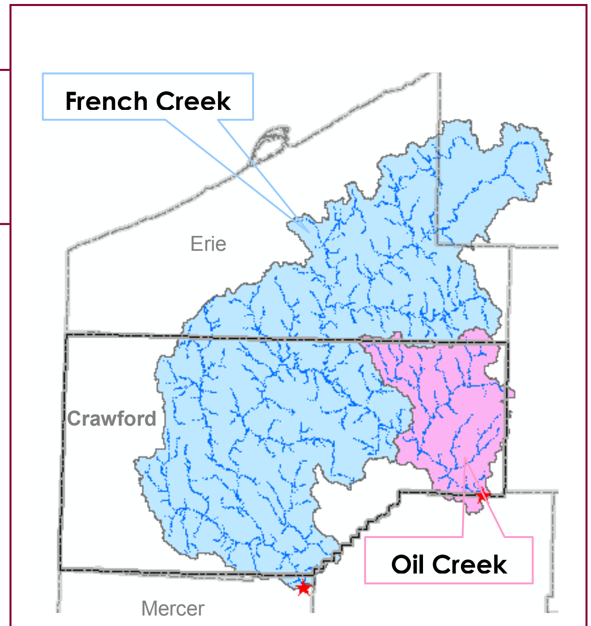
Source: Rawls, W.J., S.L. Long, and R.H. McCuen, 1981. Comparison of Urban Flood Frequency Procedures. Preliminary Draft Report prepared for the Soil Conservation Service, Beltsville, Maryland.

For simplification, a designer may use 0.3 for all pervious areas and 0.95 for all impervious areas.

TABLE IV-2 - RUNOFF CURVE NUMBERS (FROM NRCS (SCS) TR-55)

Runoff Curve Numbers for Urban Areas					
Cover Description		**Curve Numbers for Hydrologic Soil Groups**			
Cover Type and Hydrologic Condition	***Average Percent Impervious Area***	***A***	***B***	***C***	***D***
Fully Developed Urban Areas (Vegetation Established)					
Open Space (lawns, parks, golf courses, etc):					
Poor Condition (grass cover < 50%)		68	79	86	89
Fair Condition (grass cover 50% to 75%)		49	69	79	84
Good Condition (grass cover > 75%)		39	61	74	80
Impervious Areas:					
Paved Parking Lots, Roofs, Driveways, etc.		98	98	98	98
Streets and Roads:					
Paved: Curbed and Storm Sewers		98	98	98	98
Paved: Open Ditches		83	89	92	93
Gravel		76	85	89	91
Dirt		72	82	87	89
Urban Districts:					
Commercial and Business	85%	89	92	94	95
Industrial	72%	81	88	91	93
Residential Districts by Average Lot Size:					
1/8 Acres or less	65%	77	85	90	92
1/4 Acre	38%	61	75	83	87
1/3 Acre	30%	57	72	81	86
1/2 Acre	25%	54	70	80	85
1 Acre	20%	51	68	79	84
2 Acres	12%	46	65	77	82

Runoff Curve Numbers for Cultivated Agricultural Lands						
Cover Description			**Curve Numbers**			
Cover Type	***Treatment***	***Hydrologic Condition***	***A***	***B***	***C***	***D***
Fallow	Bare Soil	--	77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & Terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close Seeded or Broadcast Legumes Or Rotation Meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80
Runoff Curve Numbers for Other Agricultural Lands						
Pasture, Grassland, or Range – Continuous Forage for Grazing		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow – Continuous Grass, Protected from Grazing and Generally Mowed for Hay		--	30	58	71	78
Woods – Grass Combination (orchard or tree farm)		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmsteads – Buildings, Lanes, Driveways and Surrounding Lots.		--	59	74	82	86



Appendix A – Watershed Modeling Technical Data

An overview of the process that was used to complete the hydrologic modeling in preparation of this Plan is presented in *Section 6 – Technical Analysis* of this report. The following technical data is included here to supplement the general information provided in that section.

DATA COLLECTION

The GIS data for the hydrologic models was compiled from a variety of sources by county, state, and federal agencies. The data was collected in and processed using GIS software. A description of GIS data collected, the source and its use is provided in *Table A.1*.

Data	Source	Use
10-m Digital Elevation Model (DEMs)	USGS (2008a)	Watershed delineation, length, basin slope, stream slope, average elevation
High Resolution Streamlines	USGS (2008b)	Watershed delineation, cartography, spatial orientation
National Land Cover Dataset – Land Use 2001	USGS (2008c)	Curve number generation for watershed subareas for year 2010
Future Land Use digitized from 2000 Comprehensive Plan	Crawford County (2000)	Curve number generation for watershed subareas for year 2020
SURRGO Soils Data	NRCS (2008)	Curve number generation; analysis of infiltration limitations
Storage (percent of lakes, ponds, and wetlands)	USGS (2008d)	Calculation of parameters for USGS Regression Equations
Roadway Data	PennDOT (2009)	Cartography, spatial orientation

Table A.1. GIS Data Used in Act 167 Technical Analysis

HYDROLOGIC MODEL PARAMETER DATA

SOILS, LAND USE, AND CURVE NUMBERS

The determination of curve numbers is a function of soil type and land use. The hydrologic soil groups were defined by NRCS (2008). The 2001 NLCD was simplified to provide an estimate of curve numbers using the scheme shown in *Table A.2*.

GIS Value	NLCD (2001) Description	NRCS (1986) Description	A	B	C	D
Existing Conditions						
11	Open Water	Water	98	98	98	98
21	Developed, Open Space	Open space - Good Condition	39	61	74	80
22	Developed, Low Intensity	Residential - 1 acre	51	68	79	84
23	Developed, Medium Intensity	Residential - 1/2 acre	54	70	80	85
24	Developed, High Intensity	Commercial and Business	89	92	94	95
31	Barren Land (Rock/Sand/Clay)	Newly graded areas	77	86	91	94
41	Deciduous Forest	Woods - Good Condition	30	55	70	77
42	Evergreen Forest	Woods - Good Condition	30	55	70	77
43	Mixed Forest	Woods - Good Condition	30	55	70	77
52	Shrub/Scrub	Brush - Good Condition	30	48	65	73
71	Grassland/Herbaceous	Meadow - Good Condition	30	58	71	78
81	Pasture/Hay	Pasture - Good Condition	39	61	74	80
82	Cultivated Crops	Contoured Row Crops - Good Condition	65	75	82	86
90	Woody Wetlands	Woods - Good Condition	30	55	70	77
95	Emergent Herbaceous Wetlands	Water	98	98	98	98
Future Conditions						
800	Residential	Residential - 1/2 acre	54	70	80	85
801	Industrial	Industrial	81	88	91	93
802	Commercial	Commercial and Business	89	92	94	95
803	Urban	Commercial and Business	89	92	94	95
804	Urban Fringe	Residential - 1 acre	51	68	79	84
805	Village	Residential - 1/2 acre	54	70	80	85

Table A.2. Curve Number Determination for Crawford County

The curve numbers presented in the above tables represent "average" antecedent runoff condition (i.e. ARC = 2). In a significant hydrologic event, runoff is often influenced by external factors such as extremely dry antecedent runoff conditions (ARC=1) or wet antecedent runoff conditions (ARC=3). The antecedent runoff conditions of the above curve numbers were altered during the calibration process so that model results are within a reasonable range of other hydrologic estimates.

HYDROLOGIC MODEL PREPARATION

Two watersheds within the county were selected for hydrologic modeling: Oil Creek and French Creek. These watersheds were delineated into subwatersheds based on problem areas, significant obstructions, and natural subwatershed divides. The delineation of these subwatershed areas created points of interest at junctions where the subwatersheds were hydraulically connected in the HEC-HMS model.

OIL CREEK MODEL

The Oil Creek watershed has a drainage area of 176.5 square miles and was divided into 99 subwatersheds for the HEC-HMS model. Figure A.1 shows the Oil Creek subwatersheds and cumulative discharge points.

This watershed contains two dams that were considered to have a significant enough impact on the hydrology of the watershed. For this study, dams with small storage volumes (less than 100 acre-feet) and dams that would be completely filled during minor runoff events (0.3 inches of runoff) were generally considered "run-of-the-river dams" that only affect the immediate area near the dam. Their impacts to the overall watershed hydrology within Crawford County are negligible and were not included in this study.

Clear Lake Dam and Lake Canadohta are located in Crawford County. The tributary drainage area to these dams is relatively small (12.8 mi^2 and 7.8 mi^2, respectively) compared to the total drainage area of Oil Creek located within Crawford County. Outflow data for Clear Lake Dam was provided by DEP in the form of archived design files. Outflow data for Lake Canadohta was developed after a field investigation of the outlet structure. This information was used to model the flows from the dam within the HEC-HMS model. The following table summarizes the impoundments within the watershed.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
Clear Lake Dam	East Branch Oil Creek	Spartansburg Borough	Platt and Steadman	497
Lake Canadohta	Oil Creek	Bloomfield Twp.	Canadohta Lake Authority	190

Table A.3. Impoundments within the Oil Creek Watershed

FRENCH CREEK MODEL

The French Creek watershed has a total drainage area of 999 square miles. A large portion (about 464 mi^2) of this watershed lies within Erie County and parts of New York. The watershed was divided into eight subwatersheds which total 475 subbasins for the HEC-HMS model as depicted in Table A.4. French Creek "D", French Creek "C", and South Branch French Creek were not explicitly included in this plan but can be viewed in the Erie County Act 167 Plan. Figure A.2 through Figure A.7 illustrates the French Creek subwatersheds and cumulative discharge points.

Subwatershed	Drainage Area (mi^2)
French Creek "D"	223
South Branch French Creek	81
French Creek "C"	115
Muddy Creek	75
French Creek "B"	134
Cussewago Creek	98
Conneaut Outlet	101
French Creek "A"	172

Table A.4. French Creek Subwatersheds

For data management purposes, French Creek was broken into eight interconnected HEC-HMS Models. *Diagram A.1* depicts how the HEC-HMS Model was divided for the French Creek Watershed within Crawford County. *Figure A.2* shows the physical delineation of the model.

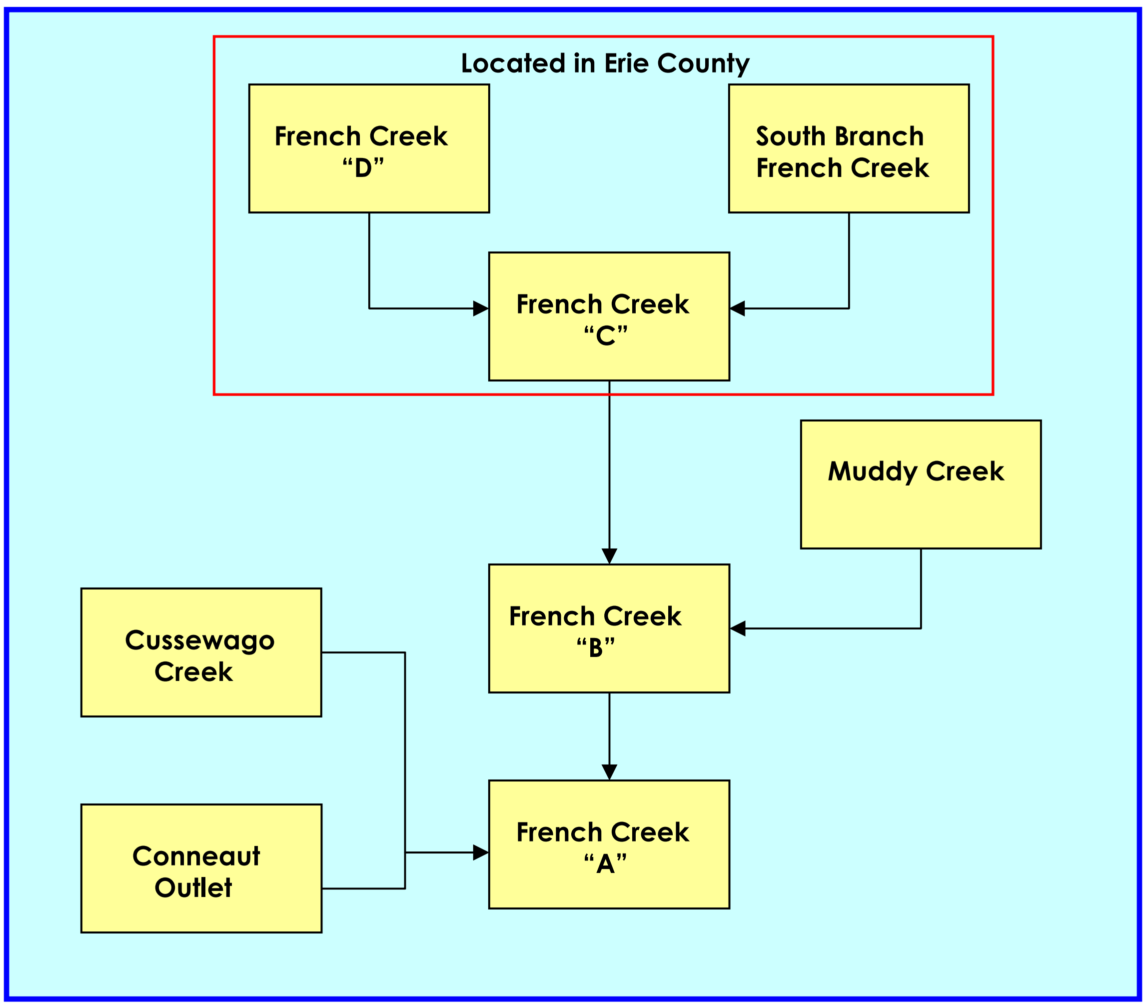


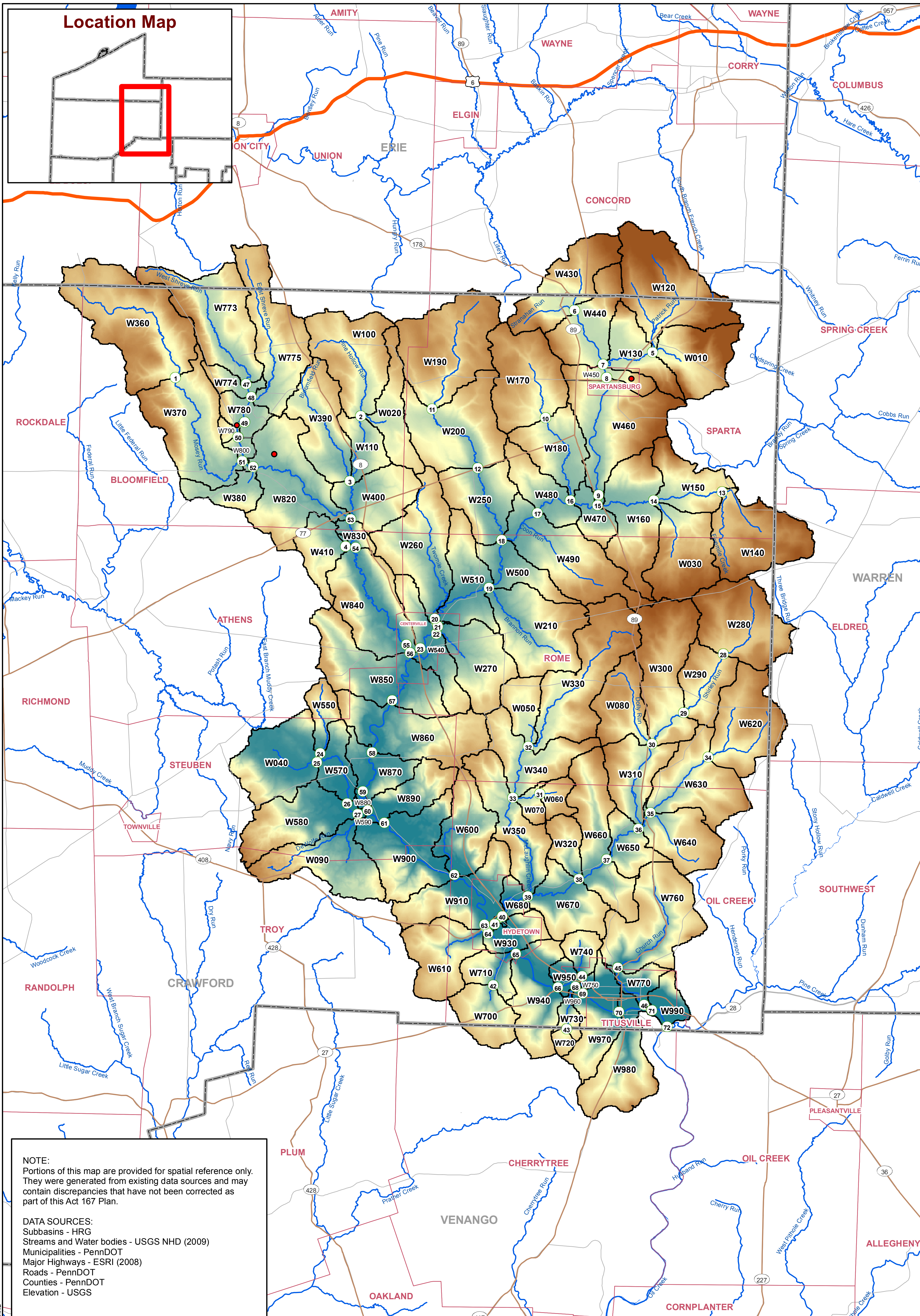
Diagram A.1. Interconnected HEC-HMS Model for French Creek

This watershed contains thirteen dams that were considered to have a significant enough impact on the hydrology of the watershed. As with Oil Creek, "run-of-the-river dam" criteria for deciding whether or not a dam would be included was used for French Creek.

The following table summarizes the impoundments within the watershed that were included in this model.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
Unnamed Dam	Conneaut Outlet	Greenwood	PA. Fish Commission	2,762
PA 461 Dam B	Mud Run	Fairfield	PA Fish Commission	2,347
PA 461 Dam A	Mill Run	West Meade	PA Fish Commission	2,347
PA 460 Dam	Mill Run	City Meadville	City of Meadville	469
Unnamed Dam	West Branch Little Sugar Creek	Randolph	PA Game Commission	613
Custards Dam	Conneaut Marsh Outlet	Union	PA Game Commission	1,227
Upper Dam	Crooked Creek	East Fallowfield	PA Game Commission	1,037
Grahamville Reservoir	East Branch Sixteenmile Creek	North East	Boro. of North East	184
Water Supply Dam	Bentley Run	Union	Boro. of Union County	306
Edinboro Lake	Conneauttee Creek	Washington	Boro. of Edinboro	2,461
Bull Reservoir	Black Brook	Greenfield	Boro. of North East	2,363
Union City Dam	French Creek	Waterford	U.S. Army Eng. Pittsburgh Dist.	47,662
Woodcock Creek Dam	Woodcock Creek	Meadville	CELRP	31,540

Table A.5. Impoundments within the French Creek Watershed



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Subbasins - HRG
Streams and Water bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI (2008)
Roads - PennDOT
Counties - PennDOT
Elevation - USGS

2 0 2 Miles

Discharge Points
USGS Gauges
Streams
Water Bodies
Limited Access
Highway
Major Road
Local Road
Dams
HEC-HMS Subbasins
Municipalities
Counties

Elevation
High : 1910 Feet
Low : 1150 Feet

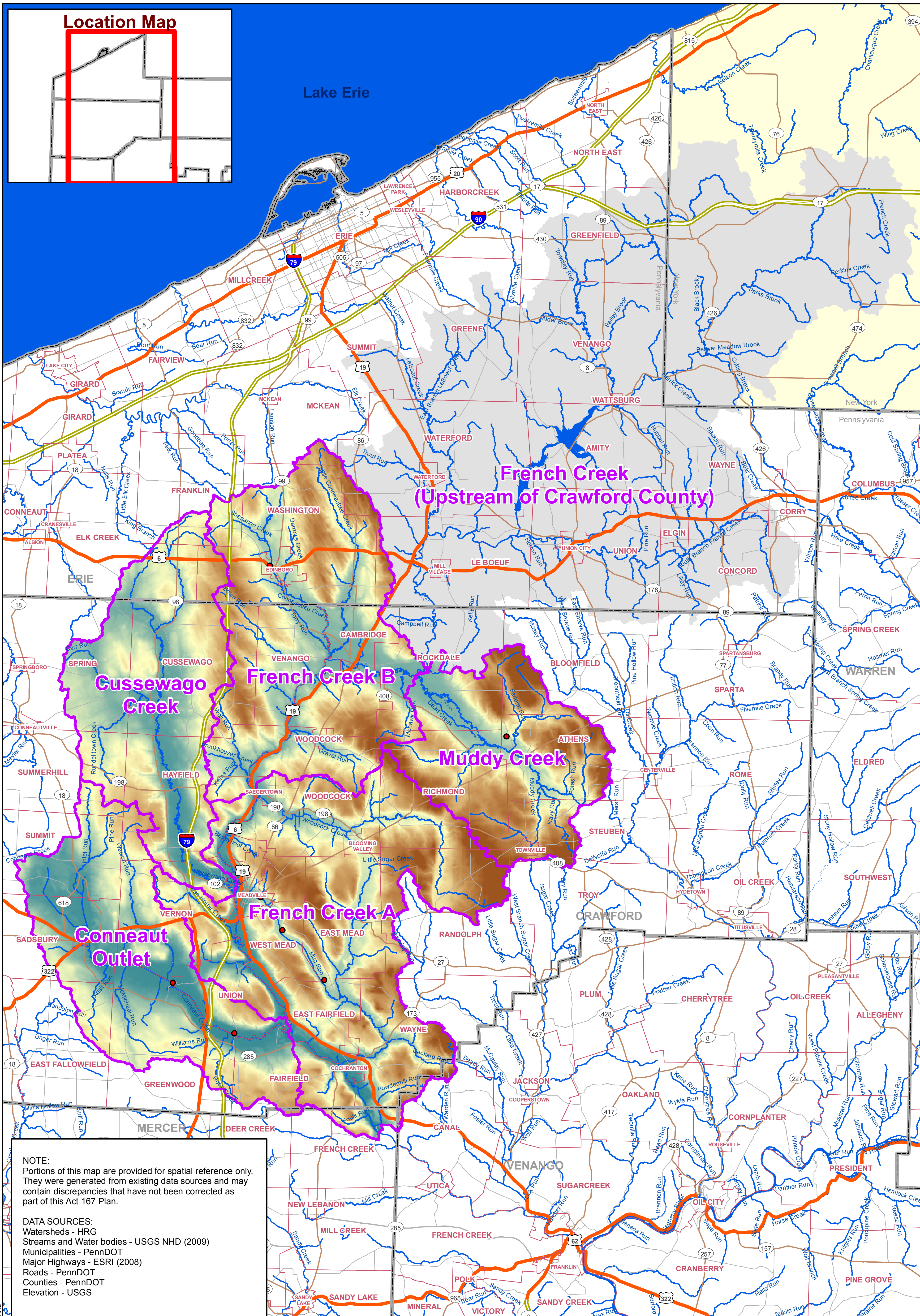
04/14/2010 | R004384.0426

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services
474 Windmere Drive
Suite 100
State College, PA 16801
814.238.7117
Fax 814.238.7126
www.hrg-inc.com
Offices Statewide

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure A.1
Oil Creek HEC-HMS Model
Crawford County, Pennsylvania

W:\43\43840\0426\Projects\Figures\Figure A_1.mxd



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Watersheds - HRG
Streams and Water bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI (2008)
Roads - PennDOT
Counties - PennDOT
Elevation - USGS

2 0 2 Miles

Dams
USGS Gauges
Streams
Water Bodies
Limited Access
Highway
Major Road
Local Road
Watershed Boundary
Municipalities
Counties
Elevation
High : 1740 Feet
Low : 1020 Feet

