Locks Pond Road and Lake Wyola Subwatershed Stormwater Improvement Study Shutesbury, Massachusetts

Prepared by: Scott A. Campbell, P.E.
Dept. of Conservation and Recreation
Division of Water Supply Protection

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Stormwater Improvement Study Overview

The purpose of this report is to suggest stormwater improvement measures to help mitigate erosion and flooding problems impacting residences and the network of private Association roads surrounding Lake Wyola (Figure 1). Uncontrolled runoff that passes across a town road, Locks Pond Road, was also identified by local residents as a principal area of concern. On December 6, 2006, Scott Campbell, Environmental Engineer for the Department of Conservation and Recreation, met on-site with members of the Lake Association and Town Administrator, David Dan. At that meeting Lake Wyola Association President, Tim McBride, Association member Bob Thompson, and Town Administrative Assistant David Dan provided local insight and contributed ideas to this collaborative effort to improve stormwater draining to Lake Wyola. This report, written by Scott Campbell (DCR), summarizes suggestions that were formed during that initial meeting and will be submitted to the Shutesbury highway department for review and consideration. The document is meant to serve as a general guide for future resource management decisions both for the area in question, and, throughout the community of Shutesbury. Preliminary drainage calculations associated with the diversion of stormwater runoff upgradient of Locks Pond Road are included in Attachment 1 and are intended solely for the purposes of evaluating the feasibility of modifying the existing network of drainage ditches along Locks Pond Road. The author recommends seeking further assistance from a stormwater professional to properly design, permit, and size a modified drainage network. Other recommendations include on-lot stormwater practices that are outlined in further detail below.

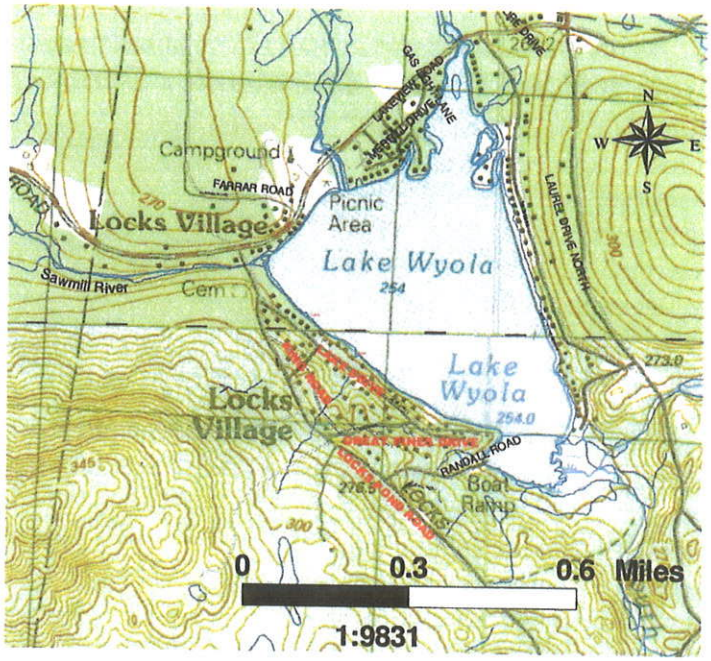


Figure 1 Locus Map - Locks Village.

The ideas expressed in this report simply reflect a compilation of information collected from various guide manuals and technical publications, including:

- A Landowner's Guide to Building Forest Access Roads, USDA
- Maine Erosion and Sediment Control Manual
  http://www.state.me.us/dep/blwq/docwatershed/camproad.pdf

- Storm Water Handbook, MassHighway
  http://www.mhd.state.ma.us/downloads/projDev/swbook.pdf
- Unpaved Roads BMP Manual, Berkshire Regional Planning Commission
  http://p2library.nfesc.navy.mil/stormwaterbmp/files/dirtroad.pdf

Lock's Pond Road – Stormwater Controls

Runoff that is carried by and across Locks Pond Road was identified as a source of concern by members of the Lake Wyola Association. The water collected on the surface of the roadway is being funneled and concentrated by a series of makeshift berms constructed by residents on the east side of the roadway. In addition, driveways on the west side of the roadway compound problems as most are pitched in a manner that funnels water directly onto and across the main travel lane (Figure 2). The pitching of driveways in this manner is especially hazardous in the wintertime; when daytime melting conditions cause sheet flow to form on driveways with the potential to refreeze on the principal travel lane of Locks Pond Road. The bulk of the water drained from the surface of Locks Pond Road is being discharged at intersecting roadways such as Great Pines Drive, Stebbins Road, King Road and Dove Lane. Because of higher grades and an unstable gravel surface, the association roads are simply not capable of carrying concentrated flows without resulting in significant erosion.

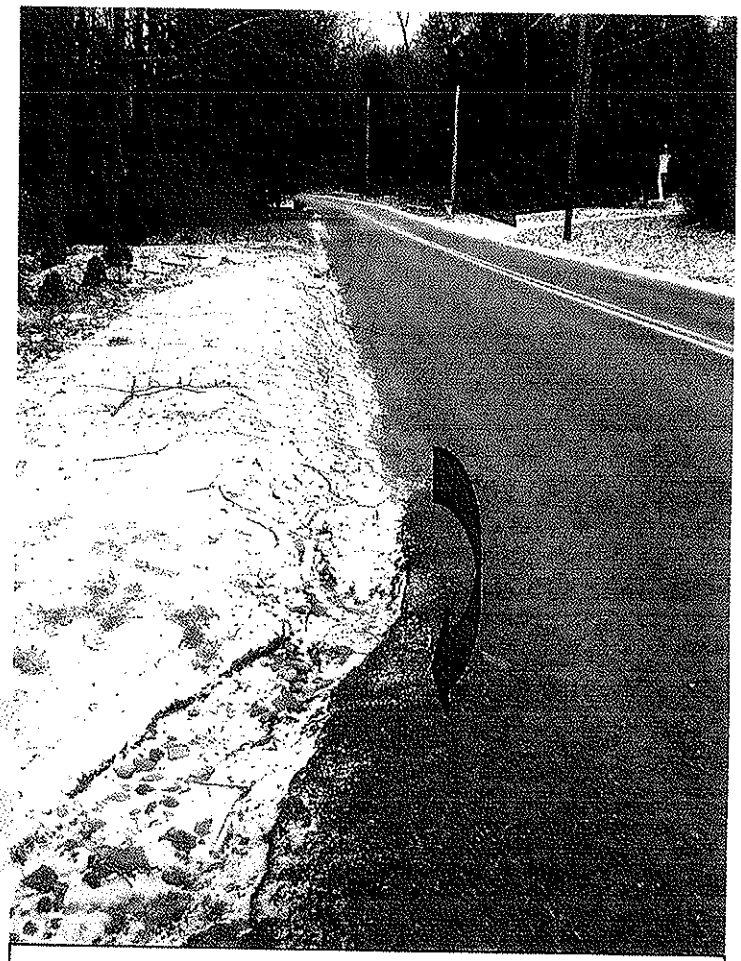


Figure 2 Locks Pond Road

Stormwater pathways due to roadside berms and driveway runoff. (DCR/DWSP)

Suggested Improvements:

- (Measure M.1) Residents should be encouraged or required through a local ordinance to direct runoff from driveways away from the travel lanes of principal roadways and into roadside ditches. Several methods are available to achieve the desired result and they include the construction of water bars/diversion ridges, use of a trench drain, or the construction of a broad based dip. Diversion ridges or water bars should be a minimum of 8 inches high and should be slanted to shunt water off of the driveway surface.
- Make-shift roadside berms on Locks Pond Road should be replaced with a non-erosive, asphalt Type-A berm (i.e. Cape Cod berms). Outfalls should be directed via a paved chute or rock-lined splash pad into naturally vegetated, roadside areas (see Measure M.2).
- **(Measure M.1)** Strategically placed, small water bars recently erected across many of the Associations gravel roads are serving to limit the extent of washing by directing the water off of the traveled way. Water bars can be an effective, inexpensive measure but are also prone to failure due to sediment build-up, wintertime plowing, and highly concentrated flows. Regular inspection and maintenance (frequent cleaning with a shovel) is needed to protect against failure due to overtopping and sediment build-up.
- (Measure M.2) At the intersections of King Road (Figure 3) and Great Pines Road small tracts of undeveloped land exist that have the potential to function as bioretention islands. Bioretention areas are small, sunken garden areas that in effect act as sponges by soaking up, infiltrating and filtering stormwater collected from paved surfaces. Alternatively, the undisturbed forest floor also can serve as an excellent buffer to trap, filter and temporarily detain stormwater.

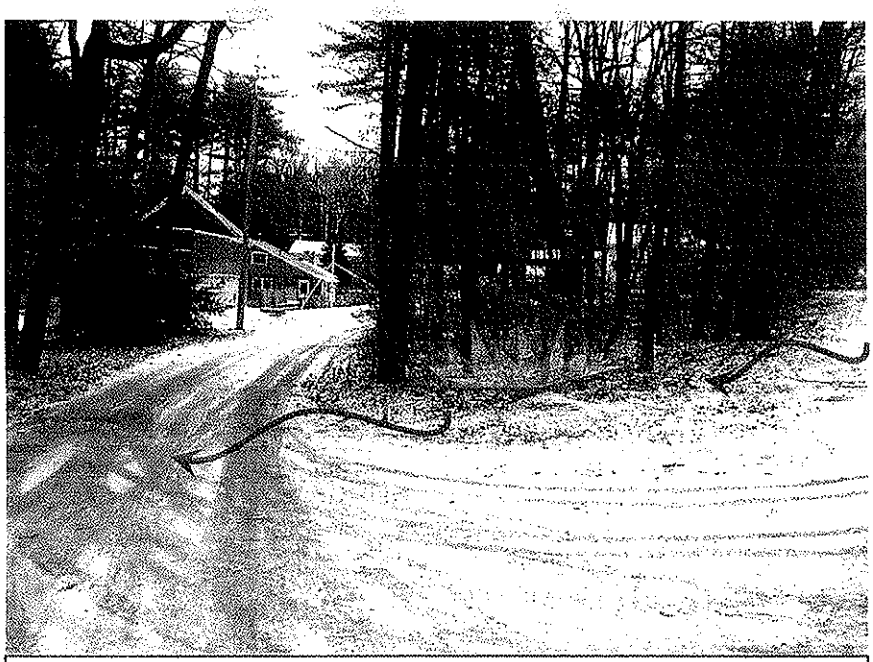


Figure 3 Potential site for rain garden on undeveloped tract of land at the corner of King and Locks Pond Road. (DCR/DWSP)

Lock's Pond Road – Stormwater Diversion

Figure 6 depicts the two subwatershed areas of Lake Wyola bisected by Locks Pond Road. The larger subwatershed area of the two drains approximately 58 acres of principally forested land on the easternmost portions of Morse Hill. Runoff drained from this subcatchment crosses Locks Pond Road via two 18-ich culverts and a 12-inch culvert pipe. The 18-inch culverts carry a perennial and an intermittent stream across Locks Pond Road while the 12-inch culvert pipe carries seasonal flows from a much smaller portion of the subwatershed. The second subwatershed area is comprised of 39 acres of principally forested land that drains the northeastern face of Morse Hill. A parabolic, earthen ditch roughly five feet wide and eight inches deep located on the western side of Locks Pond Road serves to collect off-site drainage and to a lesser extent intercept seasonally high groundwater breaking out from the side of Morse Hill. Approximately 1,000 linear feet of ditch is broken up by two 12-inch culvert pipes that funnel water across Locks Pond Road above and below the King Road intersection. Water from these two culvert pipes meanders through yards (Figure 4), passes by septic leachfields, and culminates into two point source outfalls located on the shore of Lake Wyola (Figure 5).

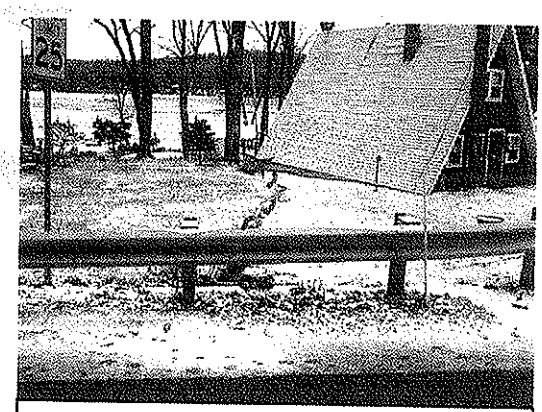


Figure 4A Small ditch below Locks Pond Road storm drain. (DCR/DWSP)

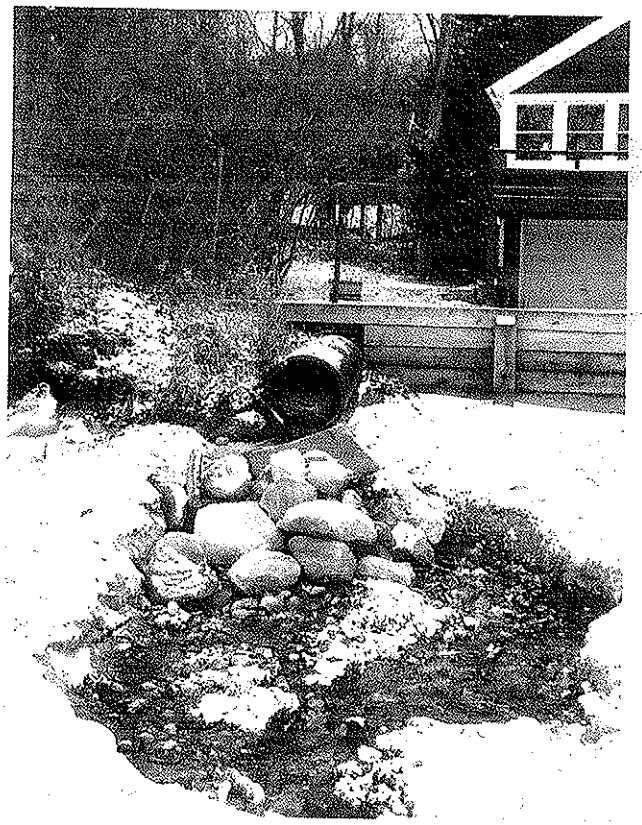


Figure 4B Storm drain outlet on shore of Lake Wyola. (DCR/DWSP)