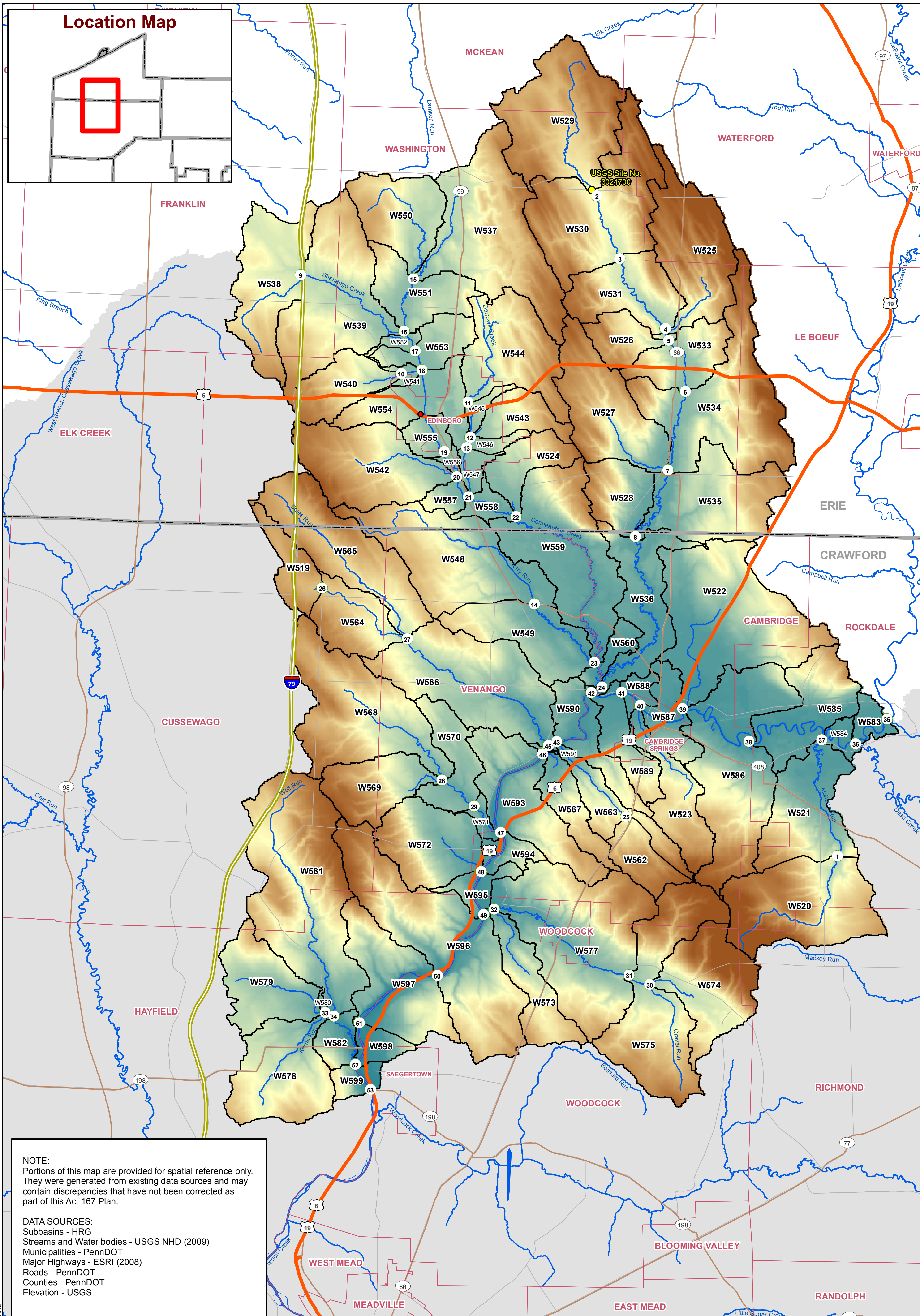
04/14/2010 | R004384.0426

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services
474 Windmere Drive
Suite 100
State College, PA 16801
814.238.7117
Fax 814.238.7126
www.hrg-inc.com
Offices Statewide

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure A.2
French Creek HEC-HMS Models
Crawford County, Pennsylvania

W:\4384\438410426\Projects\Figures\Figure A_2.mxd



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Subbasins - HRG
Streams and Water bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI (2008)
Roads - PennDOT
Counties - PennDOT
Elevation - USGS

1.5 0 1.5 Miles

Discharge Points	Dams
USGS Gauges	HEC-HMS Subbasins
Streams	Municipalities
Water Bodies	Counties
Limited Access	**Elevation**
Highway	High : 1620 Feet
Major Roads	
Local Road	Low : 1090 Feet

04/14/2010 R004384.0426

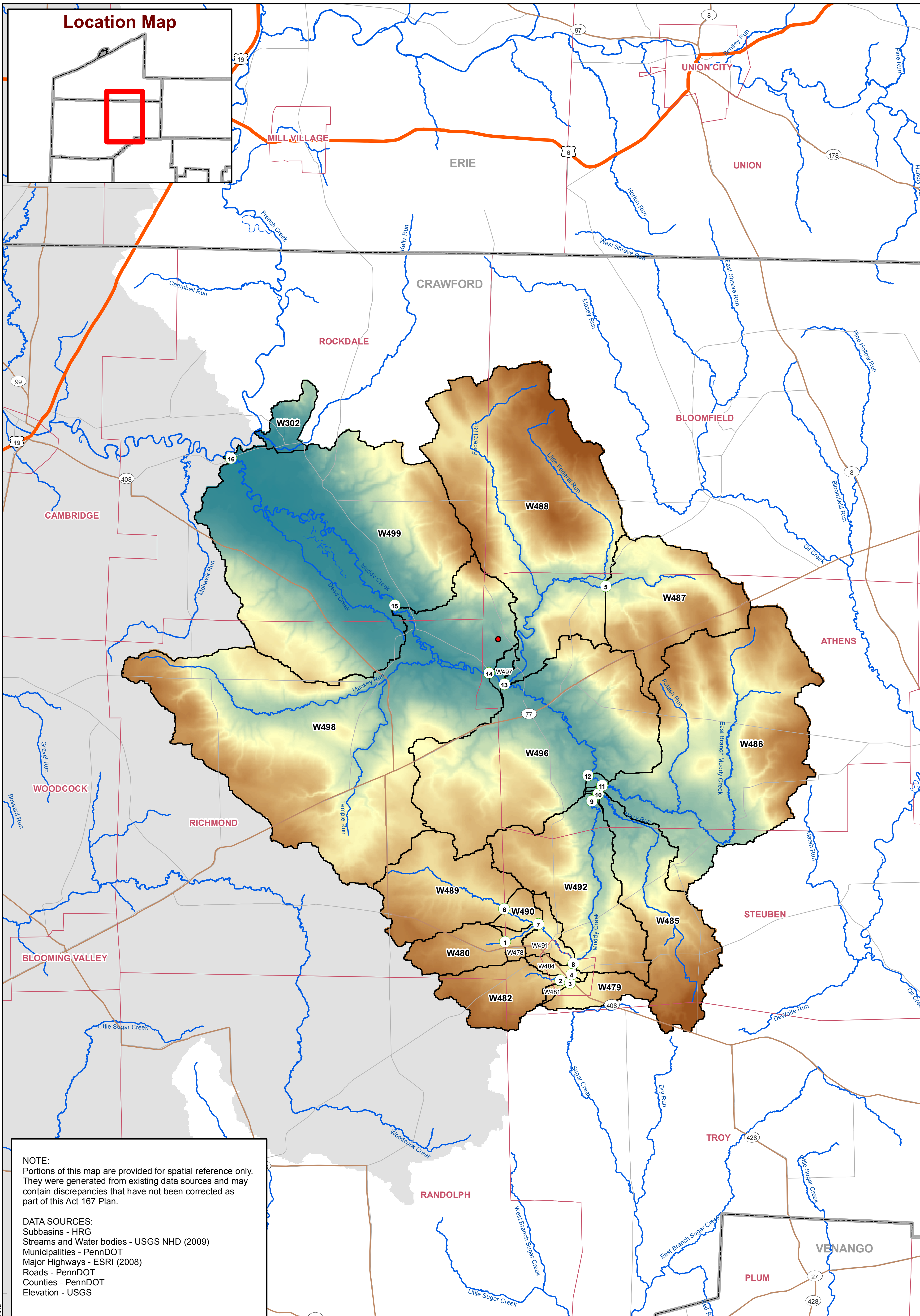
HRG Herbert, Rowland & Grubic, Inc. Engineering & Related Services

474 Windmere Drive
Suite 100
State College, PA 16801
814.238.7117
Fax 814.238.7126
www.hrg-inc.com
Offices Statewide

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure A.3
French Creek B HEC-HMS Model
Crawford County, Pennsylvania

W:\4384\438440426\Projects\Figures\Figure A_3.mxd



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Subbasins - HRG
Streams and Water bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI (2008)
Roads - PennDOT
Counties - PennDOT
Elevation - USGS

1.5 0 1.5 Miles

Discharge Points
USGS Gauges
Streams
Water Bodies
Limited Access
Highway
Major Road
Local Road
Dams
HEC-HMS Subbasins
Municipalities
Counties
Elevation
High : 1740 Feet
Low : 1110 Feet

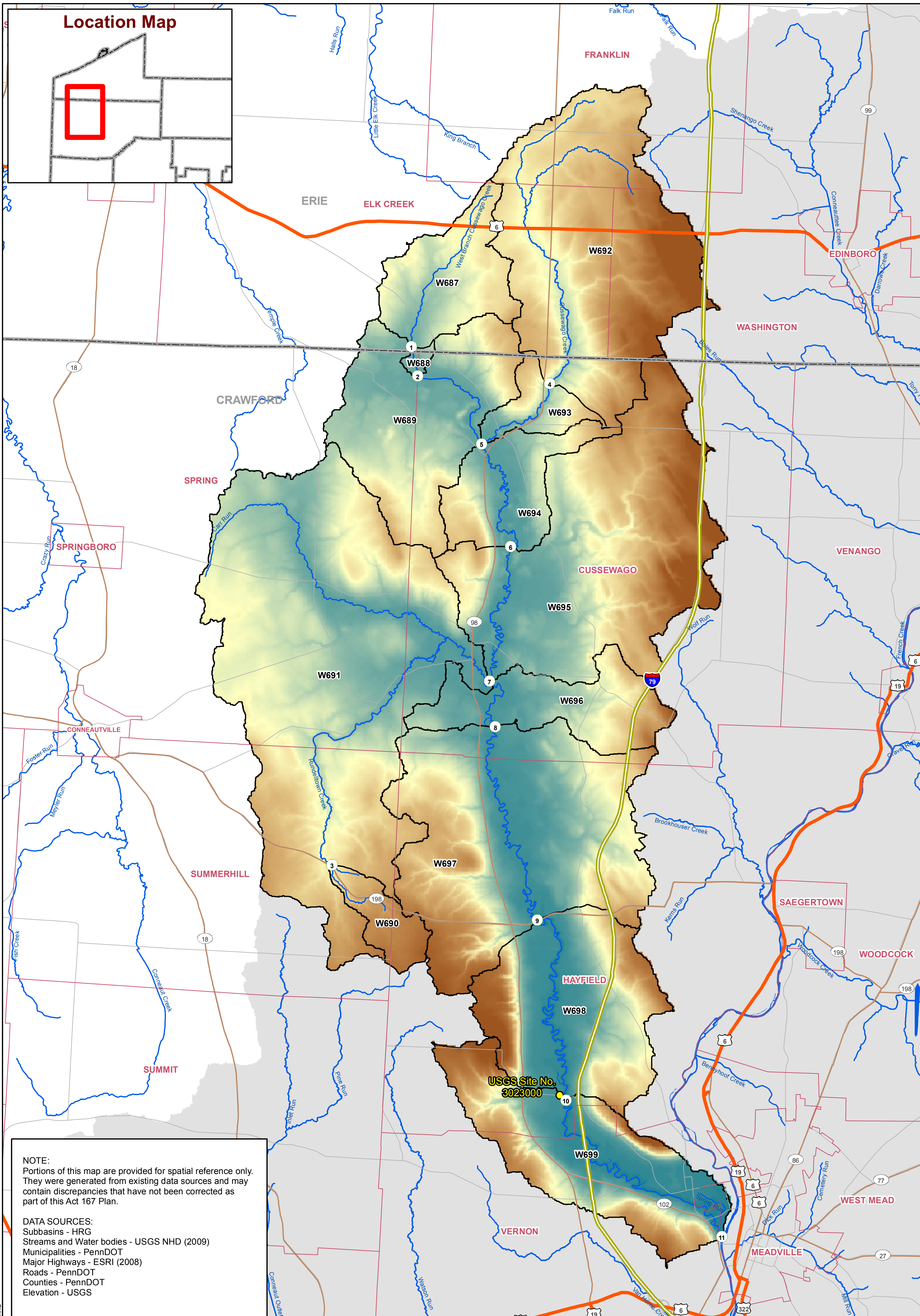
04/14/2010 R004384.0426

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services
474 Windmere Drive
Suite 100
State College, PA 16801
814.238.7117
Fax 814.238.7126
www.hrg-inc.com
Offices Statewide

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure A.4
Muddy Creek HEC-HMS Model
Crawford County, Pennsylvania

W:\4384\0426\Projects\Figures\Figure A_4.mxd



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Subbasins - HRG
Streams and Water bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI (2008)
Roads - PennDOT
Counties - PennDOT
Elevation - USGS

1.5 0 1.5 Miles

04/14/2010 R004384.0426

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services
474 Windmere Drive
Suite 100
State College, PA 16801
814.238.7117
Fax 814.238.7126
www.hrg-inc.com
Offices Statewide

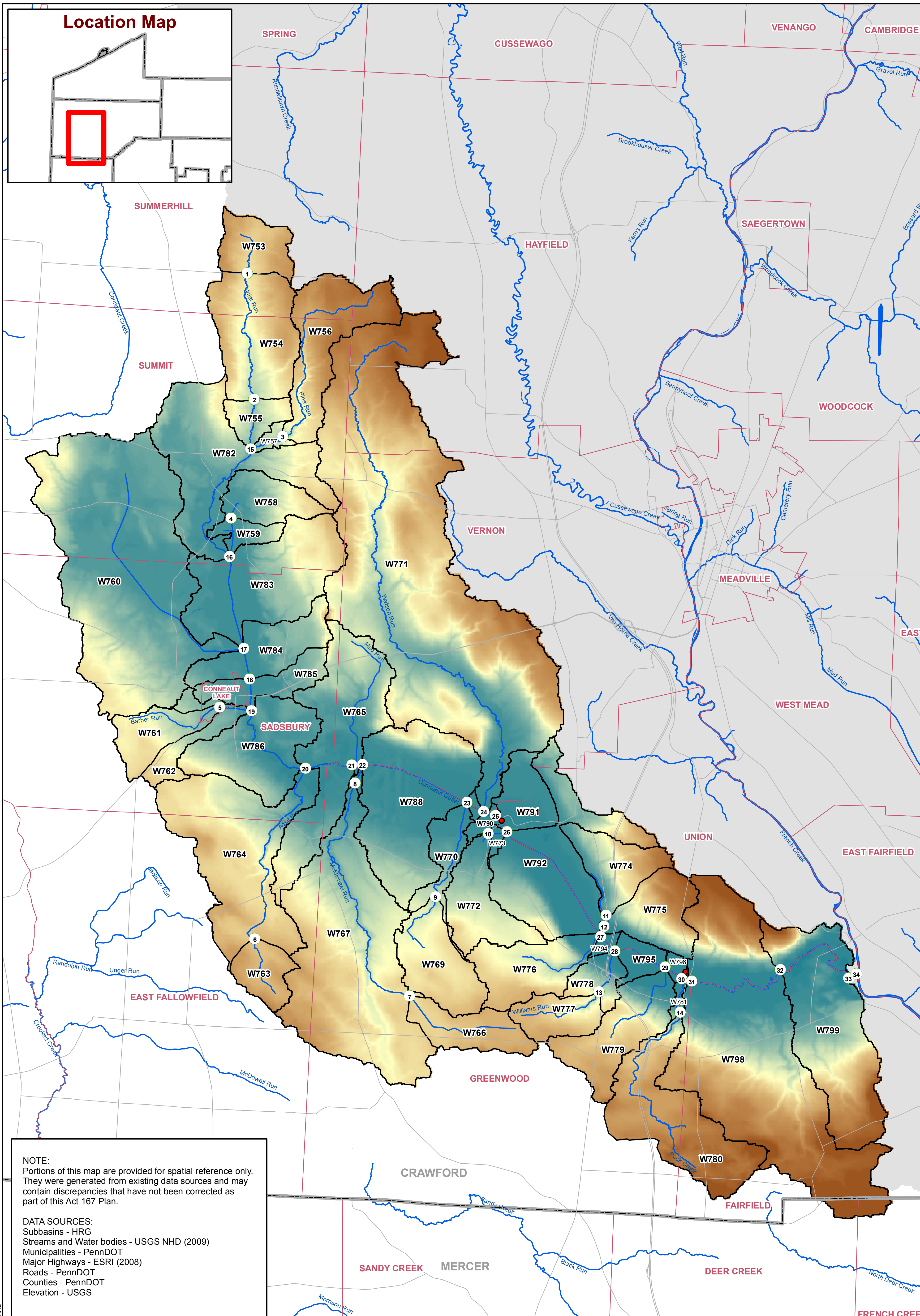
Discharge Points
Dams
USGS Gauges
HEC-HMS Subbasins
Streams
Municipalities
Water Bodies
Counties
Limited Access
Highway
Major Road
Local Road

Elevation
High : 1540 Feet
Low : 1060 Feet

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure A.5
Cussewago Creek HEC-HMS Model
Crawford County, Pennsylvania

W:\4384\438410426\Projects\Figures\Figure A_5.mxd



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Subbasins - HRG
Streams and Water bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI (2008)
Roads - PennDOT
Counties - PennDOT
Elevation - USGS

1.5 0 1.5 Miles

- Discharge Points
- Dams
- USGS Gauges
- HEC-HMS Subbasins
- Streams
- Municipalities
- Water Bodies
- Counties
- Limited Access
- Highway
- Major Road
- Local Road

Elevation
High : 1520 Feet
Low : 1040 Feet

04/14/2010 R004384.0426

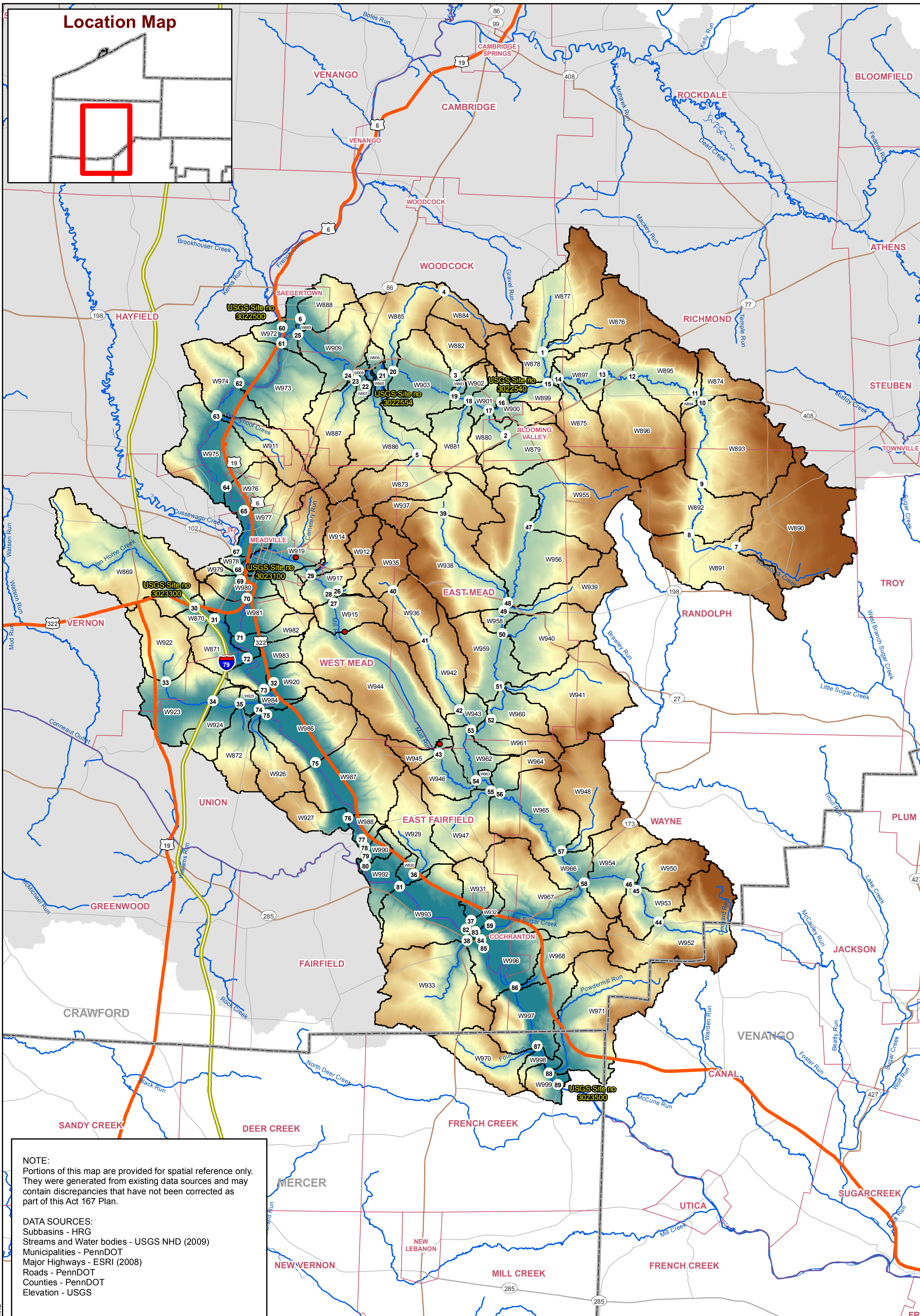
HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

474 Windmere Drive
Suite 100
State College, PA 16801
814.238.7117
Fax 814.238.7126
www.hrg-inc.com
Offices Statewide

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure A.6
Conneaut Outlet HEC-HMS Model
Crawford County, Pennsylvania

W:\4384\0426\Projects\Figures\Figure A_6.mxd



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Subbasins - HRG
Streams and Water bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI (2008)
Roads - PennDOT
Counties - PennDOT
Elevation - USGS

2 0 2 Miles

Discharge Points	Dams
USGS Gauges	HEC-HMS Subbasins
Streams	Municipalities
Water Bodies	Counties
Limited Access	**Elevation**
Highway	High : 1730 Feet
Major Road	
Local Road	Low : 1020 Feet

04/14/2010 R004384.0426

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services
474 Windmere Drive
Suite 100
State College, PA 16801
814.238.7117
Fax 814.238.7126
www.hrg-inc.com
Offices Statewide

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure A.7
French Creek A HEC-HMS Model
Crawford County, Pennsylvania

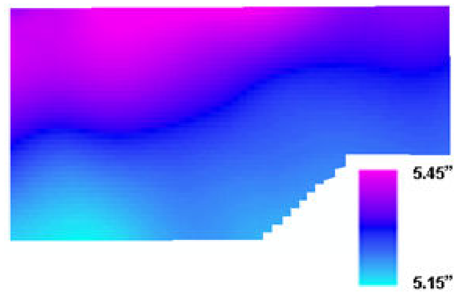
W:\43\43840\0426\Projects\Figures\Figure A_7.mxd

HYDROLOGIC MODEL PARAMETERS

The various parameters entered into the hydrologic models include subwatershed area, soil-type, land cover, lag time, reach lengths and slopes, reach cross sectional dimensions, and design rainfall depths. A brief description of these components follows.

RAINFALL DATA

Rainfall data used in this modeling effort incorporates rainfall runoff data from the NOAA Atlas 14. NOAA Atlas 14 provides the most up to date precipitation frequency estimates, with associated confidence limits, for the United States and is accompanied by additional information such as temporal distributions and seasonality. The following table provides the rainfall estimates used for various design storm frequencies for Crawford County (NOAA, 2008):



NOAA Atlas 14 100-year, 24-hour Rainfall

Design Storm (years)	County Average Design Depth (in)	Muddy Creek 24-hr Rainfall Depth (in)	French Creek "B" 24-hr Rainfall Depth (in)	Cussewago Creek 24-hr Rainfall Depth (in)	Conneaut Outlet 24-hr Rainfall Depth (in)	French Creek "A" 24-hr Rainfall Depth (in)
2	2.49	2.49	2.53	2.52	2.47	2.48
10	3.50	3.51	3.59	3.57	3.48	3.49
25	4.14	4.16	4.27	4.25	4.12	4.13
50	4.67	4.70	4.83	4.80	4.65	4.65
100	5.23	5.27	5.42	5.39	5.20	5.21

Table A.6. Rainfall Values for Crawford County

It was assumed in all of the following analyses that these single rainfall quantities could be applied uniformly over the entire subwatershed area. Additionally, the rainfall quantities were applied to the NRCS Type II storm distribution. Although this combination of Atlas 14 data with the NRCS Type II storm distribution results in a relatively conservative rainfall pattern, this approach is consistent with the guidelines in *PA Stormwater BMP Manual (2006)*.

SUBWATERSHED AREA

Generally, the subwatershed area for the modeled watersheds was 3-5 mi^2. The drainage areas may be slightly larger or smaller depending on hydrologic characteristics and location of problem areas. Subwatersheds with an area less than one (1) square mile were included in the model if they formed a junction between two larger basins or were tributary to a defined problem area.

Basins with drainage area outside of the scope of this Plan (i.e., the Act 167 designated watersheds of Oil and French Creek) were beyond the scope of study so they were not studied at the same level of detail as portions of the watershed within the scope of this Plan. Generally, they were delineated into areas between 20 and 25 mi^2 and were assumed to have only negligible changes in hydrology due to future land use. This generalized approach includes the Act 167 designated watersheds of Conneaut Outlet, Muddy Run, Cussewago Creek, and portion of the French Creek watershed located outside of Pennsylvania.

SOILS

Soil properties, specifically infiltration rate and subsurface permeability, are an important factor in runoff estimates. Runoff potential of different soils can vary considerably. Soils are classified into four Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate (*NRCS 1986*). HSG A refers to soils with relatively high permeability and favorable drainage characteristics; HSG D soils have relatively low permeability and poor drainage characteristics. The runoff potential increases dramatically in order of group A (lowest), B, C, and D (highest). Soil cover data was used in conjunction with land use cover data within GIS to develop composite curve numbers for each subwatershed in the models.