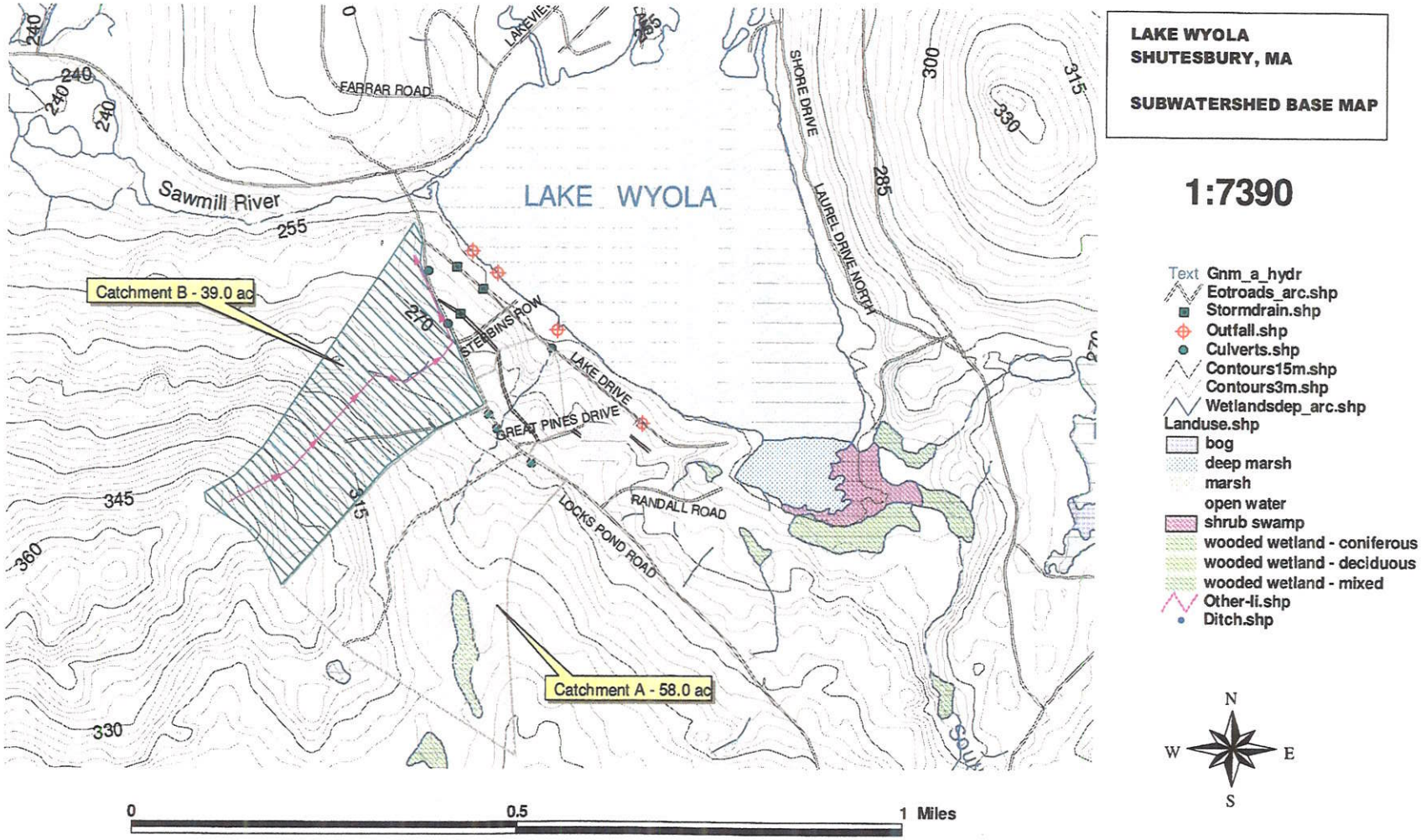


Figure 5 Subwatershed Base Map (DCR/DWSP)

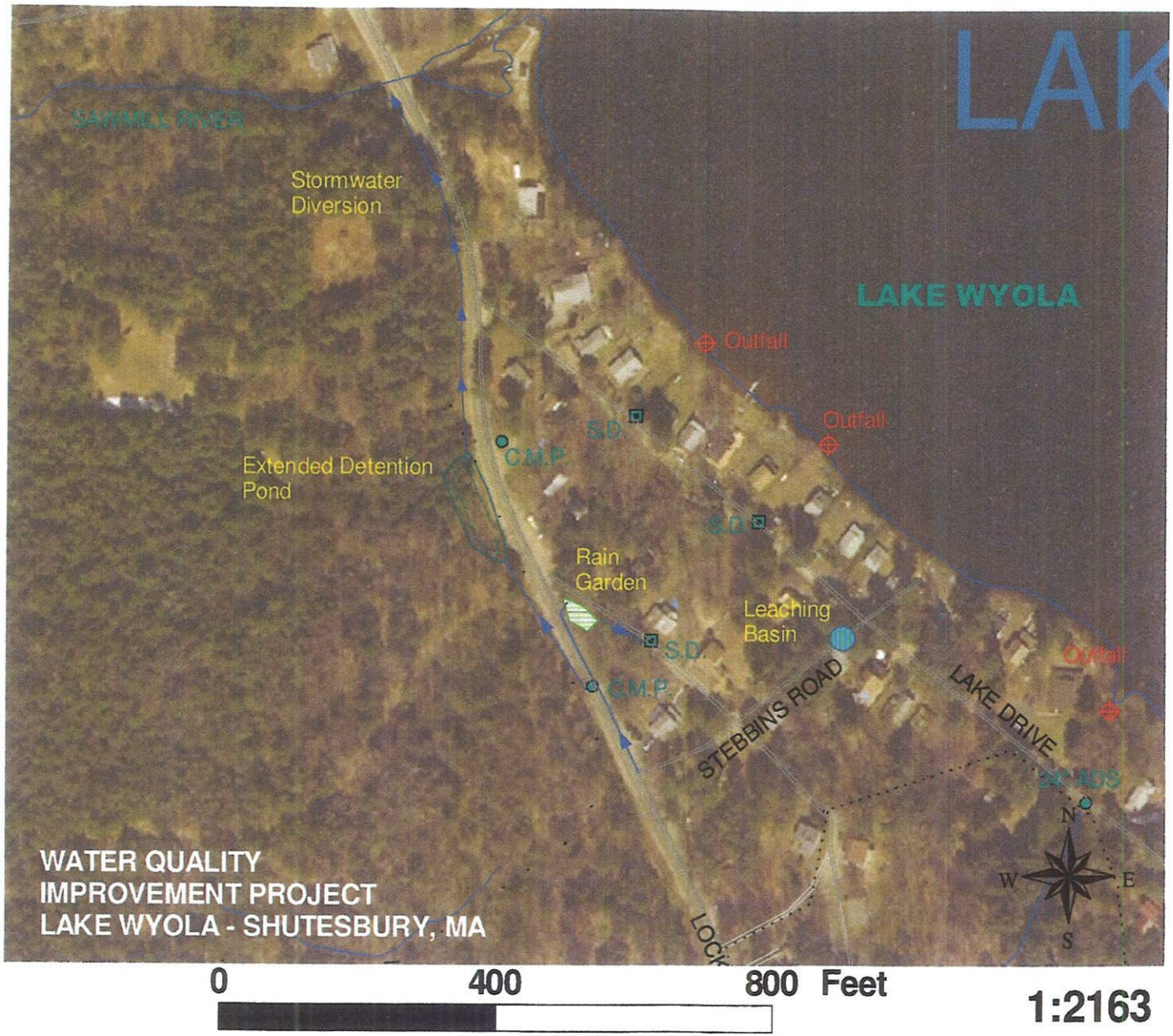


Figure 6 Conceptual Plan for Northern Area (DCR/DWSP)

Suggested Improvement Measures:

(Measure M.3) Preliminary calculations were performed to determine the feasibility of redirecting runoff from portions of Morse Hill to the Sawmill River, a Class B waterbody. Presently, stormwater collected from the northeastern face of Morse Hill is funneled across Locks Pond Road via two, 12-inch culvert pipes. Storm drain structures on King Road (2) and Lake Drive (2) collect this runoff and pipe it directly into Lake Wyola at two locations (Figure 4B). Eliminating or greatly reducing flows to these outfall pipes would greatly reduce sediment deposition and re-suspension inside of Lake Wyola. Conversely, redirecting these flows to the Sawmill River has the potential to substantially increase peak flows and contribute to in-stream bank erosion.