In Section III, Table 3.4 shows the relative percentage of hydrologic soil groups in Crawford County. Generally, the runoff potential of soils in the northwestern portion of the county is very high; the location of these soil types corresponds to the location of many of the counties' identified problem areas.

LAND USE

Existing land use was derived from the National Land Cover Dataset (USGS, 2008) and are listed within tables in Section 6. This data was converted to land uses that correspond to NRCS curve number tables (NRCS, 1986). The land use categories that were used are listed in *Table A.2*.

LAG TIME

Lag time is the transform routine when using the NRCS Curve Number Runoff Method. Lag can be related to time of concentration using the empirical relation:

$$T_{Lag} = 0.6 * T_C$$

Lag time values for the subwatersheds were based on NRCS Lag Equation and altered as depicted in the tables at the end of this section:

$$T_{Lag} = L^{0.8} \frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where: T_{lag} = Lag time (hours)

L = Hydraulic length of watershed (feet)

Y = Average overland slope of watershed (percent)

S = Maximum retention in watershed as defined by: S = [(1000/CN) – 10]

CN = Curve Number (as defined by the NRCS Rainfall-Runoff Method)

For comparison purposes, a lag time was also calculated for each subwatershed using the TR-55 segmental method. Given the rural landscape of Crawford County, the best estimate for time of concentration calculation was provided by the NRCS lag equation.

REACH LENGTHS, SLOPES, AND CROSS SECTION DIMENSIONS

Reach lengths and slopes were determined within GIS. Channel baseflow widths and depths for each river reach were estimated based on drainage area and percent carbonate using the methodology outlined in *Development of Regional Curves Relating Bankfull-Channel Geometry and Discharge to Drainage Area for Streams in Pennsylvania and Selected Areas of Maryland*

(USGS, 2005). Dimensions for the overbank area were visually determined from FEMA floodplains or visual inspection of topographic data. *Figure A.8* shows the dimensions as they are approximated.

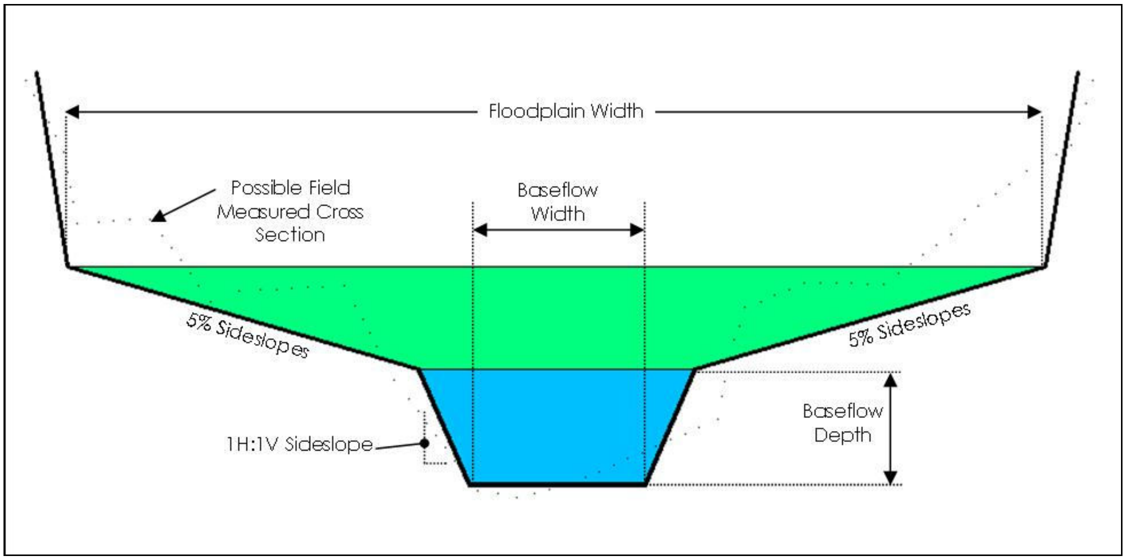


Figure A.8. Cross Sections Used for Reaches in HEC-HMS Model

The reaches were modeled using the Muskingum-Cunge routing procedure. This procedure is based on the continuity equation and the diffusion form of the momentum equation. Manning's Roughness Coefficient *n* values were assumed to be 0.055 in channel; overbank channel values were assumed to be 0.08. When necessary for calibration, Manning's *n* values and the overbank sideslopes were altered so that realistic discharge values could be obtained. The data used for each specific reach is available within the HEC-HMS Model.

INFILTRATION AND HYDROLOGIC LOSS ESTIMATES

Infiltration and all other hydrologic loss estimates (e.g., evapotranspiration, percolation, depression storage, etc.) taken into account within the HEC-HMS model was consistent with the recharge volume criteria contained in Control Guidance 1 and 2 (CG-1 and CG-2). These losses were modeled in existing conditions as the standard initial abstraction in the NRCS Curve Number Runoff method (i.e., $I_a = 0.2S$). CG1 was simulated by modifying the standard initial abstraction using the following procedure.

The runoff volume is computed by HEC-HMS using the following equation:

$$Q_{volume} = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Where P = rainfall for a specific storm event (in),
I_a = initial abstraction (in), and
S = maximum retention (in).

S is defined by the following equation which relates runoff volume to curve number:

$$S = \frac{1000}{CN} - 10$$

The standard initial abstraction I_a used in Pennsylvania is typically $0.2S$. HEC-HMS calculates this automatically if no value is entered by the user. This was the approach used for the existing and future conditions modeling scenarios.

In future conditions with implementation of CG-1, the following equation is applicable. The goal of CG-1 is to ensure there is no discharge volume increase for the 2-year storm event, so

$$Q_{CG1} = Q_{Existing} = \frac{(P - I_a)^2}{(P - I_a) + S_{Proposed}}$$

Where P = rainfall for a specific storm event(in),
I_a = initial abstraction (in), and
$S_{Proposed}$ = maximum retention in proposed conditions as a function of the proposed conditions curve number (in).

Assuming $I_a = 0.2S$ as the Initial abstraction is no longer applicable with CG-1 since BMPs are to be installed to control or remove the increase in runoff volume for the 2-year storm. Using the HEC-HMS modeling output for $Q_{Existing}$, the initial abstraction for CG-1 may be calculated using the following equation:

$$I_a = P_{2-year} - \frac{1}{2}\left(Q_{Existing} \pm \sqrt{Q_{Existing}^2 + 4Q_{Existing}S_{Proposed}}\right) \text{ for the 2-year event}$$

Thus, the volume control required by CG-1 is implicitly modeled by overriding the HEC-HMS default for initial abstraction with the above value. The qualitative effect of this will be to eliminate the increase in runoff volume for the 2-year storm and to reduce the increase in runoff volume of the more extreme events. Increases in the peak flow values are reduced for all storms, but not eliminated, since the time of concentrations for proposed condition are decreased. Figure A.9 shows the effects of implementing a CG-1 policy on an example watershed. In the first figure representing a 2-year storm event, the hydrograph volumes are exactly the same and the peaks are similar. In the second figure representing a 100-year storm event, the hydrograph volumes are not the same since only the 2-year volume is abstracted; consequently there is still a substantial increase in peak flows, although the CG-1 implementation does reduce the peak flow.

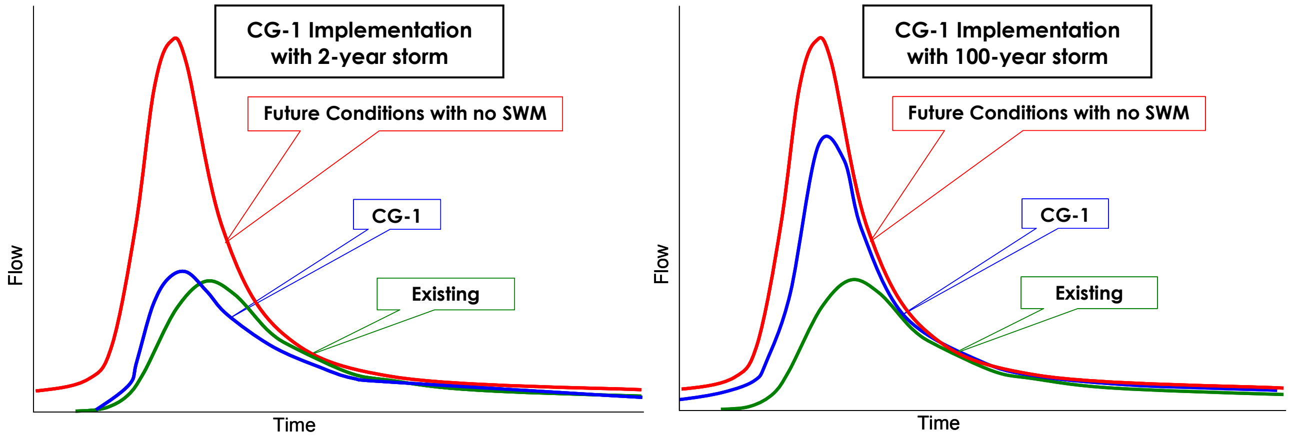


Figure A.9. Typical On-Site Runoff Control Strategy

In the case of this particular sample, release rates might be necessary to prevent increases in peak flow. In situations where there is only a small increase in impervious coverage, however, CG-1 may reduce the proposed conditions peak flow to existing conditions levels without the use of release rates.

For the 2-year event, modeling CG-1 with the above equations results in an increased approximation in initial abstraction represented by D:

$$D = I_a^{CG-1} - 0.2S$$

For every event of greater magnitude (e.g., 10, 25, 50, and 100-year events), the initial abstraction is calculated using the sum of the traditional method and the increase in initial abstraction for the 2-year event.

$I_a = 0.2S + D$ for all events greater than the 2-year event.

MODEL CALIBRATION

Three parameters were modified to develop a calibrated hydrologic model: the curve number, the time of concentration, and the Manning's coefficient used in the Muskingum-Cunge routing method.

The antecedent runoff condition was altered for each storm event so that each subbasin and calibration point was within an acceptable range of a target flow. The equation used to modify antecedent runoff condition (Maryland Hydrology Panel, 2006):

For ARC≤2:

$$CN_x = \frac{[10 + 5.8(x - 2)]CN_2}{10 + 0.058(x - 2)CN_2}$$

For ARC>2:

$$CN_x = \frac{[10+13(x-2)]CN_2}{10+0.013(x-2)CN_2}$$

Thus a unique ARC and resulting curve number was calculated for each subbasin for each storm event. The same ARC was applied in both existing and proposed conditions. The calibrated and future condition curve numbers for the two watersheds are presented in the Tables at the end of this appendix.

Additionally, lag times were calculated using both TR-55 and the NRCS lag equation. The initial model runs used the results from the NRCS lag equation. A factor between 0 and 2 was applied to the initial value to obtain a calibrated time of concentration value. The same time of concentration was applied to all existing condition storms. The future land use time of concentration was calculated using the NRCS lag equation with future land use curve numbers and it was subsequently adjusted by the same factor used in existing conditions.

Finally the Manning's n value for channels and overbank areas was modified to obtain realistic flow values. The respective ranges for the channel and overbank areas were 0.02-0.07 and 0.03-0.2.

The accuracy of the model remains unknown unless it is calibrated to another source of runoff information. Possible sources of information include stream gage data, high water marks (where detailed survey is available to facilitate hydraulic analysis), and other hydrologic models. The most desirable source of calibration information is stream gage data as this provides an actual measure of the runoff response of the watershed during real rain events.

USGS Gage 03022540 Woodcock Creek at Blooming Valley, PA

There are eleven USGS stream gages with adequate record associated with Oil Creek and French Creek. The following table lists these gages and their respective statistics.

USGS Stream Gage No.	Site Name	Drainage Area mi²	Number of Gage Years at Gage	Used in HEC-HMS Model
03022500	French Creek at Saegerstown, PA	629.0	19	Used
03022540	Woodcock Creek at Blooming Valley, PA	31.1	34	Used
03022554	Woodcock Creek at Woodcock Creek Dam, PA	45.6	17	Used
03023000	Cussewago Creek near Meadville, PA	90.2	28	Used
03023100	French Creek at Meadville, PA	788.0	20	Used
03023300	Van Horne Creek at Kerrtown, PA	4.5	6	Used
03020500	Oil Creek at Rouseville, PA	283.0	99	Used
03023500	French Creek at Carlton, PA	998.0	17	Used
03100000	Shenango River near Turnersville, PA	152.0	11	Not Used
03101000	Sugar Run at Pymatuning Dam, PA	9.34	21	Not Used
03101500	Shenango River at Pymatuning Dam, PA	167.0	75	Not Used

Table A.7. USGS Stream Gages Associated with Oil Creek and French Creek

Flow estimates were derived at this gage using the Bulletin 17B methodology outlined in USGS (1982). This method produces estimates for storms of all of the frequencies desired in this study (between the 1 and 100 year storm events) for any gage that has more than 10 years of data.

When no stream gage data is available, the next most desirable source of data for purposes of comparison is other hydrologic studies prepared by local, state, or federal agencies. FEMA Flood Insurance Studies (FIS) often provide discharge estimates at specific locations within FEMA floodplains. The estimates provided in FEMA FISs are valid sources for comparison but should be carefully considered when used for calibration since they are sometimes dependent on outdated methodology, or focus exclusively on the 100-year event for flood insurance purposes.

The third available source of information that may be used for calibration is regression equation estimates. The regression equations were developed on the basis of peak flow data collected at numerous stream gages throughout Pennsylvania. This procedure is the most up-to-date method and takes into account watershed average elevation, carbonate (limestone) area, and minor surface water storage features such as small ponds and wetlands. The methodology for developing regression equation estimates within *Pennsylvania is outlined in USGS Scientific Investigations Report 2008-5102* (USGS, 2008). Mean Elevation, Percent Carbonate Rock, and Percent Storage, the applicable parameters within Crawford County, were calculated using GIS from layers supplied from USGS Digital Elevation Model (DEM) data, Environmental Resources Research Institute (1996), and USGS (2008).

The target flow rates were determined from one of these three sources. The HEC-HMS models were then calibrated to the target flow rates at the overall watershed level, at subwatersheds where significant hydrologic features were identified (e.g., confluences, dams, USGS Gages), and at each individual subbasin. This approach was used so that a flow value anywhere in the model would compare favorably to the best available data source. The parameters of calibration for the entire overall watershed were the antecedent runoff condition, lag time, and reach routing coefficients. Detailed calibration results are provided in the form of tables at the end of this section.

The following figures (*Figures A.10-A.17*) show the overall watershed calibration results for Oil Creek and French Creek. As can be shown, the calibration results are in general agreement with the range of values for other hydrologic studies with the exception of USGS Gage 03023100 at French Creek near Meadville, PA which is affected by upstream regulation from Woodcock Creek Dam.

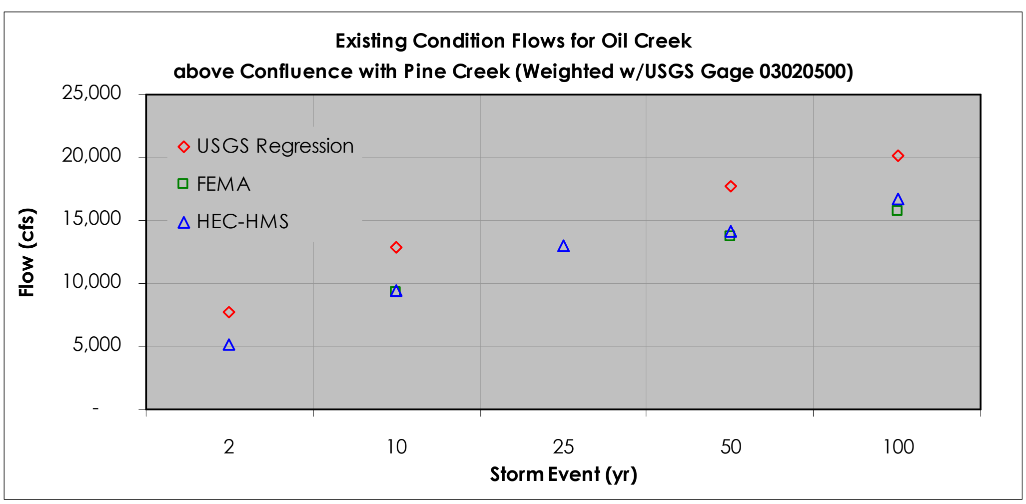


Figure A.10.

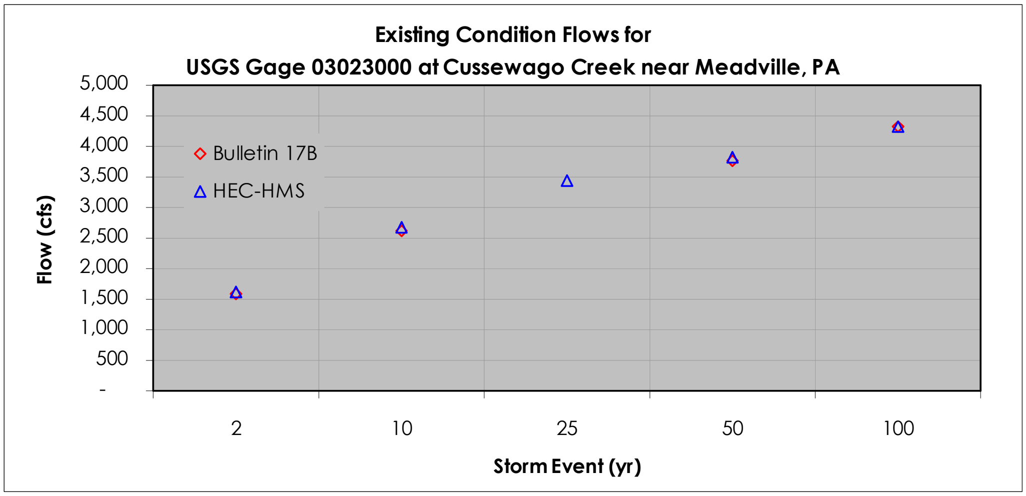


Figure A.11.

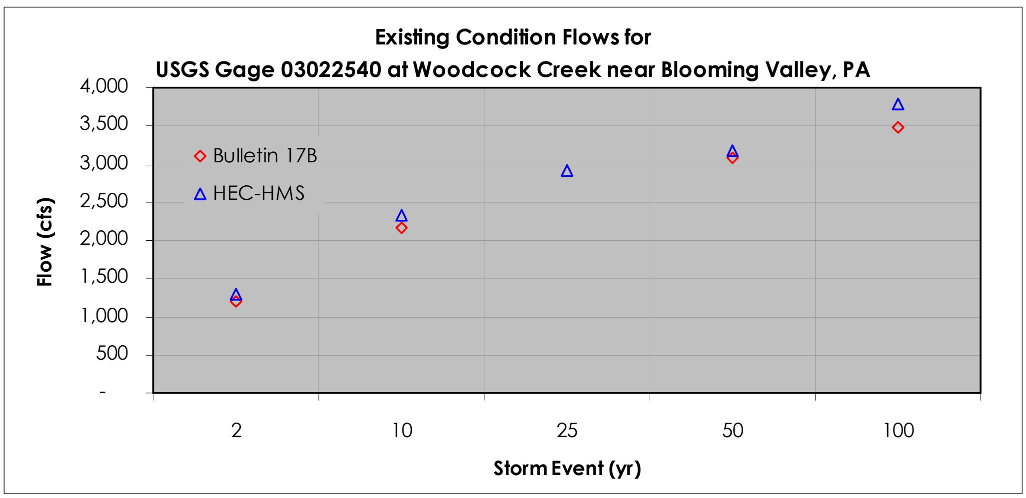


Figure A.12.

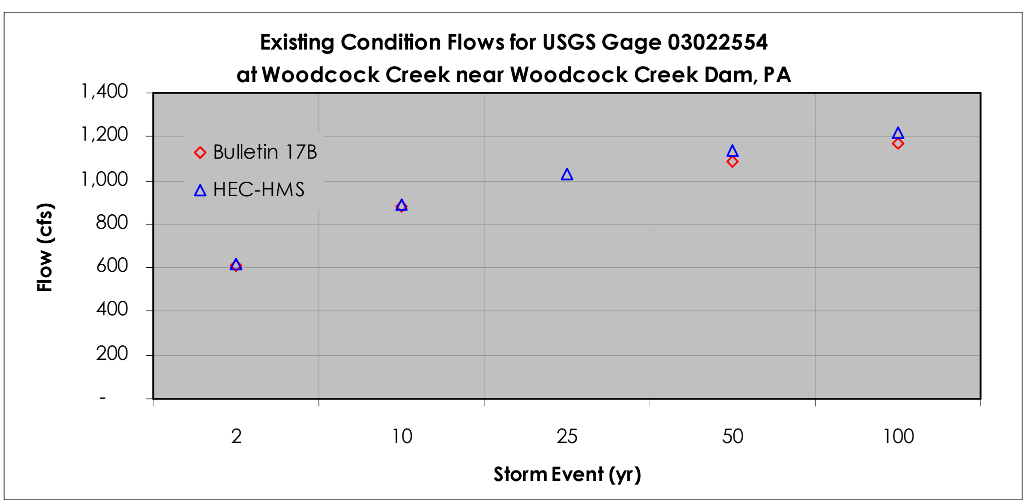


Figure A.13.

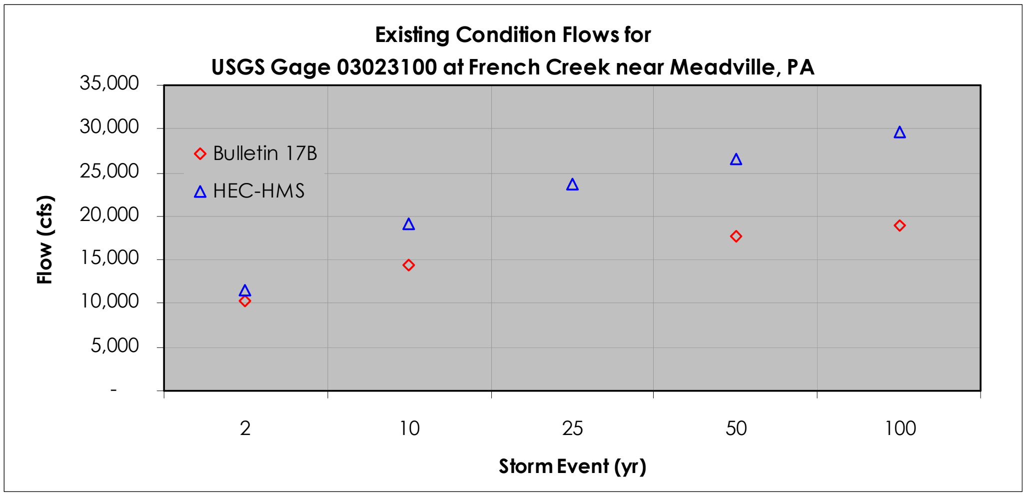


Figure A.14.

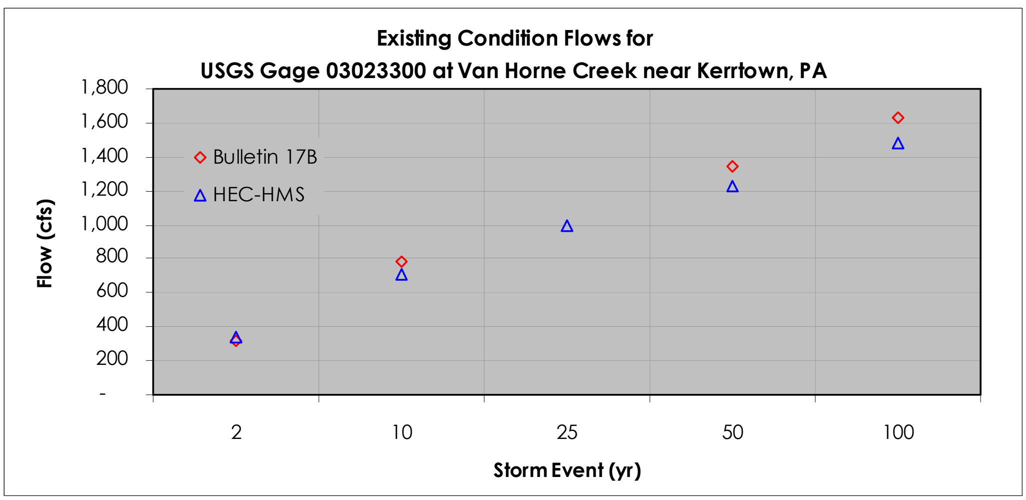


Figure A.15.