Thus, any proposed discharged must establish controls on frequently occurring storms (<3" rain) to limit peak flows and quantities. The premise for control is to detain for up to 12 to 24 hours the quantity of runoff produced from what could be considered a 2 YR Storm Event or a 3-inch rainfall. The runoff water is temporarily stored inside of a small detention basin that allows for water to be released in a gradual manner over the course of 24 hours. An area approximately 120' long by 60' wide is needed to provide temporary storage (24hrs) of stormwater to allow for the dampening of peak storm flows. An area of privately held land located above the lower 12-inch culvert pipe is presently undeveloped and has suitable slope and land area to accommodate a small basin (Figure 7). Acquiring an easement to construct and maintain a basin on this property would also prove beneficial by settling out suspended solids largely introduced during wintertime road maintenance activities.

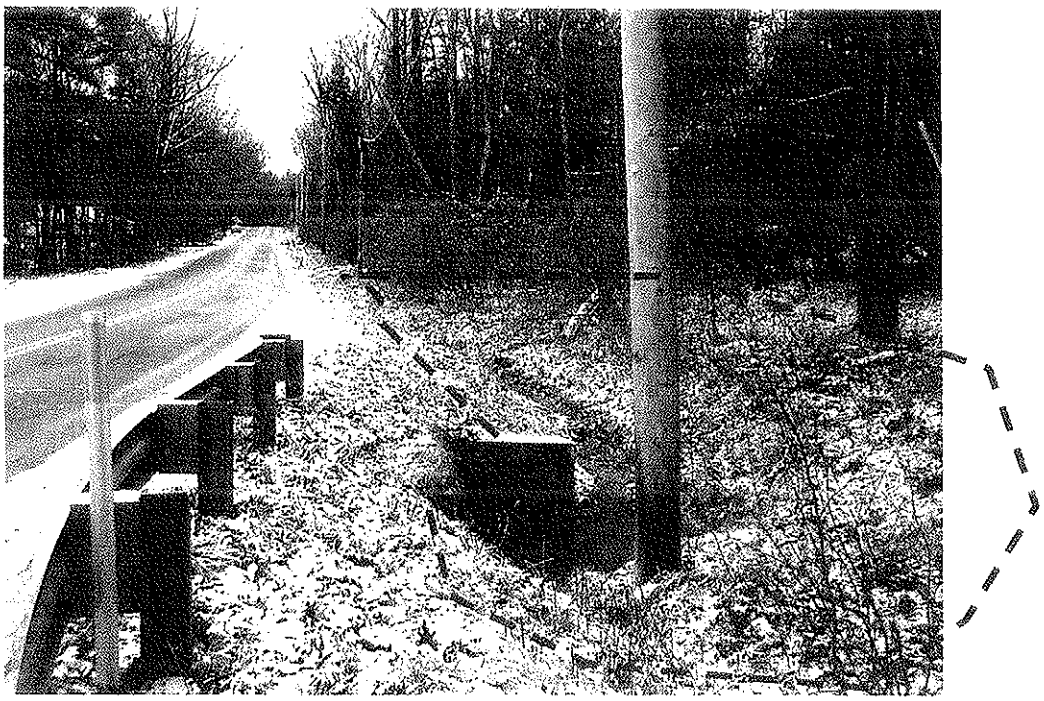


Figure 7 Location and schematic of proposed extended detention pond structure.

(Measure M.4) The existing, earth-lined roadside ditch on the west side of Locks Pond Road is not of sufficient size or lined with appropriate cover to receive increased flows. The cross-sectional area of this ditch must be increased and armoring is needed to protect against erosion. A trapezoidal, turf-reinforced mat-lined (TRM) channel is recommended to provide the needed capacity and to protect against erosion. There are several existing driveway culverts that will likely have to be reconstructed to fit to the new channel.

Strategies to control rooftop/driveway runoff

Runoff that is generated on developed properties and carried by the network of Association roads was also identified as a concern for residents. For most developed lots rooftops freely discharge stormwater and driveways quickly funnel water onto the traveled way of Association roads. Stormwater controls that were present were limited to makeshift roadside berms and four catch basin structures located along Lake Drive (2) and King Road (2). Roadways such as Lake Shore Drive are graded slightly crowned and absent of roadside ditches; therefore, any water introduced to the road surface settles within the principal travel lane causing potholes and standing water problems. Great Pines Road is badly washing due in part to its steep grade and the concentrated stormwater that it carries. Water bars recently installed and regularly maintained will help to alleviate erosion problems. However, the purposeful damming of one such diversion ditch suggests that improved homeowner education and outreach is needed.

Figure 8 Conceptual Plan for Southern Area (DCR/DWSP)

Suggested Improvement Measures:

Road Cross Section

(Measure M.5) Principal to any well maintained gravel road are the concepts of removing water from off of the traveled way as quickly as possible and dispersing water into stable, vegetated areas as frequently as possible. Removing water from the traveled way can be accomplished by exaggerating the crown of a roadway, pitching the roadway towards one side, or by intercepting water inside of roadside ditches. On Lake Drive an exaggerated crowned roadway with a small ditch on the west side of the road is recommended to remove water from the road surface and to intercept weeping water from the uphill side of the road. Ditch construction can be as simple as creating a wheel-rut by running a tractor wheel alongside the shoulder of the road. Care must be taken in low sloping areas such as Lake Drive to ensure that ditches are pitched in a manner that the ditch will drain properly and not serve as a ponding area for mosquito breeding. Alternatively, a stone filled trench and underdrain piping piped to the two catch basin structures can serve to drain and intercept standing water.

Figure 9 Great Pines Drive (DCR/DWSP)

Source Controls

(Measure M.6) The relatively high ratio of rooftop area to average lot size means that any improvements to capture rooftop runoff would result in significant benefits for stormwater control. Of the rooftops viewed, most were not guttered and if present, controls were not in-place to infiltrate or capture this source of stormwater. Rain barrels can be an effective means of converting what is now considered a nuisance into a resource as this water may be used for watering and other household applications. The barrels are relatively inexpensive and take up a small footprint. A drawback to this alternative is that in most cases it will require significant homeowner investments as most rooftops are not guttered. However, during house remodeling and likely expansion projects, these added costs can be better justified. Alternatively, driveway pavers offer benefits of being pervious and more forgiving to the New England freeze/thaw cycle. However, higher costs make pavers a less desirable option but perhaps with homeowner incentives (i.e. dues credit) these practices could be encouraged.