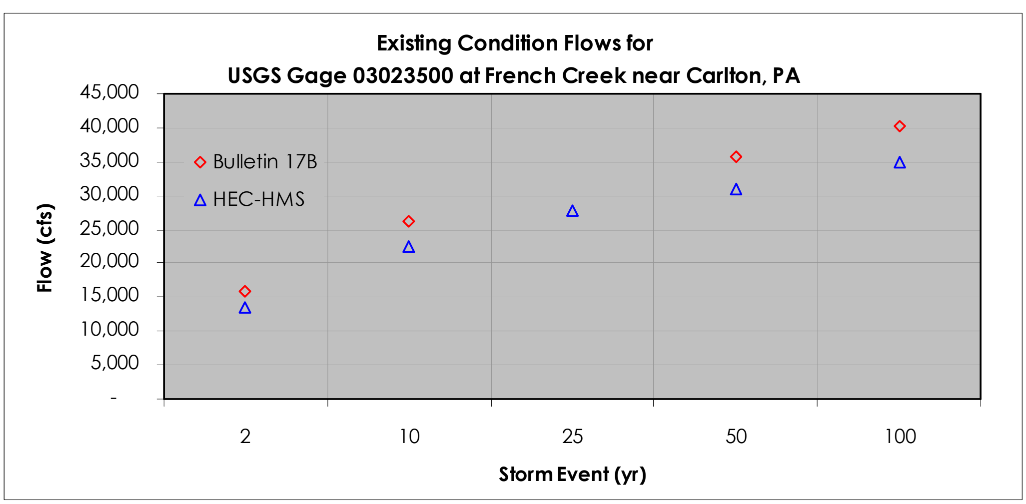


Figure A.16.

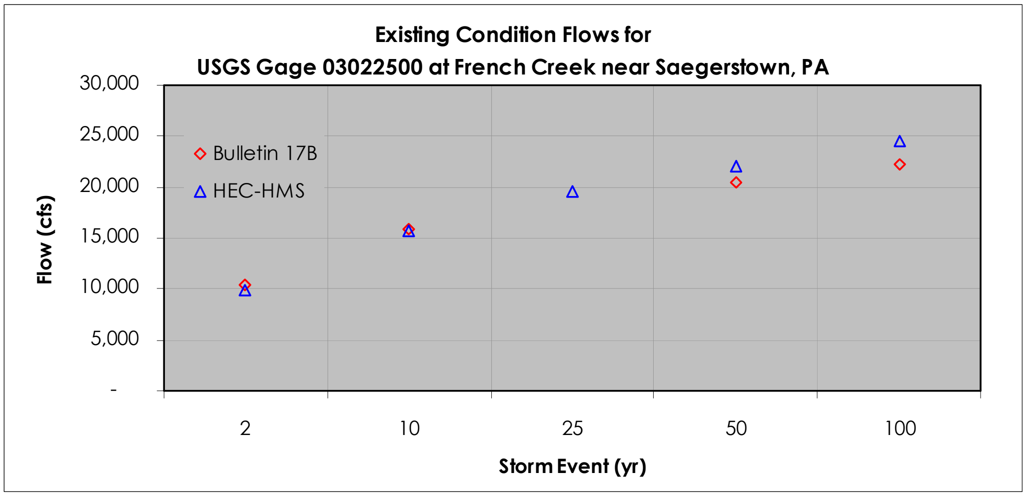


Figure A.17.

MODELING RESULTS

Once the existing conditions model was calibrated and the existing conditions peak flows were established, additional models were developed to assist in determining appropriate stormwater management controls for the watersheds. Based on a comparison of existing and future land use, most subbasins will experience varying degrees of development through the full build-out future condition.

The following simulations were performed with HEC-HMS (2, 10, 25, 50 and 100-year) for Oil and French Creeks:

Existing Conditions (Ex)

An existing conditions model was developed and analyzed using the using the calibration procedures described above. Results from the existing conditions model reflect the estimated land uses from 2010. The existing condition flows are provided in the form of tables at the end of this section.

Future Conditions with No Stormwater Controls (F-1)

A future conditions model was developed and analyzed using the projected future land use coverage for the year 2020 provided by Crawford County. The revised land use resulted in an increased curve number and a decreased time of concentration for several subbasins. It was assumed that there was no required detention or any other stormwater controls in this simulation.

Future Conditions with Design Storm Method and Release Rates (CG-1R)

A future conditions model with Stormwater Controls was developed by modifying the future conditions model to include the effects of peak rate controls and the volume removal requirements of the Design Storm Method.

The effects of peak rate controls, through detention of post development flows, was estimated by routing the post development flow for each subbasin through a simulated reservoir. The reservoirs were designed so that they could release no more than the pre-development flow estimate. This approach was assumed to simulate the additive effect of all of the individual detention facilities within a sub-basin. The volume removal requirements of the Design Storm Method were simulated using modified initial abstraction values as described above and illustrated in the form of tables at the end of this section.

The approach in this Act 167 Plan was to 1) estimate the effects of detention of post development flows and 2) apply release rates to subwatershed wherever there is a significant increases in peak flow at the points of interest. The results for each watershed are presented below; detailed results of the modeling are provided at the end of this section.

OIL CREEK

The increases in the Oil Creek watershed are focused near Lincolnville, Spartansburg, and Titusville, as shown in *Figure 6.1*.

Storm Event (year)	Effects of Future Condition on Discharges		
	Maximum % Increase in Future Conditions	Average % Increase in Future Conditions[1]	Portion of subbasins with Increase (%)
2	35.0	0.7	8.1
10	27.8	0.6	7.1
25	24.3	0.6	7.1
50	24.5	0.6	7.1
100	23.7	0.5	7.1

Notes: [1] Area weighted averages

Table A.8. Future Condition Flows with No Stormwater Management Controls for Oil Creek

Table A.9 shows the reduction in peak flows that would occur if only the Design Storm Method were implemented without any peak rate controls. The flows for the lower magnitude events are substantially reduced compared to future conditions with no stormwater management controls with the implementation of the Design Storm Method. The flows for the higher magnitude events are moderately reduced with implementation of the Design Storm Method, but significant increases still occur.

Storm Event (year)	Effects of CG-1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	2.3	0.2	21.2
10	9.6	0.3	7.1
25	11.7	0.3	6.1
50	13.4	0.3	6.1
100	14.1	0.4	7.1

Notes: [1]Area weighted averages

Table A.9 Future Subbasin Flows with Design Storm Method Only – No peak control for Oil Creek

FRENCH CREEK

As *Figure 6.2* shows, the increases in the French Creek watershed are also focused near Cambridge Springs and Meadville.

Storm Event (year)	Effects of Future Condition on Discharges		
	Maximum % Increase in Future Conditions	Average % Increase in Future Conditions[1]	Portion of subbasins with Increase (%)
2	47.4	0.7	14.5
10	43.5	0.6	13.4
25	35.5	0.5	13.2
50	31.1	0.5	12.6
100	31.1	0.5	12.6

Notes: [1]Area weighted averages

Table A.10. Future Condition Flows with No Stormwater Management Controls for French Creek

Table A.11 shows the reduction in peak flows that would occur if only the Design Storm Method were implemented without any peak rate controls. The lower magnitude events are substantially reduced with the implementation of the Design Storm Method; the higher magnitude events are helped with implementation of the Design Storm Method, but significant increases still occur.

Storm Event (year)	Effects of CG1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	2.8	0.1	12.6
10	11.0	0.3	10.9
25	12.8	0.3	9.9
50	13.6	0.3	9.7
100	15.5	0.3	10.3

Notes: [1] Area weighted averages

Table A.11. Future Subbasin Flows with Design Storm Method Only – no peak control for French Creek

STORMWATER MANAGEMENT DISTRICTS

The regional philosophy used in Act 167 planning introduces a different stormwater management approach than is found in the traditional on-site approach. The difference between the on-site stormwater control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts throughout an individual watershed. The objective of typical on-site design is to control post-development peak flow rates from the site itself; however, a watershed-level design is focused on maintaining existing peak flow rates in the entire drainage basin. The watershed approach requires knowledge of how the site relates to the entire watershed in terms of the timing of peak flows, contribution to peak flows at various downstream locations, and the impact of the additional runoff volume generated by the development of the site. The proposed watershed-level stormwater runoff control philosophy is based on the assumption that runoff volumes will increase with development and the philosophy seeks to manage the increase in volumes such that peak rates of flow throughout the watershed are not increased. The controls implemented in this Plan are aimed at minimizing the increase in runoff volumes and their impacts, especially for the 2-year storm event.

The basic goal of both on-site and watershed-level philosophies is the same, i.e. no increase in the peak rate of stream flow. The end products, however, can be very different as illustrated in the following simplified example.

Presented in *Figure A.18* is a typical on-site runoff control strategy for dealing with the increase in the peak rate of runoff with development. The Existing Condition curve represents the pre-development runoff hydrograph. The Developed Condition hydrograph illustrates three important changes in the site runoff response with development:

1. A higher peak rate,

2. A faster occurring peak (shorter time for the peak rate to occur), and

3. An increase in total runoff volume.

The "Controlled" Developed Condition hydrograph is based on limiting the post-development runoff peak rate to the pre-development level through use of detention facilities; but the volume is still increased. The impact of "squashing" the post-development runoff to the pre-development peak without reducing the volume is that the peak rate occurs over a much longer period of time. The instantaneous pre-development peak has become an extended peak (approximately two (2) hours long in this example) under the "Controlled" Developed Condition.

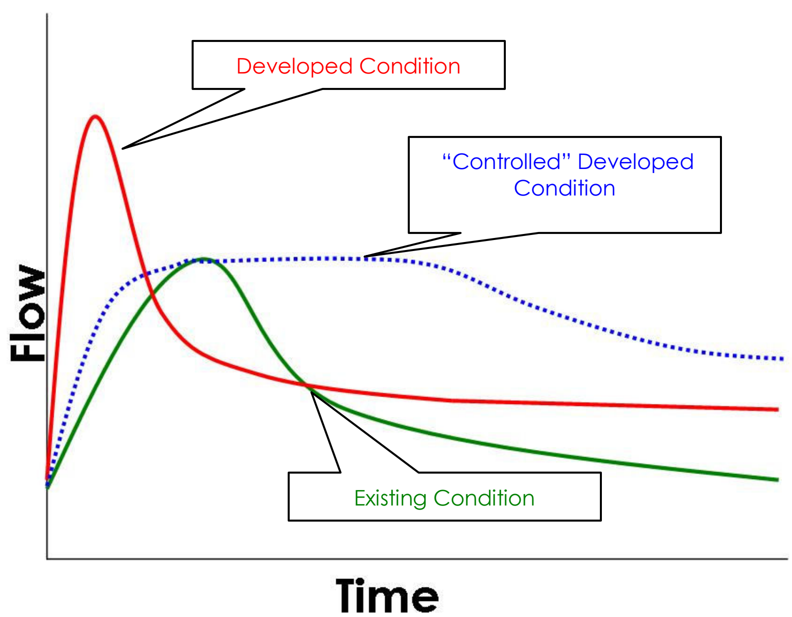


Figure A.18. Typical On-Site Runoff Control Strategy

Considering the outflow from the site only, the maintenance of the pre-development peak rate of runoff is an effective management approach. However, *Figures A.19* and *A.20* illustrate the potential detrimental impact of this approach. *Figure A.19* represents the existing hydrograph at the point of confluence of Watershed A and Watershed B. The timing relationship of the watersheds is that Watershed A peaks more quickly (at time T_{pA}) than the Total Hydrograph, while Watershed B peaks later (at time T_{pB}), than the Total Hydrograph, resulting in a combined time to peak approximately in the middle (at time T_p). Watershed A is an area of significant development pressure, and all new development proposals are met with the on-site runoff control philosophy as depicted in *Figure A.18*. The eventual end product of the Watershed A development under the "Controlled" Development Condition is an extended peak rate of runoff as shown in *Figure A.20*. The extended Watershed A peak occurs long enough so that it coincides with the peak of Watershed B. Since the Total Hydrograph at the confluence is the summation of Watershed A and Watershed B, the Total Hydrograph peak is increased under these conditions to the "Controlled" Total Hydrograph. The conclusion from the example is that simply controlling peak rates of runoff on-site does not guarantee an effective watershed level of control because of the increase in total runoff volume. The net result is that downstream peaks can increase and extend for longer durations.

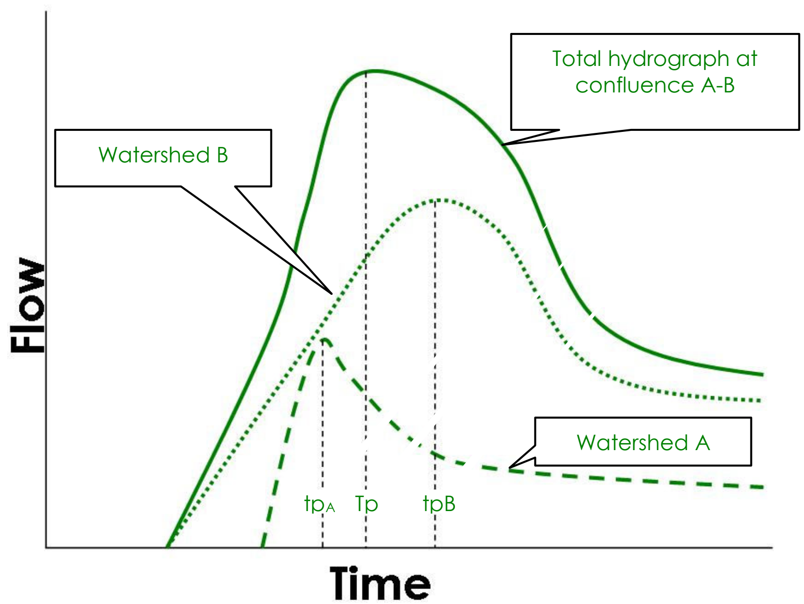


Figure A.19. Existing Hydrograph (Pre-Development)

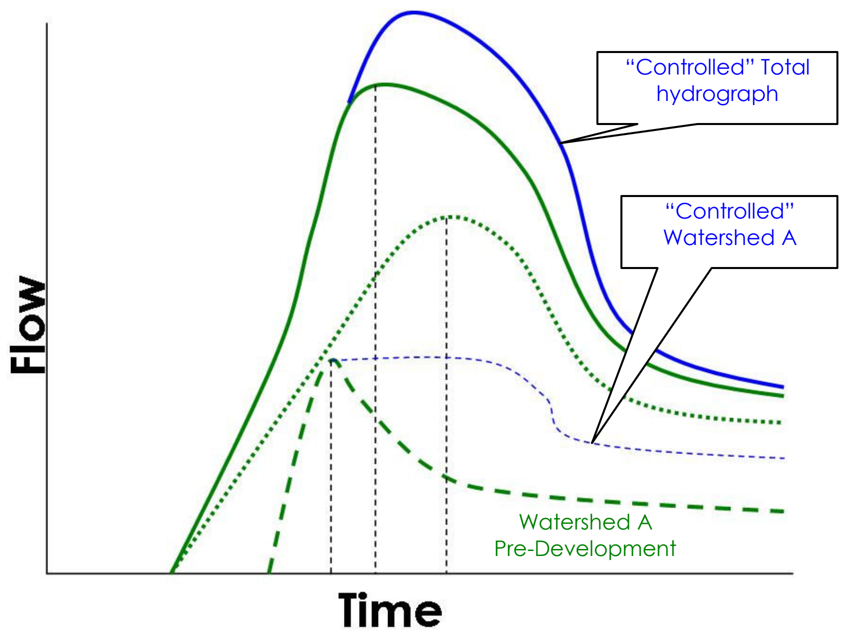


Figure A.20. Controlled Runoff Condition (Post-Development)

RELEASE RATE CONCEPT

The previous example indicated that, in certain circumstances, it is not enough to control post-development runoff peaks to pre-development levels if the overall goal is no increase in peak runoff at any point in the watershed. The reasons for this potential increase are how the various parts of the watershed interact, in time, with one another and the increased rate and volume of runoff associated with development and increases in impervious surfaces. The critical runoff criteria for a given site or watershed area is not necessarily its own pre-development peak rate of runoff but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest.

To account for increases of volume and peak flow resulting from the combination of these post-development hydrographs, stormwater management districts have been assigned to various areas within the county boundary that have more restrictive release rates than the conventional 100% release rate. As shown in Plate 10, some areas within specific watersheds have reduced release rates where CG-1 may be difficult to completely implement.

The specification of a 100% release rate as a performance standard would represent the conventional approach to runoff control philosophy, namely controlling the post-development peak runoff to pre-development levels. This is a well-established and technically feasible control that is effective at-site and, where appropriate, would be an effective watershed-level control.

It is important to acknowledge that there are several problems with the release rate concept. One of the problems is that some areas can reach unreasonably low release rates. Indeed, sub-watersheds whose runoff drains almost completely before or after the watershed peak will approach a release rate of zero (because the numerator approaches zero).

Another problem is that release rates are highly dependent on, and sensitive to, the timing of hydrographs. Since natural storms follow a different timing than design storms, it is still possible that watershed wide controls designed with release rates only, will encounter increased runoff problems. This is because the runoff rates are still much higher in the developed condition, and increased volumes over an extended time can combine to increase peak flow rates. Similar to the traditional on-site detention pond, release rates are purely a peak "rate" type of control.

Patterns of development may also determine how effective designs are that use only release rates, or any control based on timing. This is because rates based on timing assume a certain development and rainfall patterns, and the model uses uniform parameters across a sub-watershed. In reality, the actual development and rainfall patterns can be highly variable across a sub-watershed and can be quite different than the "Future Full Build Out" land use scenario used in the planning study. This uncertainty can affect any type of control, but controls based on timing alone are especially sensitive to these parameters. Some controls, such as volume controls, are less sensitive since they remove a certain amount of runoff from the storm event wherever development occurs. In a sense, volume controls tend to more closely simulate what occurs in a natural system.

Combining volume controls with peak rate controls, as proposed in this plan, will be more effective than having only peak rate controls. Volume controls have several advantages such as:

1. Increased runoff volume may infiltrate and provide recharge to existing groundwater supplies. This may not happen with rate controls since all of the runoff excess is discharged in a relatively short time frame.

2. Volume controls tend to mimic natural systems (i.e., excess runoff volume is infiltrated) and thus are more effective in controlling natural storms since they are not highly sensitive to timing issues.

3. Volume controls often have enhanced water quality benefits.

4. The Design Storm Method and The Simplified Method as implemented in this Plan, provide the benefits described above.

SUMMARY MODEL OUTPUT

The following table describes the model out for Oil Creek and French Creek in Crawford County.

Oil Creek	**Hydrologic Parameters** **Hydrologic Results**
French Creek 8 intereconnected HEC-HMS models 5 interconnected HEC-HMS Models within Crawford County	**French Creek B** Hydrologic Parameters Hydrologic Results
	Cussewago Creek (year 2010 only) Hydrologic Parameters Hydrologic Results
	Muddy Creek (year 2010 only) Hydrologic Parameters Hydrologic Results
	Conneaut Outlet (year 2010 only) Hydrologic Parameters Hydrologic Results
	French Creek A Hydrologic Parameters Hydrologic Results

Table A.12. Summary of HEC-HMS Model Output Data

Appendix B – Supporting Calculations for the Design Example

The *Model Ordinance* has been developed to implement a variety of control standards in order to achieve a holistic approach to stormwater management. The overall design process has been addressed in *Section VIII* of this Plan. The following example calculations have been provided to further clarify the design method. These calculations parallel the calculations that are made on the worksheets provided in the *Pennsylvania Stormwater Best Management Practices Manual* (PA BMP Manual) a copy of which are provided at the back of this appendix.

SUPPORTING CALCULATIONS - DESIGN EXAMPLE 1

NON-STRUCTURAL BMP CREDITS

Protect Sensitive Natural Resources
(Refer to Worksheet 2 & Worksheet 3)

Stormwater Management Area = Total Drainage Area – Protected Area

= 9.78 – 1.31 (woods) – 0.37 (minimum disturbance)
= **8.1-Acres**

This is the total area used for pre-development and post-development volume calculations.

Minimum Soil Compaction
(Refer to *Worksheet* 3)

Lawn Area (post development) protected from compaction = 16,165-ft^2

16,165-ft^2 x 1/4" x 1/12 = **337-ft^3**

To be eligible for this credit, areas must not be compacted during construction and be guaranteed to remain protected from compaction. Minimum soil compaction credits for lawn area (Open Space) are applicable for this example because specific measures were utilized to protect the back yard lawn areas of Lots 9 & 10 and this area has been placed in a permanent minimum soil compaction easement. Credits for the meadow area can be applied for areas that are not disturbed during construction and will remain in pre-development vegetated cover condition.

Disconnect Non-Roof Impervious to Vegetated Areas
(Refer to *Worksheet* 3)

Lot Impervious Area = 10 (Lots) x 1,000 (ft^2/lot) = 10,000-ft^2.
10,000-ft^2 x 1/3" x 1/12 = **278-ft^3**

This credit is applied for the impervious surfaces (driveways and sidewalks) which direct runoff to vegetated surfaces and not directly into a stormwater collection system. The 1/3" credit is used because runoff discharges across the lawn area and is received by rain gardens, which

DRAFT

are structures specifically placed to receive and infiltrate runoff. The 1/4" credit would be used for runoff not discharged to a specific infiltration structure or an area that has been protected from soil compaction.

<u>*Summation of Non-Structural BMP Credits*</u>
= 337-ft^3 + 278-ft^3 = **615-ft^3**

CHANGE IN RUNOFF VOLUME FOR THE 2-YEAR STORM EVENT

(Refer to *Worksheet 4*)

2-year, 24-hour Rainfall Depth = 2.76"

Pre-Development 2-yr Runoff Volume = 5,682 ft^3

Post-Development 2-yr Runoff Volume = 18,281 ft^3

Change in Runoff Volume for the 2-year, 24-hour storm event:

= 18,2813-ft^3 – 5,682-ft^3 = **12,599-ft^3**

This is the volume that must be managed through a combination of non-structural BMP credits and structural BMP credits.

25% LIMIT FOR NON-STRUCTURAL BMP CREDITS

(Refer to *Worksheet 5*)

*Per Chapter 8 of the Pennsylvania Stormwater BMP Manual, Non-Structural Credits may be **no greater than 25%** of the total required control volume.*

Check 25% Non-Structural Credit Limit:

= 615-ft^3 / 12,599-ft^3 = **4.9%**

Calculated credits are under the allowable 25% limit for non-structural credits.

STRUCTURAL CONTROL VOLUME REQUIREMENT

(Refer to *Worksheet 5*)

Required Structural BMP infiltration volume:

= Change in Runoff Volume – Non-Structural BMP Credits
= 12,599-ft^3 – 615-ft^3 = **11,984-ft^3**

STRUCTURAL BMP VOLUME CREDITS

The sizing of structural infiltration BMPs is based on two primary criteria:

1. <u>Maximum loading ratios</u> – There are two different loading ratios that are important when determining the size of a structural BMP. These ratios are derived from guidelines found in the *Pennsylvania Stormwater BMP Manual*.
    a. Maximum loading ratio of Impervious Area to Infiltration Area = 5:1
    b. Maximum loading ratio of Total Drainage Area to Infiltration Area = 8:1

2. Expected runoff volume loading – Structural BMPs must be sized to accommodate the runoff volume they are expected to receive from the contributing drainage area. Some of this volume will be removed and the remainder must be safely conveyed through an overflow device. The removed volume, or infiltration volume, is the important component for sizing the infiltration BMP. A good starting point for infiltration volume is to calculate the contributing area runoff volume for the 2-year, 24-hour design storm. This volume may not be suitable for a particular site design, but starting with this volume will usually result in a design that is close to what is appropriate, and it can be adjusted as necessary. Additional design restrictions may exist for certain BMPs, so these should be considered prior to using this sizing method.

Dry Wells
(Example calculations shown for Lot #1; Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum dry well surface area for each lot based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 2,150-ft^2 (typ.)
= 2,150-ft^2 / 5 = **430-ft^2**
= minimum surface area of dry well per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 2,590-ft^2 (typ.)
= 2,590-ft^2 / 8 = **324-ft^2**
= minimum surface area of dry well per pervious loading ratio

The larger of the two calculated areas is the total minimum surface area required for each lot. An individual dry well is placed at each of the four major corners of the house to promote distribution of impervious area runoff. However, the total surface area is used throughout the remaining volume credit calculations for simplicity. The surface area of each dry well is calculated below:

Total Minimum Dry Well Surface Area ÷ Number of Dry Wells
=430 ft^2 / 4 = **107.5-ft^2**

Each dry well will be 10' x 11' to meet the minimum surface area requirements.

Volume:
Find the infiltration volume for each dry well based on the expected runoff volume.

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	I_a (0.2*S)	Runoff Depth$_{2\text{-yr}}$ (in)	Runoff Volume$_{2\text{-yr}}$ (ft^3)
Open Space (good)	B	110	0.00	61	6.393	1.279	0.28	3
Impervious	B	540	0.01	98	0.204	0.041	2.53	114
TOTAL:		**650**	**0.01**				**2.81**	**116**

Runoff volume = **116-ft^3**

DRAFT

Depth:
Each dry well will be filled with aggregate. The in-place aggregate will have a 40% voids ratio; therefore the volume is divided by the available void space to get a total volume.

Depth = Total Volume / Surface Area

= (116-ft^3 / 0.40) / 110-ft^2 = **2.64-ft or approximately 2'-8"**

An overflow spillway or drain is then sized to convey any runoff that exceeds the design volume to the peak rate management facility.

Rain Gardens
(Example calculations shown for Lot #1; Refer to Worksheet 5A for additional calculations)

Surface Area:
Find the minimum surface area for each rain garden based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 1,000-ft^2
= 1,000-ft^2 / 5 = **200-ft^2**
= minimum surface area of rain garden per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 6,000-ft^2 (typ.)
= 4,775-ft^2 / 8 = **597-ft^2**
= minimum surface area of rain garden per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Rain Garden Surface Area = **597-ft^2**

Depth:
Design guidelines, from the *PA BMP Manual*, for rain gardens limit ponding depth within the facility to 12 inches or less. The rain gardens in this example have been designed with a total ponding depth of 12 inches. The overflow outlets are positioned 6 inches above the bottom elevation of the rain gardens and 6 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the rain garden is calculated by multiplying the surface area of the rain garden by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 700-ft^2 x 0.5-ft = **350-ft^3**

Bioretention
(Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum surface area for the bioretention facility based on the maximum loading ratios.

DRAFT

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 9,700-ft^2 (typ.)
= 9,700-ft^2 / 5 = **1,940-ft^2**
= minimum surface area of Infiltration Trench per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 41,400-ft^2
= 41,400-ft^2 / 8 = **5,175-ft^2**
= minimum surface area of Infiltration Trench per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Infiltration Trench Surface Area = **5,175-ft^2**

Depth:
The bioretention facility in this example has been designed with a total depth of 18 inches. The overflow outlets are positioned 6 inches above the bottom elevation, and 12 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the bioretention facility is calculated by multiplying the surface area by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 5,175-ft^2 x 0.5-ft = **2,487.5-ft^3**

STRUCTURAL CONTROL VOLUME REQUIREMENT CHECK

(Refer to *Worksheet 5*)

Check the total structural volume to be certain it is adequate to meet the structural volume requirement.

= Total Structural Volume - Structural Volume Requirement
=14,613-ft^3 – 11,984-ft^3 = 2,629-ft^3

The structural volume requirement has been exceeded by 2,629-ft^3 and no further BMP calculations are necessary.

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name:	DESIGN EXAMPLE 1
Project ID:	MILL RUN RESIDENTIAL
Owner:	
Calculated:	Date:
Checked:	Date:

WORKSHEET 1. GENERAL SITE INFORMATION

INSTRUCTIONS: Fill out *Worksheet 1* for each watershed

Date: 2/29/2010

Project Name: DESIGN EXAMPLE 1

Municipality: VENANGO TOWNSHIP

County: CRAWFORD

Total Area (acres): 9.78

Major River Basin: ALLEGHENY RIVER
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/default.htm#newtopics

Watershed: FRENCH CREEK

Sub-Basin: N/A

Nearest Surface Water(s) to Receive Runoff: MILL RUN

Chapter 93 - Designated Water Use: CWF
http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

Impaired according to Chapter 303(d) List? Yes [ ] No [X]
http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/303d-Report.htm
List Causes of Impairment:

Is project subject to, or part of:

Municipal Separate Storm Sewer System (MS4) Requirements? Yes [ ] No [X]
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/GeneralPermits/default.htm

Existing or planned drinking water supply? Yes [ ] No [X]

If yes, distance from proposed discharge (miles): ______

Approved Act 167 Plan? Yes [X] No [ ]
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/Approved_1.html

Existing River Conservation Plan? Yes [X] No [ ]
http://www.dcnr.state.pa.us/brc/rivers/riversconservation/planningprojects/

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 2. SENSITIVE NATURAL RESOURCES

INSTRUCTIONS:

1. Provide Sensitive Resources Map according to non-structural BMP 5.4.1 in Chapter 5 of PA Stormwater BMP Manual. This map should identify waterbodies, floodplains, riparian areas, wetlands, woodlands, natural drainage ways, steep slopes, and other sensitive natural areas.

2. Summarize the existing extent of each sensitive resource in the Existing Sensitive Resources Table (below, using Acres). If none present, insert 0.

3. Summarize Total Protected Area as defined under BMPs in Chapter 5.

4. Do not count any area twice. For example, an area that is both a floodplain and a wetland may only be considered once.

EXISTING NATURAL SENSITIVE RESOURCE	MAPPED? yes/no/n/a	TOTAL AREA (Ac.)	PROTECTED AREA (Ac.)
Waterbodies	yes	0.00	
Floodplains	no	0.00	
Riparian Areas	no	0.00	
Wetlands	no	0.00	
Woodlands	yes	2.29	1.31
Natural Drainage Ways	N/A	0.00	
Steep Slopes, 15% - 25%	N/A	0.00	
Steep Slopes, over 25%	N/A	0.00	
Other:	N/A		
Other:	N/A		
TOTAL EXISTING:		**2.29**	**1.31**

DRAFT

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 3. NON-STRUCTURAL BMP CREDITS

PROTECTED AREA

1.1 Area of Protected Sensitive/Special Value Features (see WS 2)	**1.31**	**Ac.**
1.2 Area of Riparian Forest Buffer Protection	**0.00**	**Ac.**
3.1 Area of Minimum Disturbance/Reduced Grading	**0.37**	**Ac.**
TOTAL	**1.68**	**Ac.**

Site Area	*minus*	Protected Area	=	Stormwater Management Area
9.78	-	**1.68**	=	**8.10**

VOLUME CREDITS

3.1 Minimum Soil Compaction

Lawn	**16,165**	ft^2	x 1/4"	x 1/12	=	**337** ft^3
Meadow	**N/A**	ft^2	x 1/3"	x 1/12	=	**0** ft^3

3.3 Protect Existing Trees

For Trees within 100 feet of impervious area:

Tree Canopy	**N/A**	ft^2	x 1/2"	x 1/12	=	**0** ft^3

For Trees within 20 feet of impervious area:

Tree Canopy	**N/A**	ft^2	x 1"	x 1/12	=	**0** ft^3

5.1 Disconnect Roof Leaders to Vegetated Areas

For runoff directed to areas protected under 5.8.1 and 5.8.2

Roof Area	**N/A**	ft^2	x 1/3"	x 1/12	=	**0** ft^3

For all other disconnected roof areas

Roof Area	**N/A**	ft^2	x 1/4"	x 1/12	=	**0** ft^3

5.2 Disconnect Non-Roof Impervious to Vegetated Areas

For Runoff directed to areas protected under 5.8.1 and 5.8.2

Impervious Area	**10,000**	ft^2	x 1/3"	x 1/12	=	**278** ft^3

For all other disconnected non-roof impervious areas

Impervious Area	**N/A**	ft^2	x 1/4"	x 1/12	=	**0** ft^3

TOTAL NON-STRUCTURAL VOLUME CREDIT* **615** ft^3

** For use on Worksheet 5*

DRAFT

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 4. CHANGE IN RUNOFF VOLUME FOR 2-YR STORM EVENT

PROJECT: DESIGN EXAMPLE 1
Drainage Area: 8.10 (acres)
2-Year Rainfall: 2.49 **inches** *(From NOAA Atlas 14)*

Total Site Area: 9.78 **acres**
Protected Site Area: 1.68 **acres**
Stormwater Management Area: 8.10 **acres** *(From Worksheet 3)*

Existing Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Woods (good)	B	42,500	0.98	55	8.1818	1.6364	0.08	286
Meadow	B	310,255	7.12	58	7.2414	1.4483	0.13	3,387
								-
								-
								-
								-
TOTAL:		**352,755**	**8.10**					**3,673**

Developed Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Meadow	B	54,060	1.24	58	7.2414	1.4483	0.13	590
Open Space (good)	B	243,035	5.58	61	6.3934	1.2787	0.19	3,908
Impervious	B	55,660	1.28	98	0.2041	0.0408	2.26	10,486
								-
								-
								-
TOTAL:		**352,755**	**8.10**					**14,984**

2-Year Volume Increase (ft^3): 11,311

2-Year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume
= 14,984 - 3,673 = 11,311 ft^3

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where
P = 2-Year Rainfall (in)
S = (1000/ CN)-10

2. Runoff Volume (CF) = Q x Area x 1/12
Q = Runoff (in)
Area = Land use area (sq. ft)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSG.

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5. STRUCTURAL BMP VOLUME CREDITS

SUB-BASIN: N/A

Check 25% Limit for Non-Structural BMP Credits: 615
÷ 11,311
5.4%

Required Control Volume (ft^3): 11,311
Allowable Non-structural Volume Credit (ft^3): - 615

Structural Volume Reqmt (ft^3): **10,696**
(Required Control Volume minus Non-structural Credit)

Proposed BMP		Area (ft^2)	Infiltration Volume (ft^3)
6.4.1	Porous Pavement		
6.4.2	Infiltration Basin		
6.4.3	Infiltration Bed		
6.4.4	Infiltration Trench		
6.4.5	Rain Garden/Bioretention	11,915	8,827
6.4.6	Dry Well / Seepage Pit	4,400	5,787
6.4.7	Constructed Filter		
6.4.8	Vegetated Swale		
6.4.9	Vegetated Filter Strip		
6.4.10	Berm		
6.5.1	Vegetated Roof		
6.5.2	Capture and Re-use		
6.6.1	Constructed Wetlands		
6.6.2	Wet Pond / Retention Basin		
6.6.3	Dry Extended Detention Basin		
6.6.4	Water Quality Filters		
6.7.1	Riparian Buffer Restoration		
6.7.2	Landscape Restoration / Reforestation		
6.7.3	Soil Amendment		
6.8.1	Level Spreader		
6.8.2	Special Storage Areas		
Other			

Total Structural Volume (ft^3): 14,613
Structural Volume Requirement (ft^3): 10,696

DIFFERENCE: 3,917 *(excess)*

* Complete BMP Design Checklist for each measure proposed

DRAFT

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5.A - INFILTRATION BMP SUPPORTING CALCULATIONS

Instructions: Complete this worksheet for each Point of Interest / Discharge (at a minimum)

Point of Interest / Discharge: *Basin Outfall*
Total Drainage Area to POI: 352,755 ft^2
Total Impervious Area: 55,660 ft^2

BMP	Proposed Infiltration BMP(s)	Infiltration Rate: Measured Infilt Rate[1] in/hr	Infiltration Rate: FOS	Infiltration Rate: Design Infilt Rate in/hr	Design Runoff Volume cu. ft.	Infiltration Period: Infilt. Period[2] hrs	Infiltration Period: Active Infilt.[3] hrs	Infiltration Period: Total Infilt Period hrs	Hydraulic Loading – Imperv. Drainage Area Loading: Imperv. DA sq. ft.	% area draining to BMP	Imperv Area Loading Ratio	Imperv Target Area sq. ft.	Hydraulic Loading – Total Drainage Area Loading: Total Drainage Area sq. ft.	% area draining to BMP[4]	Total Area Loading Ratio	Total Target Area sq. ft.	Target BMP Area[5] sq. ft.	Actual BMP Area[6] sq. ft.	Computed Infiltration Volume cu. ft.
BMP 6.4.1	**Porous Pavement w. Infilt. Bed**							*Subtotal:*			*5*				*8*				
BMP 6.4.2	**Infiltration Basin**							*Subtotal:*			*5*				*8*				
BMP 6.4.3	**Subsurface Infiltration Bed**							*Subtotal:*			*5*				*8*				
BMP 6.4.4	**Infiltration Trench**							*Subtotal:*			*5*				*8*				
BMP 6.4.5	**Rain Garden/Bioretention**							*Subtotal:*	*19,700*		*5*		*89,685*		*8*			*11,915*	*8,827*
	Rain Garden (Lot #1)	0.93	2	0.47	350	12.9	6	18.9	1,000	100.0		200	4,775	100.0		597	597	700	513
	Rain Garden (Lot #2)	0.95	2	0.48	350	12.6	6	18.6	1,000	100.0		200	5,600	100.0		700	700	700	516
	Rain Garden (Lot #3)	0.98	2	0.49	350	12.2	6	18.2	1,000	100.0		200	5,080	100.0		635	635	700	522
	Rain Garden (Lot #4)	1.01	2	0.51	300	11.9	6	17.9	1,000	100.0		200	3,625	100.0		453	453	600	452
	Rain Garden (Lot #5)	1.02	2	0.51	458	11.8	6	17.8	1,000	100.0		200	7,005	100.0		876	876	915	691
	Rain Garden (Lot #6)	1.08	2	0.54	350	11.1	6	17.1	1,000	100.0		200	5,310	100.0		664	664	700	539
	Rain Garden (Lot #7)	0.91	2	0.46	300	13.2	6	19.2	1,000	100.0		200	4,395	100.0		549	549	600	437
	Rain Garden (Lot #8)	0.99	2	0.50	238	12.1	6	18.1	1,000	100.0		200	3,000	100.0		375	375	475	355
	Rain Garden (Lot #9)	1.05	2	0.53	300	11.4	6	17.4	1,000	100.0		200	4,520	100.0		565	565	600	458
	Rain Garden (Lot #10)	1.03	2	0.52	375	11.7	6	17.7	1,000	100.0		200	4,975	100.0		622	622	750	568
	Bioretention 1	0.92	2	0.46	2588	13.0	6	19.0	9,700	100.0		1,940	41,400	100.0		5,175	5,175	5,175	3,778
BMP 6.4.6	**Dry Well / Seepage Pit**							*Subtotal:*	*21,500*		*5*		*25,900*		*8*			*4,400*	*5,787*
	Dry Well (Lot #1)	0.98	2	0.49	468	26.0	6	32.0	2,150	100.0		430	2,590	100.0		324	430	440	576
	Dry Well (Lot #2)	0.91	2	0.46	468	28.1	6	34.1	2,150	100.0		430	2,590	100.0		324	430	440	568
	Dry Well (Lot #3)	1.06	2	0.53	468	24.1	6	30.1	2,150	100.0		430	2,590	100.0		324	430	440	585
	Dry Well (Lot #4)	1.02	2	0.51	468	25.0	6	31.0	2,150	100.0		430	2,590	100.0		324	430	440	580
	Dry Well (Lot #5)	0.93	2	0.47	468	27.4	6	33.4	2,150	100.0		430	2,590	100.0		324	430	440	570
	Dry Well (Lot #6)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
	Dry Well (Lot #7)	0.97	2	0.49	468	26.3	6	32.3	2,150	100.0		430	2,590	100.0		324	430	440	575
	Dry Well (Lot #8)	1.01	2	0.51	468	25.3	6	31.3	2,150	100.0		430	2,590	100.0		324	430	440	579
	Dry Well (Lot #9)	1.04	2	0.52	468	24.5	6	30.5	2,150	100.0		430	2,590	100.0		324	430	440	582
	Dry Well (Lot #10)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
BMP 6.4.7	**Constructed Filter[7]**										5				8				
BMP 6.4.8	**Vegetated Swale[7]**										5				8				
BMP 6.4.9	**Vegetated Filter Strip[7]**										5				8				
BMP 6.4.10	**Infilt. Berm & Ret. Grading**										5				8				
																		TOTAL:	**14,613**

1 Assumes a soil testing procedure which finds hydraulic conductivity. (e.g. perc tests may also require a reduction factor)
2 Time it takes for BMP to empty once it is full. (Minimum = 24 hrs, Maximum = 72 hours; Applicable to retention and detention facilities only.)
3 Infiltration that occurs during the storm (before becoming full). Not to exceed 6 hours.
4 A portion of the total area draining to BMP from non-pervious area may be diverted.
5 Inherent in these calculations are the allowable loading ratios (5:1 and 8:1) from the BMP Manual. Higher loading ratios will need to be justified. In Karst Areas, the max. loading ratio should be 3:1.
6 Actual BMP Area may be larger than (but not smaller than) the Target BMP Area.
7 These BMPs are not well represented by this computational process. See worksheet 5.C for vegetated swales and filter strips.

DRAFT

PEAK RATE CONTROL ANALYSIS

According to the National Engineering Handbook (NRCS, 2008), the direct runoff for watersheds having more than one hydrologic soil-cover complex can be estimated in either of two ways. Runoff can be estimated for each complex and then weighted to get the watershed average. Alternatively, the CN values can be weighted, based on area, to obtain a single CN value to represent the entire drainage area. Then runoff is estimated with the single CN value. If the CN for the various hydrologic soil-cover complexes are close in value, both methods of weighting give similar results for runoff. However, if there exists a large difference in curve number value, the CN weighting method can provide drastically different results.

As described in the *National Engineering Handbook*, "the method of weighted runoff always gives the correct result (in terms of the given data), but it requires more work than the weighted CN method, especially when a watershed has many complexes. The method of weighted CN is easier to use with many complexes or with a series of storms. However, where differences in CN for a watershed are large, this method either under- or over-estimates runoff, depending on the size of the storm." This often occurs when impervious area exists in a subarea. When the relatively low curve number of lawn areas is combined with the high curve number of impervious areas, the weighted CN method will minimize the impact of the impervious surface and under-estimate the amount of runoff.

The spatial distribution of the different soil-cover complexes becomes the controlling factor in selection of the appropriate method. When different land uses behave as independent watershed the areas should be analyzed as separate drainage subareas. For example, when a large parking area is surrounded by lawn area that all flows to the same collection point, runoff from the impervious surface will occur much differently than runoff from the lawn. However, when impervious area is dispersed amongst other land uses and not directly connected to a stormwater collection system, the weighted CN method may be appropriate. The decision of whether or not to use a weighted curve number is often a site specific judgment that should be discussed between the designer and the Municipal Engineer in the early planning stages of a project.

<u>*Pre-Development Soil-Cover Complex Data*</u>

Because the wooded area along the north property line will remain unchanged, and will not be tributary to the stormwater facilities, this area has been removed from the peak rate analysis drainage areas. The weighted CN method was used for pre-development calculations in this example because Curve Numbers for the hydrologic soil-cover complexes are close in value. The drainage area and land cover information necessary to calculate the pre-development runoff is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Woods (good)	B	42,500	0.98	55
Meadow	B	310,255	7.12	58
TOTAL:		352,755	8.10	58

<u>*Pre-Development Time of Concentration*</u>

The *Model Ordinance* requires use of the NRCS Lag Equation for all pre-development time of concentration calculations unless another method is pre-approved by the Municipal Engineer.

DRAFT

$$T_{lag} = L^{0.8}\frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where:

T_{lag} = Lag time (hours)
L = Hydraulic length of the watershed (feet)
Y = Average overland slope of watershed (percent)
S = Maximum retention in the watershed, as defined by: S = [(1000/CN) – 10]
CN = NRCS Curve Number for the watershed

Lag time is related to time of concentration by the following equation:

Time of Concentration = T_c = [(T_{lag}/.6) * 60] (minutes)

One method of calculating the average overland slope of a watershed is to select locations that represent the various slopes found in the watershed and weight the slope based on the area it represents. This method is shown in the table on the following page.

Slope	End Elevation		Distance	Slope	Percent of	Product
Line	High	Low	(ft)	(%)	Total Area	(% x %)
AA	909	902	148	4.7%	5%	0.24%
BB	941	909	475	6.7%	50%	3.37%
CC	956	942	245	5.7%	15%	0.86%
DD	960	943	180	9.4%	15%	1.42%
EE	943	930	265	4.9%	15%	0.74%
					Sum of Products =	6.61%

This is an estimation of the land slope value, so the calculated number is rounded to the nearest whole number for use in the Lag Equation. The hydraulic length of the watershed was measured at 1050 ft. Therefore,

$$T_{lag} = (1050)^{0.8}\frac{((1000/CN)-10)+1)^{0.7}}{1900\sqrt{7}}$$

T_{lag} = 0.23 hours

Time of Concentration = T_C = (T_{lag} / 0.6) * 60
= (0.23 / 0.6) * 60
= 23 minutes

Pre-Development Peak Rate Flows

All of this information was used to perform a pre-development peak rate analysis using a software package based on the NRCS TR-20 procedures. The results of the analysis are as follows:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.6	4.1	7.6	11.1	15.3
Runoff Volume (ac-ft)	0.060	0.136	0.449	0.726	0.997	1.322
Runoff Depth (in)	0.09	0.20	0.66	1.08	1.48	1.96

Table B.1. Pre-Development Runoff Summary

DRAFT

Post-Development Soil-Cover Complex Data
Due to the disconnection of impervious areas and overland flow paths used in this design, the area weighted CN method was deemed appropriate and used to reduce the complexity of the model. The drainage area and land cover information for the drainage sub-area directly tributary to the bioretention facility is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Lawn (good condition)	B	9,700	0.22	61
Impervious	B	31,700	0.73	98
TOTAL:		41,400	0.95	70

Post-Development Time of Concentration
The Segmental Method was used for all post-development time of concentration calculations in this example. This method is covered in more detail in various NRCS publications (NRCS, 1986; NRCS, 2008). The following segments were used to calculate a time of concentration for the drainage sub-area directly tributary to the bioretention facility:

T_t*-1*: Sheet flow, 100' of lawn at 5% = 10.7 min
T_t*-2*: Shallow concentrated flow, 110' unpaved at 5.9% = 0.5 min
T_t*-3*: Channel flow, 80' at 4.0% = 0.2 min
T_t*-4*: Channel flow, 156' at 3.85% = 0.5 min
T_t*-5*: Pipe flow, 38' of 15" HDPE pipe at 5.2% = 0.1 min

$T_C = T_t\text{-}1 + T_t\text{-}2 + T_t\text{-}3 + T_t\text{-}4 + T_t\text{-}5 = 12$ minutes

Post-Development Peak Rate Flows
The hydrologic model for this example contains a considerable level of detail. Each structural BMP was modeled as a pond with a unique drainage area and time of concentration. Runoff was routed through each BMP and linked to downstream BMPs for subsequent routing. A detention basin with an outlet control structure was also added to the model. A graphical representation of the model is provided in *Figure B.1*.

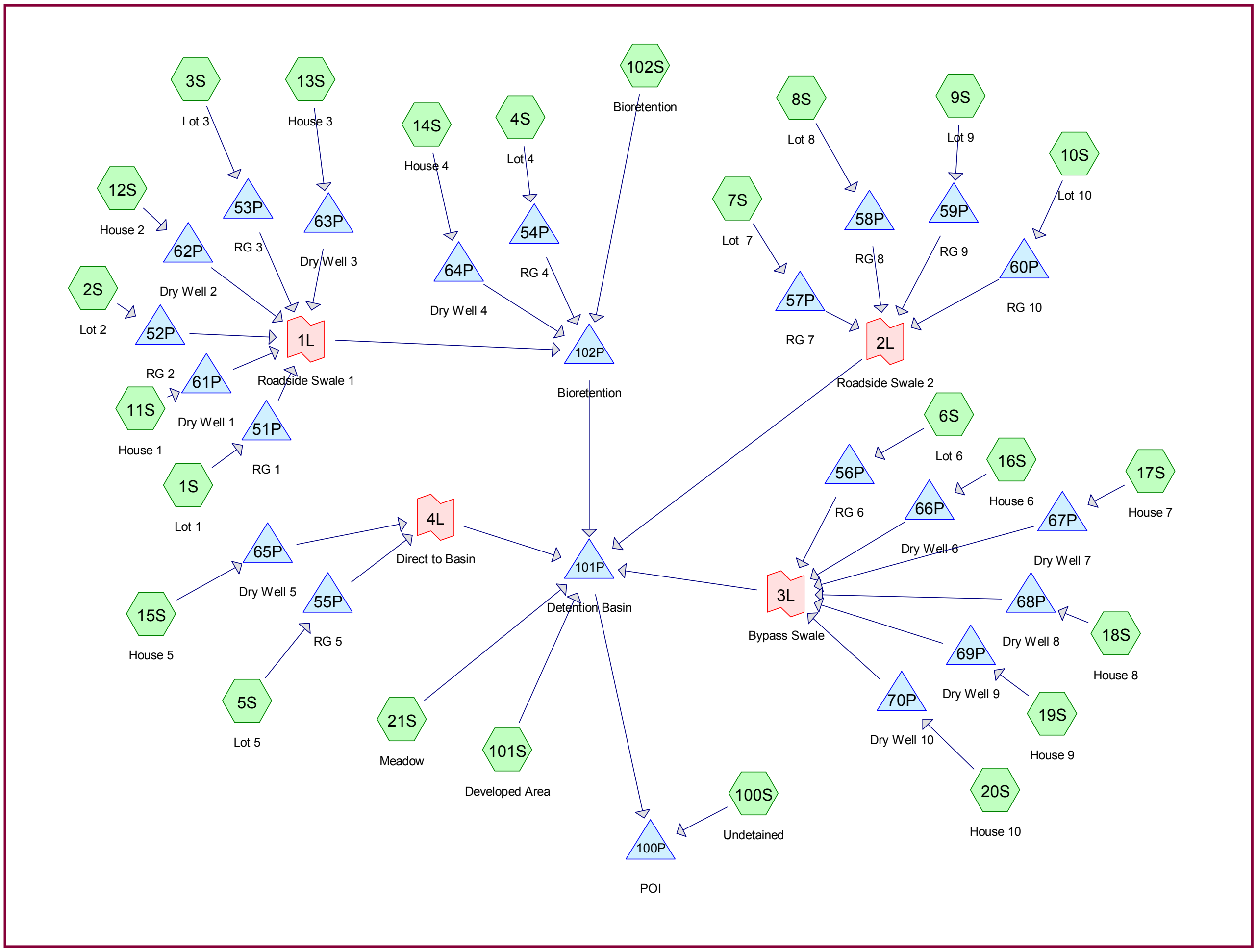


Figure B.1. Hydrologic Model of Post-Development Conditions

This model was used to estimate the post-development peak rate flows. The final configuration of the outlet structure was completed through an iterative process using the results of the model runs. This design meets the peak rate control requirements through a combination of volume removed by the structural `BMPs and the detention basin and outlet control structure. *Table B.2* shows a summary of the runoff results for the final post-development design:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.4	4.1	7.4	10.6	15.2
Runoff Volume (ac-ft)	0.079	0.147	0.445	0.717	1.011	1.367
Runoff Depth (in)	0.12	0.22	0.66	1.06	1.50	2.03

Table B.2. Summary of Post-Development Runoff with Stormwater Controls

INITIAL CONSTRUCTION COST - DESIGN EXAMPLE

Initial construction costs were estimated for each layout. The estimates include the costs incurred by the developer to complete earthwork, paving and curbing, and stormwater management facilities. All of these costs are summed to determine an initial construction cost for these facilities. This cost was then divided by the total sellable acreage of the project to determine a cost / sellable acre for each layout.