Leaching Basin

(Measure M.7) A small tract of Association property at the intersection of Great Pines Drive and Lake Drive has the potential to serve as a treatment site for stormwater carried by Great Pines Drive (Figure 10). Presently, stormwater carried by Great Pines Drive is washing the road as a meandering ditch is forming that carves across Great Pines Drive and spills across Lake Drive before cascading down to the Association beach. Installing armored (i.e. stone-lined) ditches where presently washing, increasing the crown of the roadway to 9-inches, installing 12-inch cross culverts at the intersection with King Road, and placing a sunken infiltrating catch basin structure would serve to protect the travel surface of Great Pines Road. Moreover, a rip rap plunge pool and leaching basin can enhance sediment removal, bacterial die-off and promote infiltration of stormwater. Soil type mapped for this area is the Hinkley series which is comprised of shallow, gravelly soils that are conducive to infiltration.

Figure 10 Location and schemitc representation of proposed leaching basin. (DCR/DWSP)

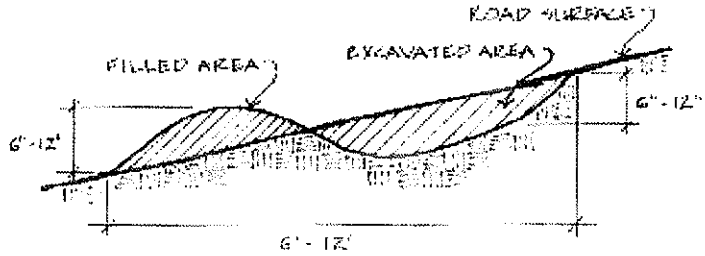
REFERENCED BEST MANAGEMENT PRACTICES

PRACTICE M.1 WATER BARS

Water bars are shallow, ridge diversions designed to divert road surface runoff to stabilized (preferably naturally vegetated) upland areas. The purpose of the water bar is to prevent gully and channel erosion of the road surface by intercepting water flow that travels along the principal travel way. Construction can be accomplished by hand tools or with the use of a small bulldozer. Ridge height should be a minimum of nine inches and spacing is recommended at 100 feet on slopes between 5 and 10 percent. The diversion channel should be set at an angle (30°) and with a positive grade not to exceed 2%.

Common Trouble Points:

- Ridge worn down by repeated vehicle traffic.
- Channel filled with deposited sediment.
- Erosion at outlets.
- Because of ridge height and vehicle clearance concerns, not suited to high speed roads.



Cross section of a waterbar

Spacing Needed Between Water Bars	
Slope	*Diversion Spacing (feet)*
< 5%	125
5 – 10%	100
10 – 20%	75
20 – 35%	50
> 35%	25

Source: Unpaved Roads BMP Manual, Berkshire Region Planning Council

PRACTICE M.2 RAIN GARDEN

A rain garden (Figure 12) uses native landscaping to soak up and infiltrate rain water from impervious surfaces such as rooftops, pavements and driveways. The garden should be constructed as shallow depressions located in upland areas. The center of the garden is sunken or a small berm is made to promote ponding of water up to a maximum of six inches deep. Plant varieties selected should be hardy, drought and salt tolerant, and capable of surviving temporary inundation (24 hours). Incorporation of organic matter such as compost into the native soil will increase the water holding capacity and nutrient retention of the soil. As a general rule of thumb, gardens are sized as a percentage (20-30%) of the total area draining to the site. The two portions of Locks Pond Road identified for a possible rain garden retrofit drain approximately 250 linear feet of crowned, 24 ft wide roadway. Using 20% as a general rule of thumb, a garden area approximately 25 ft square would be appropriate.

Figure 11 Cul-de-sac Island rain garden.

Source: Metropolitan Area Planning Council

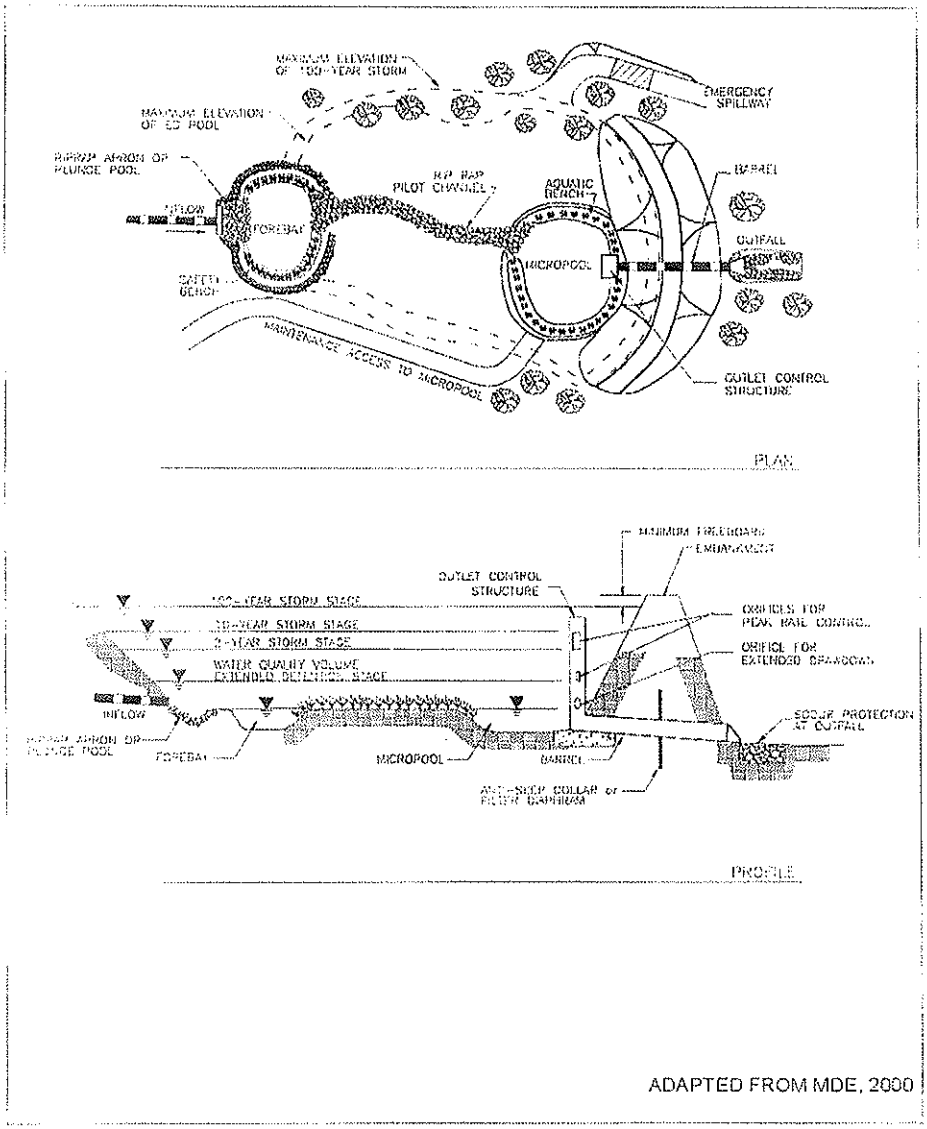
Common Trouble Points:

- Erosion occurs before vegetation is allowed to become established.
- Soil clogging due to high sediment load. Provide pretreatment (i.e. grass strip, plunge pool, etc..) for trapping of suspended solids upstream of garden.
- Overplanting.

PRACTICE M.3 EXTENDED DETENTION POND

An extended detention pond temporarily detains and stores stormwater runoff for an extended period of time (up to 24 hours after a storm). The pond outlet can be configured with multiple outlets designed to gradually release stormwater and to safely pass higher flows from extreme events. The ponding of water over an extended period of time also allows for sediments and pollutants normally found in stormwater to become trapped and settle-out. See Attachment 1 for supporting calculations.