Estimate of Initial Construction Cost ***Mill Run Residential – Traditional Layout***							
ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE		EXTENSION	
EARTHWORK				**Subtotal =**		**$**	**23,950**
1	Clearing & Grubbing	2.3	AC	$	6,000.00	$	13,800
2	Topsoil Removal/Stockpiling	5.8	AC	$	1,750.00	$	10,150
STORM DRAINAGE				**Subtotal =**		**$**	**102,769**
3	Storm Sewer, 18" HDPE	600	LF	$	55.00	$	33,000
4	Storm Inlets	7	EA	$	2,100.00	$	14,700
5	Swales	490	LF	$	10.00	$	4,900
6	Install Detention Basin	1,525	CY	$	25.00	$	38,125
7	Anti Seep Collars	2	EA	$	775.00	$	1,550
8	Outlet Structure	1	EA	$	4,000.00	$	4,000
9	Outlet Pipe, 18" HDPE	50	LF	$	55.00	$	2,750
10	DW Endwall 24"	1	EA	$	2,750.00	$	2,750
11	Rip Rap Apron	144	SF	$	6.90	$	994
PAVING & CURBING				**Subtotal =**		**$**	**138,657**
12	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	2,325	SY	$	30.00	$	69,750
13	Curbing w/Excavation & Backfill	1,465	LF	$	27.00	$	39,555
14	Sidewalk plain w/4" - stone	4,285	SF	$	6.85	$	29,352
				Initial Construction Cost =		**$**	**265,376**
				Cost / Sellable Acre =		**$**	**42,734**

Table B.3. Estimate of Construction Cost for Residential Design Example (Traditional Layout)

DRAFT

ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
	Estimate of Initial Construction Cost ***Mill Run Residential – LID Layout***				
	EARTHWORK			**Subtotal =**	**$ 14,925**
1	Clearing & Grubbing	1.0	AC	$ 6,000.00	$ 6,000
2	Topsoil Removal/Stockpiling	5.1	AC	$ 1,750.00	$ 8,925
	STORM DRAINAGE			**Subtotal =**	**$ 114,172**
3	Swales	1,620	LF	$ 10.00	$ 16,200
4	Storm Sewer, 18" HDPE	136	LF	$ 55.00	$ 7,480
5	DW Headwall 18"	1	EA	$ 2,750.00	$ 2,750
6	Storm Inlets	1	EA	$ 2,100.00	$ 2,100
7	Install Detention Basin	600	CY	$ 25.00	$ 15,000
8	Anti Seep Collars	2	EA	$ 775.00	$ 1,550
9	Outlet Structure	1	EA	$ 4,000.00	$ 4,000
10	Outlet Pipe, 18" HDPE	50	LF	$ 55.00	$ 2,750
11	Level Spreader	44	LF	$ 5.50	$ 242
12	Bioretention Area	5,175	SF	$ 12.00	$ 62,100
	PAVING & CURBING			**Subtotal =**	**$ 53,790**
13	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	1,645	SY	$ 30.00	$ 49,350
14	Gravel Shoulder	370	SY	$ 12.00	$ 4,440
				Initial Construction Cost =	**$ 182,887**
				Cost / Sellable Acre =	**$ 28,355**

Table B.4. Estimate of Construction Cost for Residential Design Example (LID Layout)

The cost of constructing the stormwater BMPs on each individual lot was not included in the comparison of initial construction costs. This is a cost that will be borne by the owner of each individual lot. This must be included in the cost comparison analysis. *Table B.5* shows an estimate of these costs.

ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
	Estimate of Stormwater BMP Construction Cost ***Mill Run Residential – LID Layout***				
	STORMWATER BMPS				
1	Rain Gardens	6,740	SF	$ 10.00	$ 67,400
2	Dry Wells	450	CY	$ 32.00	$ 14,400
				Construction Cost =	**$ 81,800**
				Cost / Sellable Acre =	**$ 12,682**

Table B.5. Estimate of Stormwater BMP Construction Cost

Determining how this additional cost to homeowners will be reflected in the market value of developed land is presumptive at best. For this example, we have assumed that some of the cost of constructing the stormwater BMPs will result in a dollar for dollar reduction in the market value of the sellable land. So, the BMP construction cost per sellable acre is subtracted from the per acre market value price of the land.

The initial construction cost is subtracted from the land sale value to determine the developers profit for each layout.

Cost = Land Sale Value - Initial Construction Cost

Traditional Layout
Cost = $310,500 - $265,376
= $45,124

LID Layout
Cost = $240,701 – $182,887
= $57,814

The final cost comparison is completed by determining the difference in profit between the two layouts. For this example, a total profit increase of $12,690 is realized by the developer using the LID layout with no additional cost to the individual homeowners.

Appendix C – Significant Problem Area Modeling and Recommendations

The following is a more detailed overview for each problem area and obstruction. *Plates 7A, 7B, 7C, and 7D* illustrate the location of the reported problem areas and obstructions throughout the county.

Due to funding constraints, no individual solutions were proposed.

Problem Area Hydrology

Although no hydrology was developed for the individual problem areas, the modeling effort as described in *Section 6* provided discharge estimates at some problem area locations, indicated in Table C.1.

Problem Area	Cumulative Area (mi^2)	2010 Discharges with Existing SWM (cfs)					Data Source
		2-Year	10-Year	25-Year	50-Year	100-Year	
CO002	2.76	160	340	532	549	610	HEC-HMS
CP080	0.85	92	140	181	209	223	HEC-HMS
CP029	1.32	98	192	258	303	350	HEC-HMS
CP078	69.08	1,509	2,499	3,313	3,754	4,214	HEC-HMS
CP086	82.64	1,621	2,702	3,492	3,893	4,393	HEC-HMS
CO006	3.63	206	454	607	699	817	HEC-HMS
CO007	3.65	227	452	580	650	799	HEC-HMS
CO026	1.05	92	194	246	281	337	HEC-HMS
CP052	1.52	125	259	331	380	452	HEC-HMS
CP054	3.20	82	120	181	233	310	HEC-HMS
CO014	3.92	288	482	651	755	757	HEC-HMS
CP003	3.83	252	686	957	1,164	1,335	HEC-HMS
CP106	2.47	182	324	440	517	526	HEC-HMS
CP110	1.60	104	177	233	257	330	HEC-HMS
CP112	1.47	53	71	107	126	186	HEC-HMS
CP168	1.56	123	335	465	570	687	HEC-HMS
CP209	819.42	11,584	19,164	23,652	26,541	29,656	HEC-HMS

Table C.1. Problem Area Hydrology

Hydraulics

Due to funding constraints, no hydraulic calculations were provided at individual problem areas.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CO001

Location: Kennedy Hill Rd **Stream:**

Problem Description:

Culvert appears undersized. There is currently a law suit against the Township by property owner. Runoff is channeled to culvert by open 2.5' CMP pipe.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Rome Township

ID: CO002

Location: Hummer Creek

Stream:

Problem Description:

Beaver dam. Evidence of flooding in the floodplain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Woodcock Township **ID:** CO003

Location: Georgia Pl **Stream:** Unnamed Trib to To French Cr

Problem Description:

Waterway is full of gravel.

Crawford County Act 167 Plan

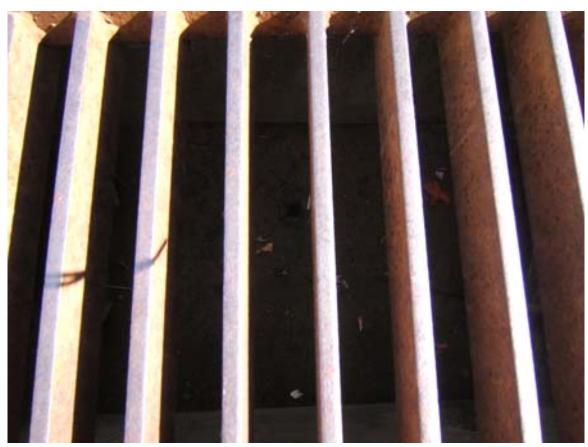
Problem Area Summary

Municipality: Townville Borough **ID:** CO004

Location: In Front of Fire Dept **Stream:**

Problem Description:

Inlet floods. Storm drain appears to be inadequate.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CO005

Location: Hill Rd **Stream:**

Problem Description:

Beaver dam; problem appears to have been addressed.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Athens Township **ID:** CO006

Location: Ongley Rd **Stream:**

Problem Description:

Flooding. A second culvert is located at 0.3% slope, 4' diameter and is 40' long.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CO007

Location: Inlet Run **Stream:**

Problem Description:

Bridge.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CO008

Location: Scott Rd **Stream:**

Problem Description:

Installed riprap at inlet. It appears Township poured concrete at intake of culvert to provide erosion protection. This should be modeled with no tailwater since there is a 3' drop at outfall.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CO009

Location: Marshall Rd **Stream:**

Problem Description:

No defined outlet.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CO010

Location: Mike Wood Blvd **Stream:**

Problem Description:

Culvert appears to be undersized; upstream and downstream channel require maintenance and cleaning; flooding results.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CO011

Location: Adams Rd **Stream:**

Problem Description:

Beaver dam.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CO012

Location: Sunset Dr **Stream:**

Problem Description:

Beaver dam.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CO013

Location: W State Rd **Stream:**

Problem Description:

Culvert appears to be undersized; upstream and downstream channel require maintenance and cleaning; flooding results.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Fairfield Township **ID:** CO014

Location: ST RT 0285 **Stream:**

Problem Description:

Bridge opening appears to be too small to convey flooding. It is in poor condition. Upstream sediment is deposited at the bridge. The solution needs to include upstream stabilization.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CO015

Location: Pastorius Rd **Stream:**

Problem Description:

Erosion of unstable roadside ditches.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CO016

Location: West Forest Rd **Stream:**

Problem Description:

Beaver dam.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CO017

Location: Fry Rd **Stream:**

Problem Description:

Beaver dam; does not appear to significantly impact flow at roadway crossing.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Saegertown Borough **ID:** CO018

Location: Erie St **Stream:**

Problem Description:

Bridge appears to have insufficient hydraulic capacity. The stream channel is severely incised and there is significant bank erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Springboro Borough **ID:** CO019

Location: Pearl St **Stream:** N/A

Problem Description:

Culvert is obstructed with sediment and debris.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: South Shenango Townsh **ID:** CO020

Location: ST RT 3010 **Stream:**

Problem Description:

Culvert appears to be collapsing. This 15" RCP culvert runs underneath existing garage structure.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Troy Township **ID:** CO021

Location: Fint Rd **Stream:**

Problem Description:

Beaver dam. No visual evidence of flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Troy Township **ID:** CO022

Location: Bowmaster Rd **Stream:**

Problem Description:

Beaver dam.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CO023

Location: N Mercer **Stream:**

Problem Description:

Culvert flows to downstream inlet box. It has a trash rack over the grate but large debris is visible in the inlet.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Venango Township **ID:** CO024

Location: Cemetery Rd **Stream:** Unnamed Trib to To Colter Run

Problem Description:

Beaver dam.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Conneaut Lake Borough **ID:** CO025

Location: Strawberry Ln/Alley **Stream:** N/A

Problem Description:

Ponding of water along 4th St from Strawberry Ln to ST RT 6; Storm sewer running along Strawberry Lane from 4th St to Conneaut Outlet pipe is too small according to Borough.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Conneaut Lake Borough **ID:** CO026

Location: Sr 0322 **Stream:**

Problem Description:

Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City

ID: CO027

Location: West End Cemetery

Stream:

Problem Description:

Culverts appear to be undersized. This is causing stream instability (erosion and sedimentation).

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP001

Location: Trib Of French Creek **Stream:**

Problem Description:

Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP002

Location: Main St **Stream:**

Problem Description:

The roadway elevation appears to be below the water surface elevation of Conneaut Marsh.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP003

Location: Mt Pleasant Rd **Stream:**

Problem Description:

Flooding and erosion around site. Beaver dams are present upstream and downstream of bridge. The area is in the floodplain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP004

Location: Wilson Chutes Rd **Stream:**

Problem Description:

Road floods frequently resulting in road closings.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP005

Location: Perry Highway At Conneaut Ma **Stream:**

Problem Description:

Road floods frequently resulting in road closings. Conneaut Marsh rises above ST RT19 (Perry Highway) and block road passage.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP006

Location: Shafer And Towpath Rd **Stream:**

Problem Description:

Frequent flooding and erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP007

Location: Wightman Rd **Stream:**

Problem Description:

Frequent flooding. Area is in the floodplain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP008

Location: Campground At French Creek **Stream:**

Problem Description:

Flooding. area is in the floodplain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP009

Location: Zimmer Hill To Towpath Rd **Stream:**

Problem Description:

Steep channel is severely eroded.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fallowfield Townshi **ID:** CP010

Location: Pine Rd **Stream:**

Problem Description:

Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fallowfield Townshi **ID:** CP011

Location: Pine Rd **Stream:**

Problem Description:

Site of debris accumulation. It appears debris has recently been removed.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fallowfield Townshi **ID:** CP012

Location: Cole And Horne Rd **Stream:**

Problem Description:

Vegetation is overtaking the roadside channels in this area. Maintenance is necessary to correct problem.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fallowfield Townshi **ID:** CP013

Location: Laird Rd **Stream:**

Problem Description:

15" HDPE under the road does not have an outlet. Area is a low lying wetland. A possible solution would be to convey water under Adams Road. or provide area for infiltration or storage along Laird Road.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fallowfield Townshi **ID:** CP014

Location: Thomas Rd **Stream:**

Problem Description:

Frequent flooding. Area is in the floodplain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fallowfield Townshi **ID:** CP015

Location: Countyline Rd **Stream:**

Problem Description:

Frequent flooding. Area is in the floodplain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Woodcock Township **ID:** CP016

Location: Stoltz Rd **Stream:** Unnamed Trib to To Woodcock

Problem Description:

Erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Woodcock Township **ID:** CP017

Location: German Rd **Stream:** Woodcock Creek

Problem Description:

Road embankment has spring seepage. The embankment becomes unstable during spring melt and erodes.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Woodcock Township **ID:** CP018

Location: Huson Rd **Stream:**

Problem Description:

Culvert appears to be undersized.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Woodcock Township **ID:** CP019

Location: Theuret Hill Rd **Stream:**

Problem Description:

Poor drainage.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough **ID:** CP020

Location: W Fremont St **Stream:**

Problem Description:

Frequent flooding, erosion, and ice jams.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough **ID:** CP021

Location: Arnold Dr **Stream:**

Problem Description:

Gravel parking area at Hazlett Sales is eroding and beginning to deposit onto Arnold Drive.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough **ID:** CP022

Location: Main St **Stream:**

Problem Description:

Runoff from neighboring property across from Hanna's Hardware ponds on Main Street.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough **ID:** CP023

Location: Cherry Ln **Stream:**

Problem Description:

Culvert appears to be corroding and in poor condition.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough **ID:** CP024

Location: W Fremont St **Stream:**

Problem Description:

Bridge appears to be in poor condition.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough **ID:** CP025

Location: E Fremont St **Stream:**

Problem Description:

Bridge appears to be in poor condition.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough **ID:** CP026

Location: E Fremont St **Stream:**

Problem Description:

Swales near E. Fremont Street appears to convey runoff sufficiently.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Townville Borough

ID: CP027

Location: Main St

Stream:

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CP028

Location: Dicksonburg Rd & Inlet Rd **Stream:** N/A

Problem Description:

Culverts are needed under Inlet Road to the East and West of Dicksonburg Road.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CP029

Location: Morris Rd **Stream:**

Problem Description:

There is no defined downstream channel after the flow crosses Morris Road. The results is upstream flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CP030

Location: Inlet Rd **Stream:** N/A

Problem Description:

Road flooding resulting from field runoff in two locations. There is a high point between edge of road and roadside ditches.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CP031

Location: Crozier Rd **Stream:**

Problem Description:

Frequent erosion problems.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CP032

Location: Canal Rd **Stream:** Unnamed Trib to Conneaut Cre

Problem Description:

The culvert under the railroad and Canal Road has recently been replaced. The problem appears to have been addressed.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CP033

Location: Fish Creek **Stream:**

Problem Description:

Roadway damage from erosion. Steel culverts are collapsing causing roadway damage. Concrete debris at outlet may be causing capacity issues during storm events.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summerhill Township **ID:** CP034

Location: Canal Rd **Stream:**

Problem Description:

Flooding of roadway. Upstream and downstream of culvert are sumped. The upstream and downstream channels are poorly defined and choked with sediment.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Athens Township **ID:** CP035

Location: Hamilton Rd **Stream:** Muddy Creek

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Athens Township **ID:** CP036

Location: Dewey Rd **Stream:**

Problem Description:

Beaver Dam. Runoff is undermining Dewey Road due to beaver activity.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Athens Township **ID:** CP037

Location: Dewey Rd **Stream:**

Problem Description:

Roadway damage from erosion. Problem has recently been corrected.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Athens Township **ID:** CP038

Location: Cemetery Rd **Stream:**

Problem Description:

Road closed due to bridge in poor condition on Back Dirt Road.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Steuben Township **ID:** CP039

Location: Mystic Park Rd **Stream:**

Problem Description:

Frequent flooding. The road is located in the floodplain. Severe bank erosion has occurred due to constricted flow and high velocities.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Steuben Township **ID:** CP040

Location: Old Grade Rd **Stream:** N/A

Problem Description:

Frequent flooding resulting from no downstream channel.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Steuben Township

ID: CP041

Location: Mercer Rd

Stream: N/A

Problem Description:

See CP179.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Steuben Township **ID:** CP042

Location: Wheelock Rd **Stream:**

Problem Description:

Culvert has collapsed. Sediment is also blocking flow passage.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP043

Location: Porter Rd **Stream:** N/A

Problem Description:

Runoff from road is eroding bank along east side of road.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP044

Location: Faust Rd **Stream:**

Problem Description:

Runoff from road shoulder is eroding and depositing at the culvert inlet.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP045

Location: Faust Rd **Stream:**

Problem Description:

No visual evidence of severe erosion was found around culvert. Area is heavily vegetated and difficult to observe.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP046

Location: Hindman Rd **Stream:**

Problem Description:

Beaver Dam was reported but it was not found during field inspection.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP047

Location: Agnew Rd **Stream:** Conneaut Creek

Problem Description:

Bridge was recently rehabilitated. Upstream streambank was improved and riprap was added to bank. Some sediment deposition was noted in stream channel under the bridge.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP048

Location: Gibson Rd, Gibson Park **Stream:** Pine Run

Problem Description:

Stream bank erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP049

Location: Port Ave **Stream:** N/A

Problem Description:

Frequent flooding; Entire Area is low lying and only slightly above the water level of the lake.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** CP050

Location: Walnut & 4th St **Stream:** N/A

Problem Description:

Frequent flooding; swales along road with no outlets.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP051

Location: Mcmichael Rd **Stream:**

Problem Description:

Erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP052

Location: Mill Rd & Main St **Stream:**

Problem Description:

Frequent flooding.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP053

Location: Capt Williams Rd **Stream:**

Problem Description:

Problem area (erosion) has recently been repaired.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP054

Location: Rock Creek **Stream:**

Problem Description:

Bridge may be in need of replacement or rehabilitation. No flooding reported.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP055

Location: Mercer Pike **Stream:**

Problem Description:

Beaver Dam was reported but it was not found during field inspection.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP056

Location: Mattocks Rd **Stream:**

Problem Description:

Bridge may be in need of replacement or rehabilitation. No flooding reported.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP057

Location: Brick Church Rd **Stream:**

Problem Description:

Bridge headwalls. bridge is in poor condition. no flooding reported.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP058

Location: Williams Rd **Stream:**

Problem Description:

Old stone culvert.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Greenwood Township **ID:** CP059

Location: Miller Rd **Stream:**

Problem Description:

Beaver Dam was reported but it was not found during field inspection.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CP060

Location: Quick Run **Stream:**

Problem Description:

Significant erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CP061

Location: Trib Of Sugar Run **Stream:**

Problem Description:

Area overgrown cattle are crossing the stream.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CP062

Location: Bush Rd **Stream:**

Problem Description:

Streambank erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CP063

Location: Bush Rd **Stream:**

Problem Description:

Streambank erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Shenango Townshi **ID:** CP064

Location: West Lake Rd **Stream:**

Problem Description:

High velocity of flow during storm events cause severe erosion and is a safety danger.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Rockdale Township **ID:** CP065

Location: Mier Station Rd **Stream:** Kelly Run

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Rockdale Township **ID:** CP066

Location: Miller Station Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP067

Location: Boghollow Rd **Stream:**

Problem Description:

Significant erosion.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP068

Location: N Goodwill Rd **Stream:**

Problem Description:

Significant erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP069

Location: Gilson Ridge Rd **Stream:**

Problem Description:

Frequent flooding; Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP070

Location: Finney Rd **Stream:**

Problem Description:

Frequent flooding; Culvert pipe is crushed and is obstructing the flow.

Crawford County Act 167 Plan

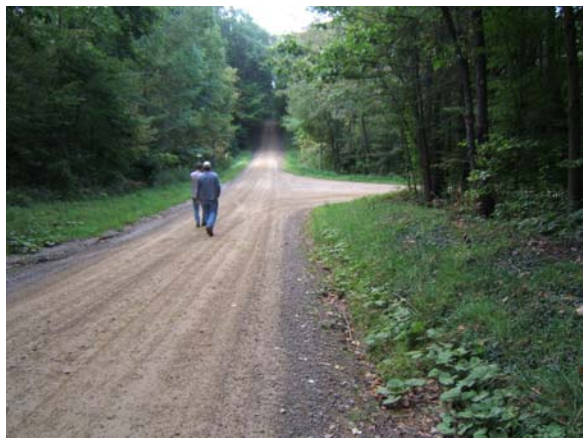
Problem Area Summary

Municipality: Oil Creek Township **ID:** CP071

Location: Kinsack Rd **Stream:**

Problem Description:

Erosion.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP072

Location: Foote Rd **Stream:**

Problem Description:

Previous dirt and gravel roads project consisting of underdrains in the road ditches. The road surface is eroding and is depositing in the road ditches.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP073

Location: Cherrytree Rd **Stream:**

Problem Description:

Roadside ditches are eroded and usually filled with water.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP074

Location: Dotyville Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP075

Location: Duncan Rd **Stream:** Unnamed Trib to To Pine Cree

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Oil Creek Township **ID:** CP076

Location: Mckinney St **Stream:**

Problem Description:

An unstable road ditch with no erosion protection. Additional flow outlets are needed at various locations.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP077

Location: Center Rd **Stream:** N/A

Problem Description:

Frequent flooding; 15" CMP under roadway with very small effective flow area. The flow may also be restricted by 12" diameter SDR culvert immediately downstream.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP078

Location: Creek Rd **Stream:** Cussewago Creek

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP079

Location: Game Rd **Stream:** N/A

Problem Description:

Problem appears to have been repaired recently. It appears that runoff from ST RT 98 causes erosion at intersection.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP080

Location: Fry Rd **Stream:** N/A

Problem Description:

Roadway damage from erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP081

Location: Hecker Rd **Stream:** N/A

Problem Description:

Roadway damage from erosion; no evidence of roadway erosion during site visit.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP082

Location: West Center Rd **Stream:** N/A

Problem Description:

Road and ditch erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP083

Location: Hecker Rd **Stream:** N/A

Problem Description:

Roadway damage from erosion; no evidence of roadway erosion during site visit.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cussewago Township **ID:** CP084

Location: Hillview Rd **Stream:**

Problem Description:

Erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Saegertown Borough **ID:** CP085

Location: ST RT 0198 **Stream:**

Problem Description:

Diffuse drainage; very flat shoulder area, and insufficient structures. With no proper drainage structure, water regularly ponds along the roadway.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Hayfield Township **ID:** CP086

Location: ST RT 0198 **Stream:** Cussewago Creek

Problem Description:

Bridge debris.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Springboro Borough **ID:** CP087

Location: ST RT 0018 **Stream:**

Problem Description:

Unstable stream banks. Stream assessment needed.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Springboro Borough **ID:** CP088

Location: Union St **Stream:** N/A

Problem Description:

Culvert runs parallel to street and discharges into an inlet box. Culvert inlet is clogged with sediment and debris.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Springboro Borough **ID:** CP089

Location: Depot St **Stream:**

Problem Description:

Culvert is clogged with debris.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Springboro Borough **ID:** CP090

Location: ST RT 0018 **Stream:** Unnamed Trib to Conneaut Cre

Problem Description:

Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Springboro Borough **ID:** CP091

Location: Beaver St **Stream:**

Problem Description:

Culvert has some sediment accumulation.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP092

Location: Konneyaut Tr **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

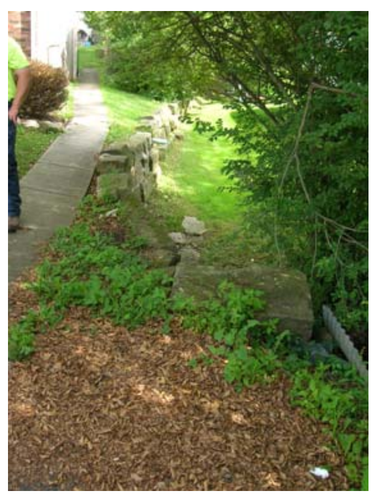
Problem Area Summary

Municipality: Sadsbury Township **ID:** CP093

Location: **Stream:**

Problem Description:

Roadway / home flooding; Township has since fixed the problem by replacing an undersized culvert.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP094

Location: Lakeview Dr **Stream:**

Problem Description:

Roadway / home flooding. This is an outlet area from CP188. Several pipes are located under cottages.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP095

Location: Lakes Side Acres Subdivision **Stream:**

Problem Description:

Roadway / home flooding; general flooding of entire residential area.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP096

Location: Third St **Stream:**

Problem Description:

Roadway / home flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP097

Location: Oakmont Dr **Stream:**

Problem Description:

Severe runoff volume issues, entire area is affected, no specific problem sites.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: South Shenango Townsh **ID:** CP098

Location: Winthrop Ln **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: South Shenango Townsh **ID:** CP099

Location: Smith Dr **Stream:**

Problem Description:

Frequent flooding.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Centerville Borough **ID:** CP100

Location: Sparta St **Stream:**

Problem Description:

Frequent flooding; outlet of culvert pipe empties into Two Mile Creek. Culvert is partially blocked and the downstream channel is full of sediment.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Centerville Borough **ID:** CP101

Location: Sparta St **Stream:**

Problem Description:

Streambank erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cambridge Springs Boro **ID:** CP102

Location: Mccellan St **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cochranton Borough **ID:** CP103

Location: High School Athletic Fields **Stream:**

Problem Description:

Problem could not be identified at the area of the Cochranton HS athletic fields. The area is flat and may flood from nearby creek.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cochranton Borough **ID:** CP104

Location: North St **Stream:**

Problem Description:

Culvert appears to be undersized.

Crawford County Act 167 Plan

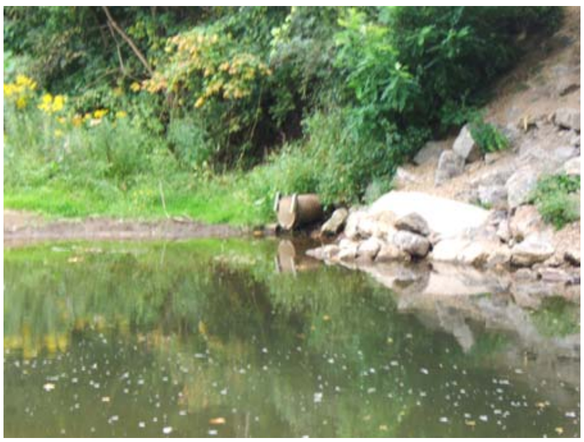
Problem Area Summary

Municipality: Cochranton Borough **ID:** CP105

Location: Cochranton Fairgrounds **Stream:**

Problem Description:

Complaints that the check valve at the end of a stormwater pipe is blocked. The check valve did not appear blocked during the site visit.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Mead Township **ID:** CP106

Location: Shaffer Rd **Stream:**

Problem Description:

Frequent flooding; Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Mead Township **ID:** CP107

Location: South Wayland Rd **Stream:**

Problem Description:

Frequent flooding; Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Mead Township **ID:** CP108

Location: Smith Rd **Stream:**

Problem Description:

Frequent flooding; Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Mead Township **ID:** CP109

Location: North Wayland Rd **Stream:**

Problem Description:

Frequent flooding; Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Mead Township **ID:** CP110

Location: Hobbs Rd **Stream:**

Problem Description:

Beaver dam.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Mead Township **ID:** CP111

Location: Pine Grove Church **Stream:**

Problem Description:

Beaver dam.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Blooming Valley Borough **ID:** CP112

Location: Woodcock Creek **Stream:** Woodcock Creek

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Blooming Valley Borough **ID:** CP113

Location: State St **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Hydetown Borough **ID:** CP114

Location: Patterson Rd **Stream:**

Problem Description:

Streambank erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Hydetown Borough **ID:** CP115

Location: ST RT 0008 **Stream:**

Problem Description:

Frequent flooding; It appears that runoff from a grass lined ditch may carry enough water to overtop culvert. The inlet connected to the culvert is too high to drain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Hydetown Borough **ID:** CP116

Location: ST RT 408 **Stream:**

Problem Description:

Poor drainage. Storm drain pipes are filled with sediment and it appears that more inlets are needed.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Hydetown Borough **ID:** CP117

Location: ST RT 408 **Stream:**

Problem Description:

Frequent flooding reported by no evidence of flooding observed during field visit.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Hydetown Borough **ID:** CP118

Location: ST RT 408 **Stream:**

Problem Description:

Frequent flooding. One inlet filled with sediment. No other problems noted.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Hydetown Borough **ID:** CP119

Location: ST RT 408 **Stream:**

Problem Description:

Roadway erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Wayne Township **ID:** CP120

Location: Deckards Rd **Stream:**

Problem Description:

Existing retaining wall is beginning to collapse. Additional downstream streambank protection/stabilization is needed.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Troy Township **ID:** CP121

Location: Newton Town Rd **Stream:**

Problem Description:

Streambank erosion.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP122

Location: W Erie St Ext **Stream:**

Problem Description:

Frequent flooding. Channel has become overgrown with vegetation. Outlet end of culvert is half covered in debris.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP123

Location: Gilliland Rd **Stream:**

Problem Description:

Frequent flooding; Culvert appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP124

Location: Harmonsburg Rd & ST RT 6 **Stream:** N/A

Problem Description:

Poor drainage at intersection. Water ponds near inlet at intersection. Additional inlet may be needed. The outfall culvert needs to be cleared for debris.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township

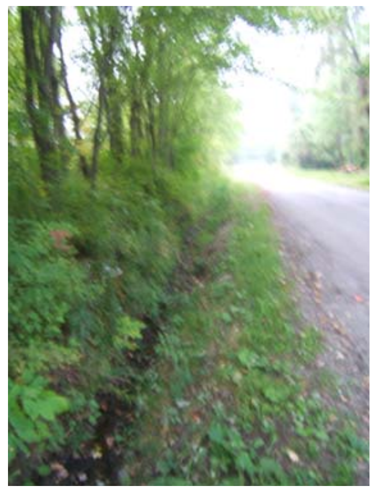
ID: CP125

Location: Lewis Ave

Stream:

Problem Description:

Slight channel erosion along Lewis Ave.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP126

Location: Eveningside Dr **Stream:**

Problem Description:

Channel along Edgewood and Eveningside has an abrupt turn and is beginning to erode at the bend.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP127

Location: Homestead Ave **Stream:** N/A

Problem Description:

Frequent flooding; The upstream channel has some rock/sediment build-up. There is no downstream channel to convey water away from the area, only a low spot to collect water.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP128

Location: Maples St **Stream:**

Problem Description:

The upstream side of road is beginning to erode and accumulate debris.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP129

Location: W Erie St Ext **Stream:**

Problem Description:

Runoff from roadway is eroding the streambank to the downstream channel at culvert crossing.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Pine Township **ID:** CP130

Location: S Chestnut St **Stream:**

Problem Description:

Frequent flooding; All nearby drainage facilities including a 2x2 inlet box and a drainage swale are normally have water. The only down slope is a wetlands area that is usually full.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP131

Location: Stratton **Stream:**

Problem Description:

Frequent flooding; Grass swale between road & baseball field drains to a low area with no outlet. All surrounding drainage facilities are clogged and full of water.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough

ID: CP132

Location: Beach St

Stream: N/A

Problem Description:

Unable to locate during field visit.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP133

Location: N Church St **Stream:** N/A

Problem Description:

Frequent flooding; no visual evidence of flooding although there are several low areas with potential for ponding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough

ID: CP134

Location: S Water St

Stream:

Problem Description:

Frequent flooding; stormwater inlet surcharges and floods the roadway. Outlet is an 8" SDR pipe.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP135

Location: W Pine St **Stream:** N/A

Problem Description:

Frequent flooding; area was historically a wetland area that was filled in. Area collects water in storm events.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP136

Location: N Water **Stream:**

Problem Description:

Frequent flooding; inlet backs up when stream water level rises.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP137

Location: S Chestnut **Stream:** N/A

Problem Description:

Outlet from inlet is 8" SDR. Larger conveyance pipes are most likely needed.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP138

Location: S Chestnut **Stream:**

Problem Description:

Low area with no drainage outlet in the middle of athletic fields.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP139

Location: Penn St **Stream:** N/A

Problem Description:

Frequent flooding; swale floods during storm events.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Linesville Borough **ID:** CP140

Location: Erie St **Stream:**

Problem Description:

Frequent flooding; no visible signs of flooding; photos taken of inlet.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Venango Township **ID:** CP141

Location: Cemetery Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP142

Location: Riceville Rd **Stream:**

Problem Description:

Frequent flooding; no defined roadside channels.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP143

Location: Danner Dr **Stream:**

Problem Description:

Frequent flooding; Sues Mill Road floods in low spots. It appears a berm has been added in front of business to prevent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Cambridge Township **ID:** CP144

Location: Henry Rd **Stream:**

Problem Description:

Culvert that is completely blocked.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP145

Location: Baldwin St **Stream:**

Problem Description:

Frequent flooding. culvert discharges to inlet box.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP146

Location: Thurston Rd **Stream:**

Problem Description:

Erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP147

Location: Park St **Stream:**

Problem Description:

Roadside channel appears to be lined with concrete. No erosion was present during field visit.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP148

Location: Tamarack Dr **Stream:**

Problem Description:

Roadside erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP149

Location: Arthur Hill **Stream:**

Problem Description:

Erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP150

Location: Morgan St **Stream:**

Problem Description:

Frequent flooding; culvert of unknown dimensions and connection appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP151

Location: Alden St **Stream:**

Problem Description:

Problem could not be accessed due to the stream running along private properties.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP152

Location: Baldwin St **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP153

Location: ST RT 0322 **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP154

Location: ST RT 0322 **Stream:**

Problem Description:

Frequent flooding. Area is in the floodplain.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP155

Location: Townline Rd **Stream:**

Problem Description:

Erosion.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: West Mead Township **ID:** CP156

Location: Williamson Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP157

Location: Turtle Lake **Stream:**

Problem Description:

Channel flooding. Area is located very close to wetlands.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP158

Location: Church Rd **Stream:**

Problem Description:

Frequent flooding; backwater from a closed bridge causes flash flooding upstream. Additionally, the roadside channels are eroding.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP159

Location: Church Rd **Stream:**

Problem Description:

Frequent flooding. Channel capacity does not appear to have adequate capacity.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP160

Location: Crom Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP161

Location: Lake Shore Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP162

Location: Lake Shore Rd **Stream:**

Problem Description:

Frequent flooding. Appears to come from downstream source (i.e., backwater).

Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP163

Location: Lake Shore Rd **Stream:**

Problem Description:

Frequent flooding. Culvert in poor condition and appears to be undersized.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: North Shenango Townshi **ID:** CP164

Location: Lake Shore Rd **Stream:**

Problem Description:

Frequent flooding. No defined downstream channel.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Vernon Township **ID:** CP165

Location: Radio Tower Hill **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fairfield Township **ID:** CP166

Location: Little Sugar Creek **Stream:**

Problem Description:

Little Sugar Creek floods and overtops Shaffer Road.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fairfield Township **ID:** CP167

Location: Mud Run **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fairfield Township **ID:** CP168

Location: French Creek **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP169

Location: Church Run **Stream:**

Problem Description:

Stream swells throughout Oil Creek Township.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP170

Location: West End Of Westlawn Cemet **Stream:** Unnamed Trib to To Oil Creek

Problem Description:

Frequent flooding; box culvert appears to have excessive sediment deposition. Forested area in upstream watershed has been heavily logged (see also CO-027).

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP171

Location: Hammond Run **Stream:**

Problem Description:

Water appears to infiltrating into storm drain structures, reducing their hydraulic capacity. Some of the storm drains appear to be very small (e.g., 6" diameter SDR).

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP172

Location: Burgess Park **Stream:**

Problem Description:

Retention area is reported to floods soccer fields & homes.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP173

Location: White Oak Discharge **Stream:**

Problem Description:

Unable to locate during field visit.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP174

Location: Hillside Above East Main St **Stream:**

Problem Description:

Abandoned well. Spring water is now running down roadside ditches.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP175

Location: North Of City **Stream:**

Problem Description:

Diffuse from artesian well.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP176

Location: Myer Complex (Elks) **Stream:**

Problem Description:

Spring flow.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Titusville City **ID:** CP177

Location: 700 Block Rockwood Dr **Stream:**

Problem Description:

Field that has be recently clear-cut for agriculture.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Richmond Township **ID:** CP178

Location: Eddie Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

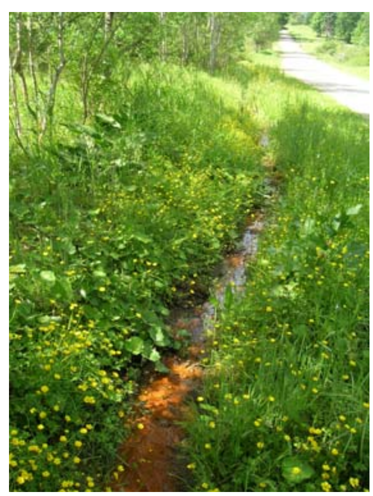
Problem Area Summary

Municipality: Richmond Township **ID:** CP179

Location: Mercer Rd **Stream:**

Problem Description:

Eroded roadside channel.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Richmond Township **ID:** CP180

Location: Mercer Rd **Stream:**

Problem Description:

Eroded roadside channel.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Richmond Township **ID:** CP181

Location: Johnson Rd **Stream:**

Problem Description:

Eroded roadside channel.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Richmond Township **ID:** CP182

Location: Russel Rd - West End **Stream:**

Problem Description:

Guiderail in area appears to be in poor condition. Erosion is occurring downstream.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Richmond Township **ID:** CP183

Location: Carpenter Rd **Stream:**

Problem Description:

Beaver dam.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Richmond Township **ID:** CP184

Location: Lyona Blvd **Stream:**

Problem Description:

Frequent flooding. Invert of 15" HDPE culvert is above road elevation which appears cause flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Richmond Township **ID:** CP185

Location: Stanford Rd **Stream:**

Problem Description:

Roadside channel does not appear to have adequate hydraulic capacity.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP186

Location: Konneyaut Trail **Stream:**

Problem Description:

Frequent flooding; storm sewer network appears to be inadequate and causes flooding. Entire network needs to be analyzed.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP187

Location: Anderson'S Bark Park **Stream:**

Problem Description:

Frequent flooding; existing pond with large drainage area has very little detention capacity. Outlet structure appears to release water without any effect on downstream area. This area is the headwaters to CP190.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP188

Location: Prebor Property **Stream:** N/A

Problem Description:

There are currently no problem as this site. The township is hoping to use this site as a remediation area to reduce downstream flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP189

Location: Victory Family Worship **Stream:**

Problem Description:

There are currently no problems as this site. The township is hoping to use this site as a remediation area to reduce downstream flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP190

Location: Lakeside Acres **Stream:**

Problem Description:

There are currently no problems as this site. The township is hoping to use this site as a remediation area to reduce downstream flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Sadsbury Township **ID:** CP191

Location: Lakeview Dr (T-451) **Stream:**

Problem Description:

There are currently no problems as this site. The township is hoping to use this site as a remediation area to reduce downstream flooding.

Crawford County Act 167 Plan

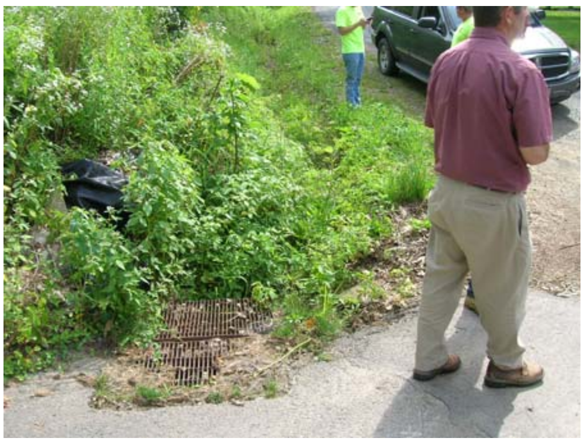
Problem Area Summary

Municipality: Sadsbury Township **ID:** CP192

Location: Oakmont Dr (Private) **Stream:**

Problem Description:

Frequent flooding; Oakmont Dr and Pine Ridge Rd area needs continual maintenance need as the system clogs with sediment and debris from upstream.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP193

Location: Area West Of West View Dr **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP194

Location: South End Of Island Ave **Stream:** North Inlet Run

Problem Description:

Frequent flooding from high lake levels.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP195

Location: Willow Ave **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP196

Location: Int Of Willow And Lakeview Rd **Stream:**

Problem Description:

Frequent flooding. There appears to be no stormwater system.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP197

Location: Lakeview Rd **Stream:**

Problem Description:

Frequent flooding. There appears to be wetland on both sides of the road.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP198

Location: Int of Teddy Dr And Lakeview **Stream:**

Problem Description:

Frequent flooding. There are no stormwater structures and there is little potential for outlets due to level of the lake in relation to flooding site.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP199

Location: Ent To Frog Pong Restaurant **Stream:**

Problem Description:

Frequent flooding. There are no stormwater structures and there is little potential for outlets due to level of the lake in relation to flooding site.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP200

Location: Int Of Circuit Dr And First Ave **Stream:**

Problem Description:

Culvert appears to be undersized; upstream and downstream channel require maintenance and cleaning.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP201

Location: Danner Dr **Stream:**

Problem Description:

Small depressed areas along roadside show evidence of ponding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP202

Location: Westside Dr **Stream:** N/A

Problem Description:

Frequent flooding. Stormwater runoff from Shreve Ridge and Mount Pleasant Rd floods roadway.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP203

Location: Lakeview Dr &Circuit Dr **Stream:**

Problem Description:

Frequent flooding depending on the seasonal water level in nearby lake.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP204

Location: Bottom Of King Rd **Stream:**

Problem Description:

Frequent flooding. There is 2' of water in the culverts prior to storm events.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP205

Location: Lincolnville/Riceville Rd **Stream:**

Problem Description:

Low wetland areas are located along both sides of the road; roadway flooding occurs during storm events.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Bloomfield Township **ID:** CP206

Location: Lincolnville/Riceville Rd **Stream:**

Problem Description:

Exact location of flooding not verified during field visit. Existing PennDOT bridge with some sediment accumulation under bridge. The bridge appears to be in poor condition.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: East Fairfield Township **ID:** CP207

Location: Area @ 24678 Griffin Rd **Stream:**

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Springboro Borough

ID: CP208

Location: Between Union St And Oak St

Stream: Unnamed Trib to Conneaut Cre

Problem Description:

Frequent flooding; The stream runs west from the end of CP090 to Depot St. .

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** CP209

Location: Shilling Rd **Stream:**

Problem Description:

Storm events cause stream erosion. Residents stated that road washed out due to a tree blocking the culvert intake during a 50yr event.

Crawford County Act 167 Plan

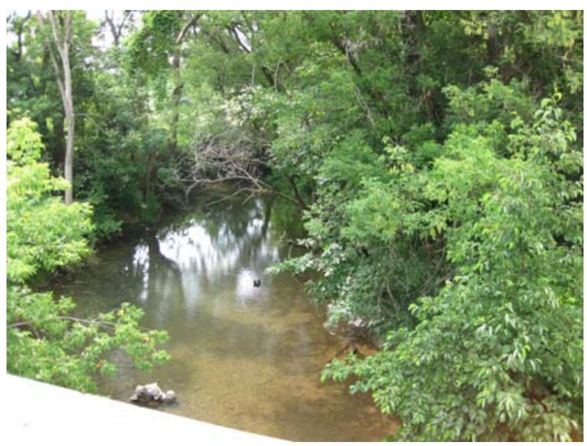
Problem Area Summary

Municipality: Conneautville Borough **ID:** CP210

Location: Jefferson St **Stream:** Conneaut Creek

Problem Description:

Frequent flooding of residential property along stream (north of Mulberry St to south of Center St).



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Conneautville Borough **ID:** CP211

Location: Ponding Along Route 18 **Stream:** N/A

Problem Description:

Inlet along ST RT 18 filled with sediment. There was evidence of ponding along the roadway.

Crawford County Act 167 Plan

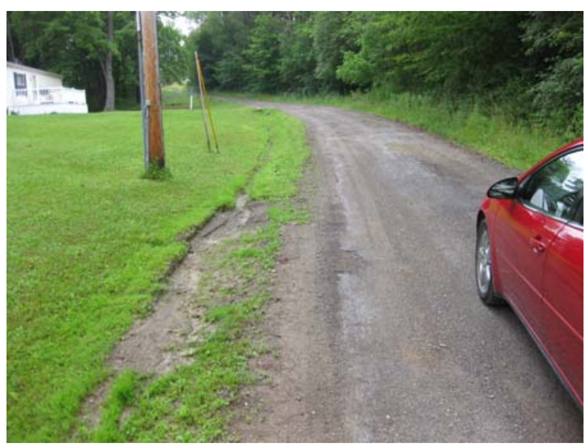
Problem Area Summary

Municipality: Conneautville Borough **ID:** CP212

Location: Prospect St **Stream:** N/A

Problem Description:

Erosion in roadside swales.



Crawford County Act 167 Plan

Problem Area Summary

Municipality: Conneautville Borough **ID:** CP213

Location: Jefferson St **Stream:** N/A

Problem Description:

Erosion in roadside swales.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Conneautville Borough **ID:** CP214

Location: Grove St **Stream:** N/A

Problem Description:

Erosion in roadway and in roadside swale on steep section of gravel road; gravel washes out at intersection with ST RT 18.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: Conneautville Borough **ID:** CP215

Location: Old Linesville Rd **Stream:** Foster Run

Problem Description:

Severe bank erosion threatens integrity of road; stream is at the bottom of a very steep incline and a section of the hillside has collapsed into the stream.

Crawford County Act 167 Plan

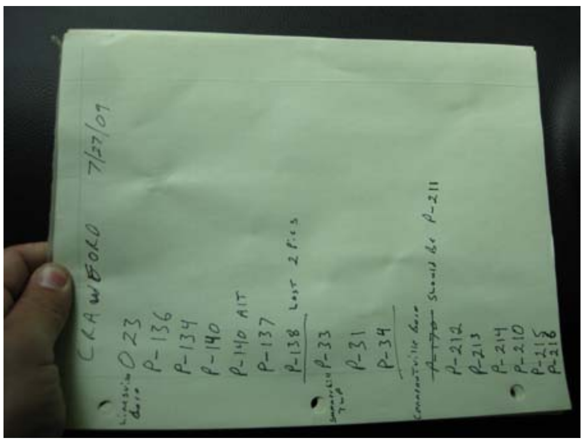
Problem Area Summary

Municipality: Conneautville Borough **ID:** CP216

Location: High St **Stream:** N/A

Problem Description:

Erosion along street; no evidence of erosion on site visit. The problem area may have already been repaired.



Crawford County Act 167 Plan

Problem Area Summary

Municipality:

ID: CP217

Location: North Lake Rd

Stream:

Problem Description:

Frequent flooding.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: ______________________ **ID:** CP218

Location: Grove St To Mill Run **Stream:** Neason Run

Problem Description:

Downstream channel appears to have insufficient conveyance capacity.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: ______________________ **ID:** CP219

Location: Above Rainbow Lake Dam **Stream:** Mill Run

Problem Description:

Emergency spillway is undersized. PADEP is requiring modification to spillway in order to be compliant with conveyance capacity requirements.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: ______

ID: CP220

Location: Stewart Ln Near Walgreens

Stream: Dick Run

Problem Description:

Runoff appears to be piping underneath box culvert.