MASS HIGHWAY



Example of Extended Detention Basin

PRACTICE M.4 TURF REINFORCED MAT LINED CHANNEL

Figure 12 Turf Reinforced Mat Placement on Route 32A in Hardwick, MA. (DCR/DWSP)

Turf reinforcement mats are manufactured of UV and chemically resistant polypropylene fibers that form a matrix capable of holding soil and seed in-place under high shear loads. The mats offer a cost effective and "green" alternative to the conventional paved and rip rap armored solutions typically used to prevent erosion in problem areas. Treatment benefits of these channels can be enhanced with the placement of shallow check dams that cross the channel every 50 to 75 feet. Check dams serve to promote infiltration, increase storage and reduce flow velocities.

Common Trouble Points:

- Erosion occurs at the interface along the edge of road or on the side slope. Prevent erosion by making an armored (paved chute) connection between the road surface and the bottom of the channel.
- Erosion occurs at channel outlet. Prevent erosion with an armored plunge pool of dumped rip rap.
- Overtopping caused by deposited sediment or debris. Remove sediment and debris periodically from roadside channels. Perform mowing at a minimum of once per year to prevent woody species.

PRACTICE M.5 CROWNED ROADWAY

Providing a proper crown is the surest way to drain water from the surface of a gravel roadway. As a general rule, crown height should be set at 1/2 inch of rise per foot of road width (e.g. ½" X 12 ft road width = 6" crown). An exaggerated crown of ¾ inch per foot may be necessary on steep sections of road (>5% slope) to counteract the tendency for water to flow downhill over the road surface. Since normal use and wintertime plowing depress crowns they must be reshaped annually with grading equipment. The present schedule of grading Association roads on a semi-annual basis (late spring/late fall) seems sufficient. A grader is the preferred piece of equipment for creating a crown. Bulldozers are not generally recommended because of the difficulty in shaping the road with a straight blade.

Complimentary to a good crown is a roadside ditch that is capable of carrying water to a point of ultimate disposal. Ditches that are continually eroding threaten the road itself and lead to sedimentation problems inside of ditches and pipes. Lining of a ditch with a geotextile fabric and rip rap should be considered on slopes exceeding 6% to prevent erosion. Frequent relief of ditches into stabilized, vegetated areas ensures dispersal but also protects against erosion and topping of the ditch itself.

Common Trouble Points:

- Wheel ruts can form on the road surface where the soil base is poor negating the effects of a good crown and ditch.
- Ditch undersized.

PRACTICE M.6 RAIN BARRELS

A rain barrel collects and stores rainwater collected from a rooftop gutter drain system. Storing runoff water allows it to be used later for lawn watering and gardening and prevents water running off of your property and overwhelming street storm drains or ditches. Rain barrels are 55 gallon plastic drums that are relatively inexpensive starting at $85.00. The lightweight of plastic makes installation easy and adaptable to most situations.

Common Trouble Points:

- Darker colored barrels such as blue or green are recommended because they block out light, preventing algal growth. Note that plastic barrels may be painted the color of your choice.

Reference:
*New England Rain Barrel http://www.nerainbarrel.com/Product.html
*_No endorsement or recommendation is implied._

PRACTICE M.7 LEACHING BASIN

A leaching basin is a catch basin fabricated of barrel and riser sections that permits the infiltration of runoff into the ground. The leaching basin should be designed with a pretreatment mechanism and with the ability for larger storm events to safely overflow or by-pass these devices. The contributing area of these devices should be limited to one acre or less.

Common Trouble Points:

- Because of a higher sediment load expected from a gravel road surface, pretreatment of ditch/culvert outfalls in the form of a block and gravel inlet protector is recommended to trap sediment (see detail below).
- Because fine sediments will eventually clog the soil pores of the surrounding soil, the device should be restricted to sites where surrounding native soil is comprised of highly permeable sand and gravel.
- The double washed stone surrounding the basin must be encapsulated by a geotextile fabric designed to prevent the migration of fines into the void spaces of the stone.
- Outfall shall be properly stabilized to prevent against erosion. Rip rap armoring or alternatively a stone level spreader may be used to dissipate and reduce flow velocities downstream of the device.

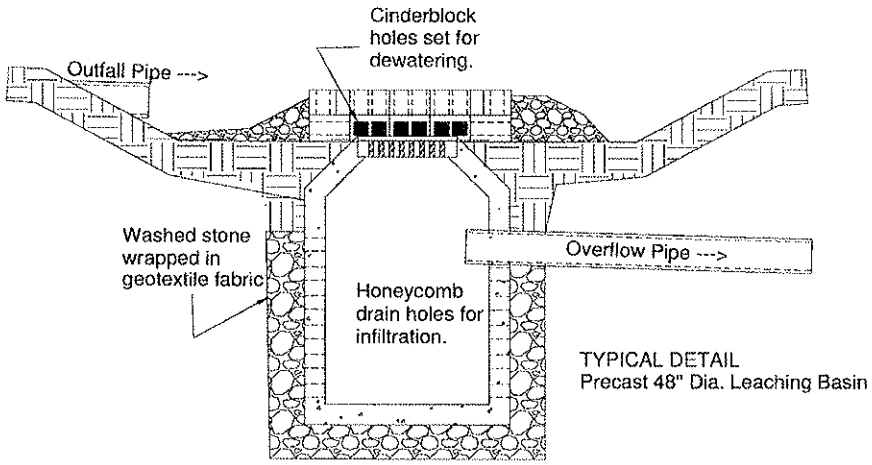


Figure 13 Schematic drawing of a leaching basin protected by a block and gravel inlet protector. (DCR/DWSP)