Crawford County Act 167 Plan

Problem Area Summary

Municipality: ______

ID: CP221

Location: From Jefferson To Mill Run

Stream: Unnamed Trib to Mill Run

Problem Description:

Conveyance system appears to be inadequate near Greendale Cemetery.




Crawford County Act 167 Plan

Problem Area Summary

Municipality: ______________________ **ID:** CP222

Location: Allegheny College **Stream:** Unnamed Trib to French Creek

Problem Description:

Tributary appears to constricted by a box culvert from Terrace Street and under French Creek Parkway.

Appendix D – Natural Resource Activities Impacting Stormwater Runoff

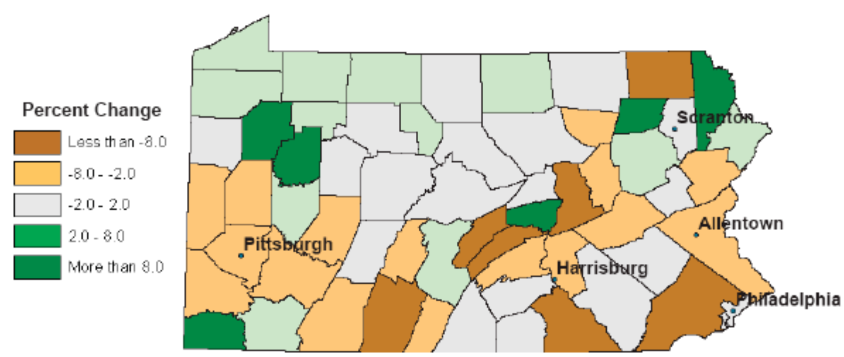
As demonstrated throughout this Plan, land use is a key factor in stormwater runoff. The County and its municipalities have the ability to control most types land use through regulations. The Plan Advisory Committee and the municipalities they represent have identified two types of land uses that greatly effect the water quality and quantity within the watersheds of the County yet they have little ability to control – oil & gas wells and timber harvesting.

Acts 67 and 68 ammendments to the Pennsylvania's Municipalities Planning Code (as part of its 2000 Smart Growth package) limit the regulatory control of municipalities on forestry and timber harvesting.

Oil and gas well development in Pennsylvania is regulated by several chapters of the Pennsylvania Code and various state acts. The state's oil and gas laws (Oil and Gas Act – Act 223, Coal and Gas Resource Coordination Act – Act 214, and Oil and Gas Conservation Law – Act 359), as well as environmental protection laws that include the Clean Streams Law, the Dam Safety and Encroachments Act, the Solid Waste Management Act, and the Water Resources Planning Act give PA DEP the authority to regulate these activities while limiting the regulatory control of municipalities.

FORESTY IN CRAWFORD COUNTY

According to U.S. Forest Service inventories, forest once covered more than 90% (27.3 million acres) of Pennsylvania's land area in the pre-European settlement era (1630s). By the early 1900s, industrial timber harvesting and agricultural land clearing had diminished the forest land base to only 32% (9.2 millions acres). During the 1900's forest land increased steadily and has been relatively stable for the last half century representing 58% of Pennsylvania's land surface.



Change in forest land 1989-2004
(ref. Pennsylvania's 2004 Forest, USDA Forest Service)

Section IX – Natural Resource Activities Impacting Stormwater Runoff

Forestry is an important industry in Pennsylvania where it accounts for 11% of manufacturing jobs. The industry is one of the states largest and produces about $5.5 billion worth of products annually. In some rural areas the forest products industry is the primary source of economic activity.

The northwestern Pennsylvania communities surrounding the Allegheny National Forest (ANF) receive the bulk of their annual funds for schools and roads from payments in lieu of taxes from the federal government and 25% of all timber sale revenues in the ANF. The four counties surrounding the ANF receive $6 million from timber sale receipts. Rural communities also receive in lieu of tax payments for the Commonwealth for having state forest, game and parkland within their borders.

On a national level, forestry management activities contribute approximately 3 to 9% of the nonpoint source pollution to the Nation's waters (USEPA, 1992). Water quality concerns related to forestry were addressed in the 1972 Federal Water Pollution Control Act Amendments and later, more comprehensively, as nonpoint sources under section 208 of the 1977 Clean Water Act and section 319 of the 1987 Water Quality act. Local impacts of timber harvesting and road construction can be severe, especially in smaller headwater streams. Sediment is the primary nonpoint source pollutants associated with forest harvesting. Other NPS pollution includes organic debris, nutrients, and chemicals.

IMPACTS

The major impacts associated with forestry practices and their potential impacts on Crawford County are discussed below. It is noted that none of the stream segments in Crawford County are listed in Pennsylvania's Section 303(d) listing as having forestry as the primary source of water quality problems.

Erosion - In forested areas, runoff is low and sedimentation is a slow, naturally occurring process. Undisturbed forest areas produce a limited amount of runoff and produce very low pollutant loads for nitrogen, phosphorus and sediments. Once the forest cover is removed, stormwater runoff increases and greatly increases erosion. Coupled with this increase in erosion is the increased transport of nutrients, which can account for a drastic increase in the loss of large particulate phosphorus (12 fold increase), mostly as inorganic bedload (Hobbie and Likens, 1973).

Poor timber harvesting practices can increase the sedimentation, which can adversely affect streams, rivers, ponds, and wetlands. While forest management practices do not remove entire forests, erosion and sediment (with the associated loss of nutrients) are the primary potential non-point source pollution problems associated with forest management activities. This is particularly a problem at stream crossings for forest roads and skid trails. The sediment from these areas enters streams and can gradually degrade the water quality of receiving waters. Several studies on forestland erosion have concluded that surface erosion rates on roads often equaled or exceeded erosion reported for severely eroding agricultural lands. These effects are of greatest concern where forestry activity occurs in high quality watershed areas that provide water supplies and/or support cold-water fisheries.

Sediment Loss - Sediment has been identified as a significant water quality issue in the Crawford County watersheds. Sediment is often the primary pollutant associated with forestry activities. Sediment transported into waterbodies can be particularly detrimental to the stream ecosystem, especially to many fish species. Suspended sediments in runoff increase water turbidity limiting the ability of sight-feeding fish to find and obtain food. In addition, the increased turbidity limits the depth to which light can penetrate and adversely affecting aquatic vegetation, increase water temperatures and lower dissolved oxygen concentrations. These effects also compromise recreational values.

When suspended sediment settles, it can fill gravel spaces in streambeds, destroying fish spawning areas and food sources. With large areas of accumulated sediment, the flow capacity of stream channels are reduced and the storage capacity is reduced which leads to increasing flooding and decreased water supplies. In addition, nutrients and other pollutants may become adsorbed to sediment particles and be subsequently transported downstream.

Organic Debris Resulting form Forestry Activities - Organic debris includes residual logs, slash, litter, and soil organic matter generated by forest activities. Logging slash and debris in or near streams can alter stream flows by forming debris dams, and can also redirect flow in the channel, increasing bank cutting and resulting in sedimentation. Organic debris can adversely affect water quality by causing increased biochemical oxygen demand, resulting in decreased dissolved oxygen levels in watercourses.

Temperature - Increased water temperature can result from vegetation removed in the riparian zone from harvesting. These temperatures increases can be dramatic in smaller (lower order) streams, adversely affecting aquatic species and habitat.

Streamflow - Increased stream flow often results from vegetation removal (Likens et al. 1970). Tree removal reduces evapotranspiration, which increases water availability to stream systems. The amount of stream flow increase is related to the total area harvested, topography, soil type, and harvesting practices (Curtis et al. 1990). Increased stream flow can scour channels, erode streambanks, increase sedimentation, and increase peak flows.

FORESTRY ACTIVITIES AFFECTING WATER QUALITY

Many forestry activities lead to water quality issues cited above. The types of forest activities affecting NPS pollution include road construction and use, timber harvesting, mechanical equipment operation.

Roads - Roads are considered to be the major source of erosion from forested lands, contributing the majority of the total sediment production from forestry operations. Erosion potential from roads is accelerated by increasing slope gradients on cut-and fill slopes, intercepting subsurface water flow, and concentrating overland flow on the road surface and in channels.

Timber Harvesting Management - Many detrimental effects of harvesting are related to the access and movement of vehicles and machinery. These effects include soil disturbance, soil compaction, and direct disturbance of stream channels. Poor harvesting and transport techniques can increase sediment production by 10 to 20 times and disturb as much as 40 percent of the soil surface. In contrast, careful logging disturbs as little as 8 percent of the soil surface. Logging operation planning, soil and cover type, and slope are the most important factors influencing harvesting impacts on water quality.

Careful selection of equipment and methods of timber removal from the harvest area to areas where logs are gathered can significantly reduce the amount of soil disturbed and delivered to water bodies. Stream channels should be protected from logging debris at all times during harvest operations.

RECOMMENDED BMP'S FOR FORESTRY ACTIVITIES

The means of minimizing impacts of Forestry Activities begins with proper planning and the use appropriate, or best management practices (BMPs). These are simple, often low cost practices and techniques that can be incorporated in timber harvesting practices. The following guidance is provided to assist the harvester as well as the land owner and municipality.

Planning

Purpose	To minimize pollutant delivery to waterbodies and to protect riparian buffer areas.
Target Pollutant	Primarily sediment. Organic matter, thermal modification, nutrients pesticides and toxics are also controlled.
Description	Proper planning of harvest operations involves the thorough collection and use of information about the harvest area. The plan integrates the need of the managed forest with the need to protect water resources.

Riparian Buffer Protection

Purpose	Maintain filtering and thermal buffering capabilities
Target Pollutant	Primarily sediment, organic matter and thermal modification. Nutrients, pesticides and toxics are also controlled.
Description	Riparian buffer protection involves the identification and preservation of corridors along streams and other water bodies. Standard buffer distances are designated.

Planned watercourse crossing

Purpose	To prevent damage to bed and banks of streams.
Target Pollutant	Sediment, fuel and lubricants.
Description	Planned watercourse crossings may be bridges, culverts, or fords installed for use as skidders, trucks, and other logging vehicles.

Planned access routes

Purpose	To minimize the potential for sediment delivery from logging access routes to waterbodies.
Target Pollutant	Sediment
Description	Determining the size, location and future use of the area to be harvested plans access routes.

Road Water Management

Purpose	To minimize sediment delivery from roads and trails to waterbodies and other roads
Target Pollutant	Sediment
Description	Road water management involves the properly integrated use of component measures such as drainage dips, turnouts, water bars, cross-drain culverts, road ditches and road grading.

Vegetation Restoration

Purpose	To stabilize erodible areas and prevent sediment and nutrients from entering waterbodies.
Target Pollutant	Sediment and nutrients; runoff volume
Description	Vegetation establishment involves the rough grading, mulching, and application of lime, fertilizer and seed to exposed forest soils.

GAS WELL DEVELOPMENT

The Marcellus Shale underlies approximately two-thirds of Pennsylvania and portions of New York and West Virginia between 5,000 to 8,000 feet below the surface. In 2002, the United States Geological Survey's Assessment of Undiscovered Oil and Gas Resources of the Appalachian Basin Province calculated that the Marcellus Shale contained an estimated undiscovered resource of about 1.9 trillion cubic feet of gas.

In 2003 Range Resources – Appalachia, LLC drilled a Marcellus well in southwestern Pennsylvania and found a promising flow of natural gas. Once thought cost prohibitive to extract, recent advances in drilling technology that worked in the Barnett Shale of Texas as well as increased natural gas prices have created a boom industry with more than 375 gas wells permitted in Pennsylvania.

Purpose and Assumptions
The purpose is to share and encourage the use of best practices that will promote the sound, efficient, and environmentally appropriate development of Marcellus Shale natural gas resources. It is hoped that by applying BMPs, conflicts will be reduced, the environment will be conserved, and efficiencies in production are realized. Utilizing these practices may require more effort early in the Marcellus Shale Gas development process, but the benefits will mitigation of environmental impacts and increased economic efficiencies.

The Marcellus Shale Gas development entails the construction of new roads, pipelines, compressors, water impoundments, and other facilities and will change landscapes. The development of this resource may cover extensive areas and requires the use of large amounts of water. Marcellus Shale Gas development in Pennsylvania is a matter of local, regional, and national interest.

Although BMPs do not replace state and federal requirements, their use will aid in compliance. While the Guidance and BMPs can be broadly applicable, each location is different and will present different challenges. Some or all of the Guidance and BMPs presented may or may not be applicable for some locations.

PLANNING

Planning is essential to successful Marcellus Shale Gas development which provides significant benefits, both environmentally and economically. Objective planning that considers many various interests is essential to effectively address aspects of a project that could otherwise become challenging issues.

GUIDANCE: Develop plans to provide a comprehensive description of the characteristics of the area, along with the anticipated nature of Marcellus Shale Gas development. Planning needs will differ by location and should be applied in different ways, depending on such things as subsurface geology, terrain, and land use. Plans could be complex or simple, depending upon the circumstances, and will need to be customized to fit the individual conditions within a Marcellus Shale Gas project.

The following items should be included in the plan:

- Identification of land ownership
- Identification of existing and expected surface uses (including number and spacing of wells, roads, pipelines, water disposal and treatment facilities, compression facilities, gathering and transmission pipelines, etc.)

- Identification of existing and required infrastructure and utility corridors
- Map of the area with location of existing facilities (i.e., wells) and potential (optimal) locations for future facilities, including production facilities (wellsites, processing units, etc.), roads, and utility corridors. The map should include geographic features such as streams and other water bodies, and special ecosystems, as well as topographic information.
- Identification of opportunities to avoid, reduce, and mitigate adverse impacts
- Identification of regulatory requirements
- Water management plan (strategy)
- Identification of strategies for reclamation of disturbed areas
- Consider a strategy for establishing a baseline and monitoring and steps to apply monitoring information to existing and future actions

A development plan established during the early stages of anticipated development provides the framework for avoiding or minimizing surface disturbance, protecting other resources, mitigating environmental impacts, and alleviating or addressing concerns of landowners and communities. It serves as a tool for comprehensive, coordinated planning to guide strategic development. It can also assist in meeting the requirements of the Clean Water Act, the Clean Air Act, the Endangered Species Act, and other applicable federal, and state laws.

BMP's:

Non-Structural (refer to PA BMP Manual)
BMP 4.3.1. Background Site Factors
BMP 4.3.2. Site Factors Inventory
BMP 4.3.3. Site Factors Analysis

Protection of Wetland/Riparian Areas

GUIDANCE: To protect the ecological function and hydrologic features of riparian areas, wetlands, and floodplains, locate all well pads and other nonlinear facilities outside a buffer-zone of these areas.

GUIDANCE: Avoid crossings of wetland/riparian areas by pipelines and roads to the extent practicable. Where crossings cannot be avoided, impacts can be minimized through use of the following and other measures.

- Developing site-specific avoidance and mitigation plans prior to approval process for all proposed disturbance to wetland/riparian areas, including their buffer areas
- Constructing any crossings perpendicular to wetland/riparian areas
- Scheduling construction adjacent to wetland areas to minimize the duration of construction activity, and to concentrate such activity during dry conditions, or when the ground is frozen during the winter
- Locating stockpiles outside the buffer areas
- Locating drilling mud pits outside of buffer areas
- Beginning reclamation of disturbed wetland/riparian areas as soon as possible after project activities are complete
- Monitor any stream channel for erosion, sedimentation, degradation, and riparian health

BMP's:

Non-Structural (refer to PA BMP Manual)
BMP 5.4.1 Protect Sensitive and Special Value Features
BMP 5.4.2 Protect/Conserve/Enhance Riparian Areas
BMP 5.4.3 Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design

PERMITTING

The drilling of oil and gas wells in Pennsylvania is regulated by several chapters of the Pennsylvania Code and various state acts. The state's oil and gas laws (Oil and Gas Act – Act 223, Coal and Gas Resource Coordination Act – Act 214, and Oil and Gas Conservation Law – Act 359), as well as environmental protection laws that include the Clean Streams Law, the Dam Safety and Encroachments Act, the Solid Waste Management Act, and the Water Resources Planning Act give PA DEP the authority to regulate these activities while limiting the regulatory control of municipalities.

PERMIT	SOURCE/NOTES
Well Drilling Permit and Addendum	Pursuant to the Oil and Gas Act; an application addendum outlining a water management plan for that operation, pursuant to Title 25 PA Code 78.11-33.
Earth Disturbance Permit (ESCGP-1)	Required from PA DEP regulating implementation of e&s controls, including SWM, if disturbance >5 acres. E&S plan is required if under 5 acres. Chapter 102
Preparedness, Prevention and Contingency (PPC) Plan	The plan must address the types of wastes generated, disposal methods and a spill prevention plan. Construction and operation of on-site storage impoundments must also be described.
Water Withdrawal Permits	PA DEP has required water withdrawal permits for all withdrawals of surface or ground water. Separate withdrawl permits for projects in the Delaware or Susquehanna Basin or Susquehanna River Basin Commission
Chapter 105 Obstruction and Encroachment Permit	Permit from PA DEP for work in a wetland, stream, or body of water. (also required under the Oil and Gas Act)
Water Quality Management Permit	Permit if a centralized impoundment will hold fluids other than fresh water (such as drilling or fracking fluids). The siting, construction, use and closure of temporary pits are regulated under Chapter 78. Permits are only required if the pit is part of a treatment facility.

FACILITIES

Marcellus Shale Gas development can impact the environment by affecting soils, land use, wildlife, aesthetics, and surface drainages with the construction of roads, utility corridors, wells, and other facilities. Guidance and BMPs for this infrastructure can determine what may be impacted, the extent of the impacts, and mitigation strategies. The impact on communities, the landscape, and habitat can be avoided and minimized through careful practices and infrastructure design considerations to minimize surface disturbances.

In general, there needs to be a heightened awareness of habitat fragmentation in sensitive areas where there are high levels of biodiversity, or sensitive and critical habitats.

Access and Roads

The location and construction of access roads require careful planning. Special attention should be given to steep slopes, surface waters, soils, and other potential hazards. Access roads should be designed with grades between 2 and 10%, located outside buffers of water features, and should have cuts and fills minimized.

GUIDANCE: Location. Utilize existing roads to the facilities to the maximum extent possible. Locate new roads in areas that will optimize year-round, all-weather access, and minimize surface disturbance and environmental impacts.

GUIDANCE: Minimizing Road Development. Where it is operationally feasible and safe, roads typically have the following features: flat to gently rolling country; stable soils.

GUIDANCE: Road Construction and Reclamation. Plan, maintain and construct all roads in conformance with road standards. Major access roads to the general development area should be constructed to a higher standard of road to avoid excess maintenance caused by poorly planning and constructed. Practices that can enhance reclamation include:

- Reclaim and re-vegetate all disturbed surface that will not be used for gas operations in a manner that restores topsoil and minimizes erosion.
- Use re-forestation as a reclamation strategy where forest land was impacted during the development.
- Use only certified and inspected seed that is free of noxious weeds for reclamation/re-vegetation.

GUIDANCE: Access Routes. Plan heavy equipment and high volume of trucks routes to the site with input from the local municipality and PennDOT.

GUIDANCE: Consider operational traffic and plan for the long-term operations of the facility considering maintenance as well as potential issues including safety and with dust, compaction, and debris.

BMP's:

Non-Structural (refer to PA BMP Manual)	
BMP 5.7.1 Reduce Street Imperviousness	
BMP 5.7.2 Reduce Parking Imperviousness	
E&S (refer to PA E&S Manual)	
Sediment Barriers and Filters	Compost Filter Sock, Rock Filter Outlet, Super Silt Fence, Sediment Filter Log, Straw Bale Barrier, Rock Filter, Vegetative Filter Strip
Runoff Conveyance BMPs	Broad-based Dip, Access Road Swale, Ditch Relief Culvert, Turnout
Sediment Capture & Treatment	Construction Entrances, Compost Sock Sediment Trap
Stabilization Methods and Standards	
Structural (refer to PA BMP Manual)	
BMP 6.4.1 Pervious Pavement with Infiltration Bed	
BMP 6.4.7 Constructed Filter	
BMP 6.4.8 Vegetated Swale	

BMP 6.4.9 Vegetated Filter Strip

Well site Development

GUIDANCE: Minimize surface disturbance with techniques such as drilling multiple wells from the same pad, are encouraged to minimize surface impacts, if technically feasible.

GUIDANCE: Remove all equipment not necessary for well operations.

GUIDANCE: Locate well construction activities with the following considerations:

- Locate well sites in stable, non-erosive soil areas, with grass or brush cover and on relatively level areas that minimize pad construction. Choose sites that avoid steep slopes, unstable soils, stream bottoms, wetlands and floodplains.
- Divert runoff from entering the constructed pad site to avoid transporting of pollutants.
- Locate facilities and roads away from occupied dwellings.
- Locate in visually acceptable areas (avoid dwelling view sheds) and paint facilities colors that blend in with the natural environment.
- Locate where safe access can be maintained year round.

GUIDANCE: Restore disturbances as soon as reasonably possible after drilling and development is completed. Reduce the drill site to the minimum area required for production operations and to restore the disturbed areas to their pre-disturbance condition, or better. Restoration should include the following:

- Re-contour disturbed areas to be compatible with existing grades.
- Replace topsoil to at least the depth and quality that existed prior to disturbance for final reclamation of the site upon abandonment of the well.
- Re-vegetate disturbed areas using native vegetation and including re-forestation.
- Remove all chemicals, equipment, materials, and waste not necessary for sustaining production from the well pad.

BMP's:

Non-Structural (refer to PA BMP Manual)	
BMP 5.5.1 Cluster Uses at Each Site; Build on the Smallest Area Possible	
BMP 5.6.1 Minimize Total Disturbed Area – Grading	
BMP 5.6.2 Minimize Soil Compaction in Disturbed Areas	
BMP 5.6.3 Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species	
BMP 5.7.2 Reduce Parking Imperviousness	
BMP 5.9 Source Control	
E&S (refer to PA E&S Manual)	
Sediment Barriers and Filters	Compost Filter Sock, Rock Filter Outlet, Super Silt Fence, Sediment Filter Log, Straw Bale Barrier, Rock Filter, Vegetative Filter Strip
Runoff Conveyance BMPs	Channels, Top of Slope Berm, Temporary Slope Pipe
Sediment Capture & Treatment	
Outlet Protection	
Stabilization Methods and Standards	

Structural (refer to PA BMP Manual)
BMP 6.4.1 Pervious Pavement with Infiltration Bed
BMP 6.4.7 Constructed Filter
BMP 6.4.8 Vegetated Swale
BMP 6.4.9 Vegetated Filter Strip
BMP 6.6.1 Constructed Wetland
BMP 6.6.2 Wet Pond/Retention Basin
BMP 6.6.3 Dry Extended Detention Basin
BMP 6.6.4 Water Quality Filters & Hydrodynamic Devices
BMP 6.7.1 Riparian Buffer Restoration
BMP 6.7.2 Landscape Restoration
BMP 6.7.3 Soil Amendment & Restoration
BMP 6.7.4 Floodplain Restoration
BMP 6.8.1 Level Spreader

Pipelines
GUIDANCE: Corridors. Use existing disturbance corridors whenever possible (ideally following access routes or existing pipeline routes).

GUIDANCE: Trenches. Locate all lines in the same trenches (or immediately parallel to), and at the same time, if possible.

BMP's:

Non-Structural (refer to PA BMP Manual)	
BMP 5.4.1 Protect Sensitive and Special Value Features	
BMP 5.4.2 Protect/Conserve/Enhance Riparian Areas	
BMP 5.4.3 Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design	
BMP 5.6.3 Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species	
E&S (refer to PA E&S Manual)	
Crossings	Roadways, stream, wetlands
Outlet Protection	
Stabilization Methods and Standards	

WORKS CITED

(USEPA, 1993) Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA 840-B-92-002 January 1993.

(Hobbie and Likens, 1973) "The output of phosphorus, dissolved organic carbon and fine particulate carbon from Hubbard Brook watersheds". Limnol. Oceanogr. 18(5): 734-742.

(Likens etal 1970) Effects of Forest Cutting and Herbicide Treatment on Nutrient Budgets in the Hubbard Brook Watershed-Ecosystem. *Ecological Monographs*, 40(1):23-47.

(Curtis, 1970) Curtis, J.G., D.W. Pelren, D.B. George, V.D. Adams, and J.B. Layzer. Effectiveness of Best Management Practices in Preventing Degradation of Streams Caused by Silvicultural Activities in Pickett State Forest, Tennessee. Tennessee Technological University, Center for the Management, Utilization and Protection of Water Resources.

(McWilliams etal, 2007) USDA Forest Service NRS-20. *Pennsylvania's 2004 Forest.* PDF File.

(Milici, Rober C., and others, 2002) United States Geological Survey. *USGS Assessment of Undiscovered Oil and Gas Resources of the Appalachian Basin Province, 2002.* Fact Sheet 009-03. PDF File.

(Harper, John A, 2008) Pennsylvania Bureau of Topographic and Geologic Survey. *The Marcellus Shale - An Old "New" Gas Reservoir in Pennsylvania. Pennsylvania Geology, Volume 38, Number 1*. PDF File.

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

(DEP, 2000) Pennsylvania Department of Environmental Protection. *Erosion and Sediment Pollution Control Program Manual.* Document 363-2134-008. Print.