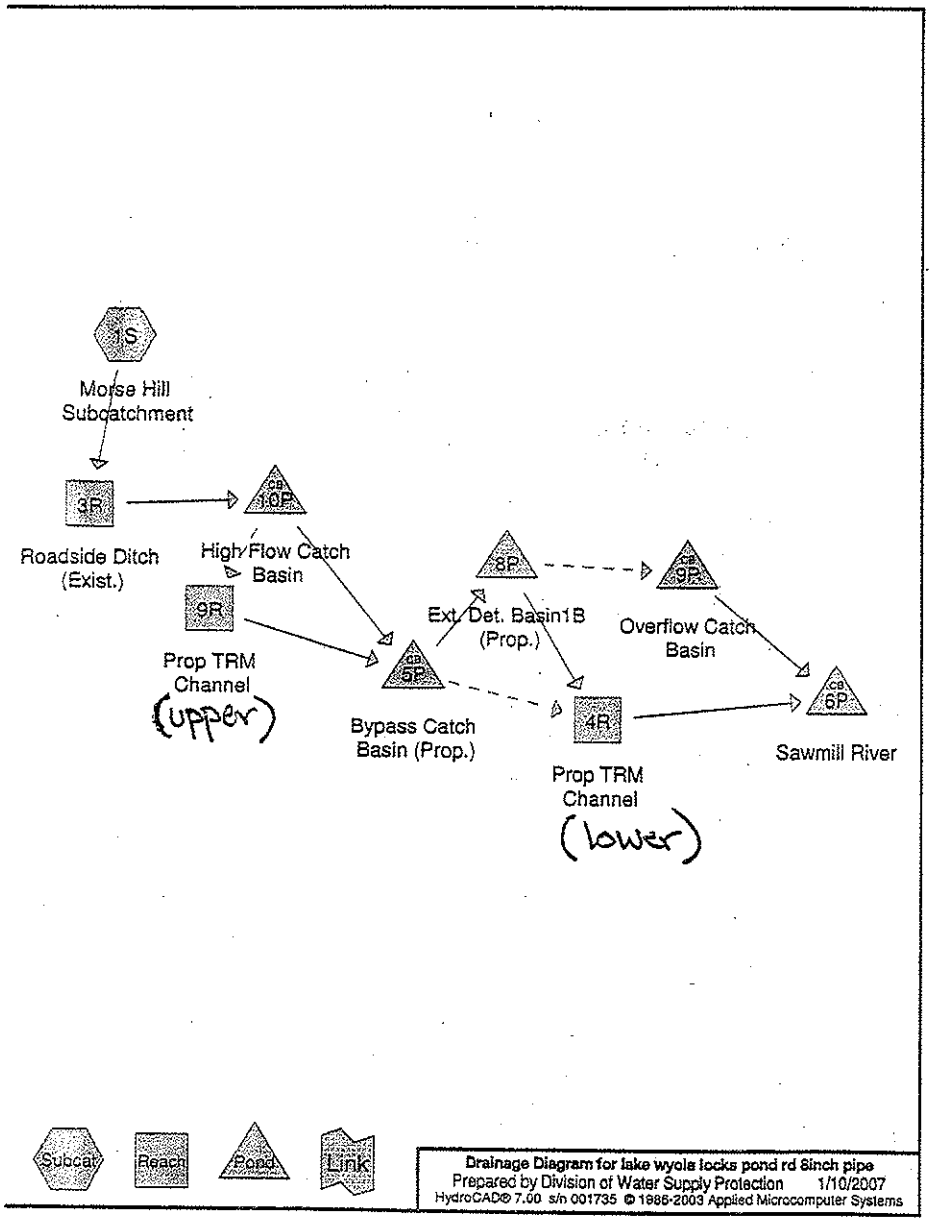
ATTACHMENT 1

HYDROCAD MODEL – LOCKS POND ROAD

KEY FINDINGS:

- ***EXISTING ROADSIDE DITCH UNDERSIZED TO HANDLE EXTREME STORM EVENTS (>3" RAIN).***
- ***TRUF REINFORCED MAT LINED (TRM) CHANNELS CAPABLE OF SAFELY CARRYING EXTREME FLOWS.***
- ***PROPOSED EXTENDED DETENTION POND SIZED TO CAPTURE 3" RAINFALL AND TO SAFELY PASS EXTREME EVENTS.***
- ***ED POND REDUCES 2 YEAR STORM PEAK FLOW BY 39%.***
- ***EXTREME STORM EVENTS (>3" RAIN) REQUIRE COMBINATION OF DITCHED AND PIPED CONVEYANCE.***

ATTACHMENT 1



Time span=11.00-28.00 hrs, dt=0.05 hrs, 341 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Morse Hill Subcatchment *Runoff Area=40.180 ac Runoff Depth=0.67"*
Flow Length=2,745' Tc=31.4 min CN=69 Runoff=14.89 cfs 2.242 af

Reach 3R: Roadside Ditch (Exist.) Peak Depth=0.68' Max Vel=6.9 fps Inflow=14.89 cfs 2.242 af
n=0.030 L=1,000.0' S=0.0600 '/' Capacity=18.41 cfs Outflow=14.78 cfs 2.242 af

Reach 4R: Prop TRM Channel (lower) Peak Depth=0.31' Max Vel=4.7 fps Inflow=4.32 cfs 1.881 af
n=0.034 L=340.0' S=0.0824 '/' Capacity=24.26 cfs Outflow=4.32 cfs 1.680 af

Reach 9R: Prop TRM Channel (upper) Peak Depth=0.00' Max Vel=0.0 fps Inflow=0.00 cfs 0.000 af
n=0.034 L=340.0' S=0.0600 '/' Capacity=39.46 cfs Outflow=0.00 cfs 0.000 af

Pond 5P: Bypass Catch Basin (Prop.) Peak Elev=871.54' Inflow=14.78 cfs 2.242 af
Primary=14.70 cfs 2.242 af Secondary=0.08 cfs 0.000 af Outflow=14.78 cfs 2.242 af

Pond 6P: Sawmill River Peak Elev=855.32' Inflow=9.01 cfs 2.033 af
Outflow=9.01 cfs 2.033 af

Pond 8P: Ext. Det. Basin1B (Prop.) Floor El. 861.0 Peak Elev=864.18' Storage=23,601 cf Inflow=14.70 cfs 2.242 af
Discarded=0.19 cfs 0.109 af Primary=4.32 cfs 1.881 af Secondary=4.70 cfs 0.153 af Outflow=9.21 cfs 2.142 af

Pond 9P: Overflow Catch Basin Peak Elev=855.93' Inflow=4.70 cfs 0.153 af
24.0" x 50.0' Culvert Outflow=4.70 cfs 0.153 af

Pond 10P: High Flow Catch Basin Peak Elev=875.77' Inflow=14.78 cfs 2.242 af
Primary=14.78 cfs 2.242 af Secondary=0.00 cfs 0.000 af Outflow=14.78 cfs 2.242 af

Total Runoff Area = 40.180 ac Runoff Volume = 2.242 af Average Runoff Depth = 0.67"

Subcatchment 1S: Morse Hill Subcatchment

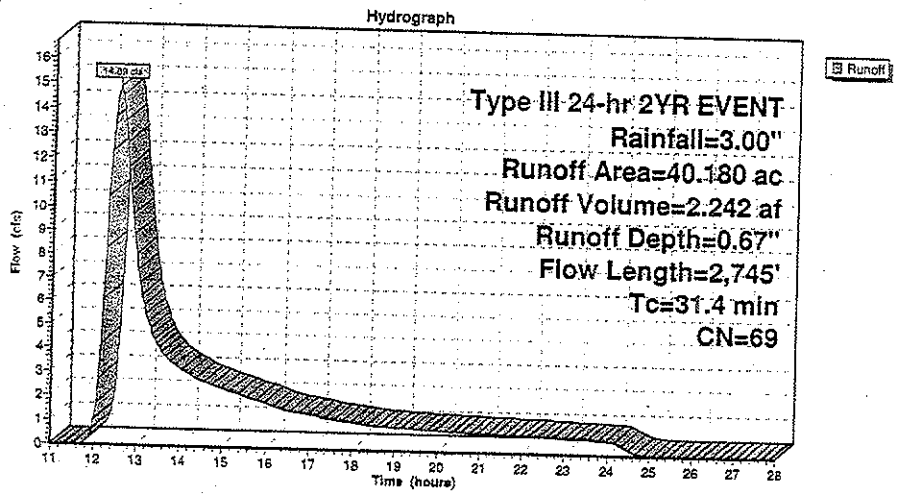
Runoff = 14.89 cfs @ 12.51 hrs, Volume= 2.242 af, Depth= 0.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Type III 24-hr 2YR EVENT Rainfall=3.00"

Area (ac)	CN	Description
39.000	68	Composite Woods - Good Cond.
1.180	90	Roadway
40.180	69	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.9	30	0.0500	0.1		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.00"
21.1	1,600	0.0900	1.3		**Lag/CN Method, Woods**
4.4	1,115	0.0600	4.3	12.78	**Channel Flow, Channel Flow** Area= 3.0 sf Perim= 6.7' r= 0.45' n= 0.050
31.4	2,745	Total			

Subcatchment 1S: Morse Hill Subcatchment



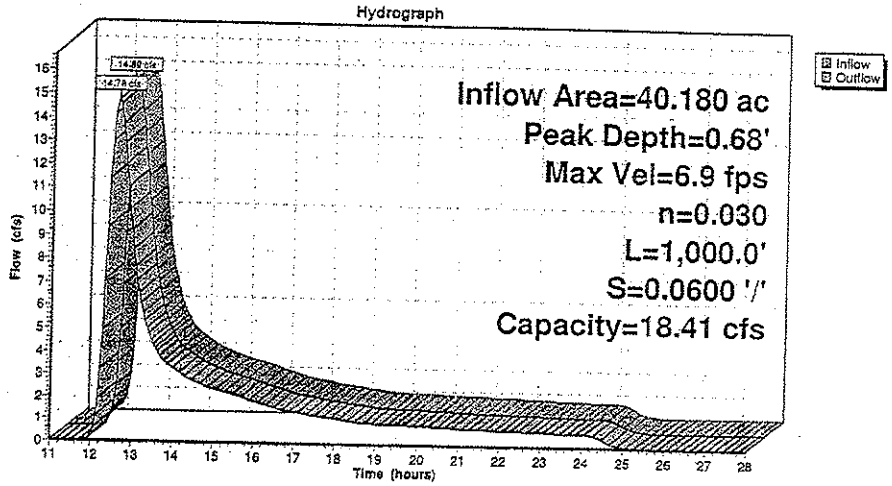
Reach 3R: Roadside Ditch (Exist.)

Inflow Area = 40.180 ac, Inflow Depth = 0.67" for 2YR EVENT event
Inflow = 14.89 cfs @ 12.51 hrs, Volume= 2.242 af
Outflow = 14.78 cfs @ 12.58 hrs, Volume= 2.242 af, Atten= 1%, Lag= 4.2 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.9 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 2.8 fps, Avg. Travel Time= 5.9 min

Peak Depth= 0.68' @ 12.54 hrs
Capacity at bank full= 18.41 cfs
Inlet Invert= 930.00', Outlet Invert= 870.00'
5.00' x 0.75' deep Parabolic Channel, n= 0.030 Length= 1,000.0' Slope= 0.0600 '/'

Reach 3R: Roadside Ditch (Exist.)



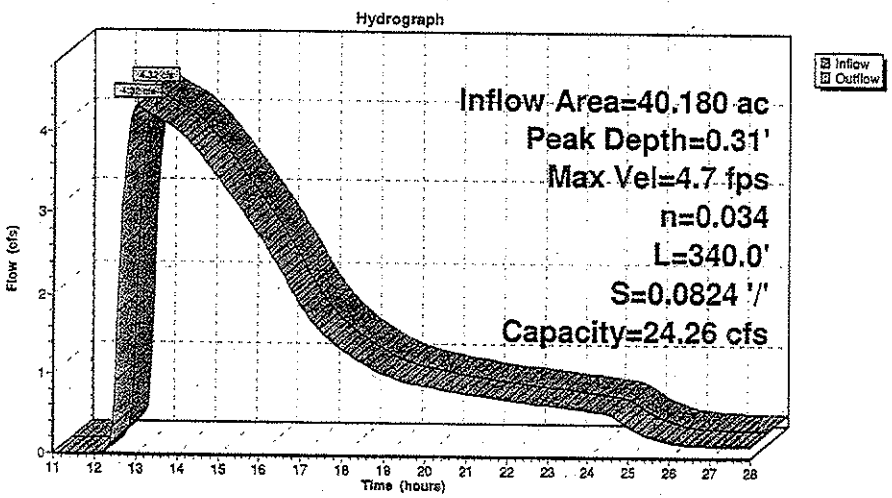
Reach 4R: Prop TRM Channel

nflow Area = 40.180 ac, Inflow Depth = 0.56" for 2YR EVENT event
nflow = 4.32 cfs @ 12.96 hrs, Volume= 1.881 af
Outflow = 4.32 cfs @ 13.00 hrs, Volume= 1.880 af, Atten= 0%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.7 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 3.0 fps, Avg. Travel Time= 1.9 min

Peak Depth= 0.31' @ 12.97 hrs
Capacity at bank full= 24.26 cfs
Inlet Invert= 858.00', Outlet Invert= 830.00'
1.00' x 0.75' deep channel, n= 0.034 Length= 340.0' Slope= 0.0824 '/'
Side Slope Z-value= 3.0 '/'

Reach 4R: Prop TRM Channel



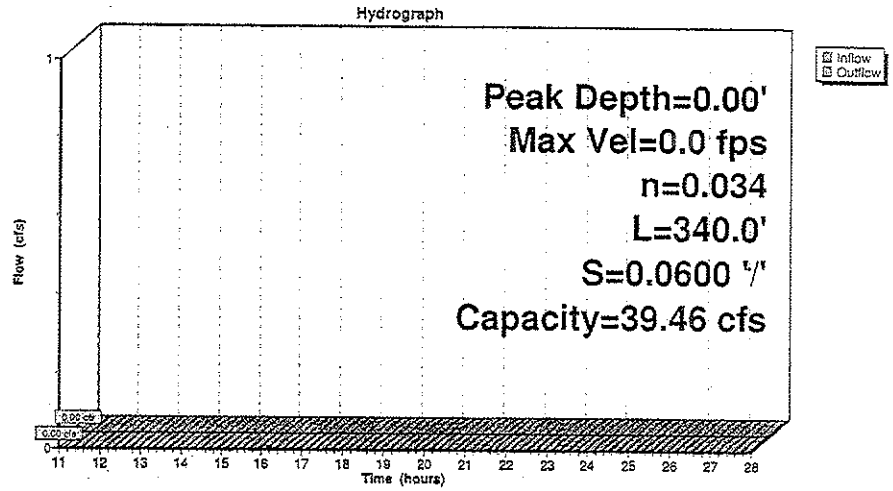
Reach 9R: Prop TRM Channel

Inflow = 0.00 cfs @ 11.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 11.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.0 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 0.0 fps, Avg. Travel Time= 0.0 min

Peak Depth= 0.00' @ 11.00 hrs
Capacity at bank full= 39.46 cfs
Inlet Invert= 858.00', Outlet Invert= 837.60'
2.50' x 1.00' deep channel, n= 0.034 Length= 340.0' Slope= 0.0600 '/'
Side Slope Z-value= 2.0 3.0 '/'

Reach 9R: Prop TRM Channel



Pond 5P: Bypass Catch Basin (Prop.)

Crested just above weir. O.K.

[57] Hint: Peaked at 871.54' (Flood elevation advised)
[63] Warning: Exceeded Reach 9R inflow depth by 13.53' @ 12.60 hrs
[79] Warning: Submerged Pond 10P Primary device # 1 OUTLET by 2.53'

Inflow Area =	40.180 ac,	Inflow Depth =	0.67"	for	2YR EVENT event
Inflow =	14.78 cfs @	12.58 hrs,	Volume=	2.242 af	
Outflow =	14.76 cfs @	12.58 hrs,	Volume=	2.242 af,	Atten= 0%, Lag= 0.0 min
Primary =	14.70 cfs @	12.58 hrs,	Volume=	2.242 af	
Secondary =	0.08 cfs @	12.59 hrs,	Volume=	0.000 af	

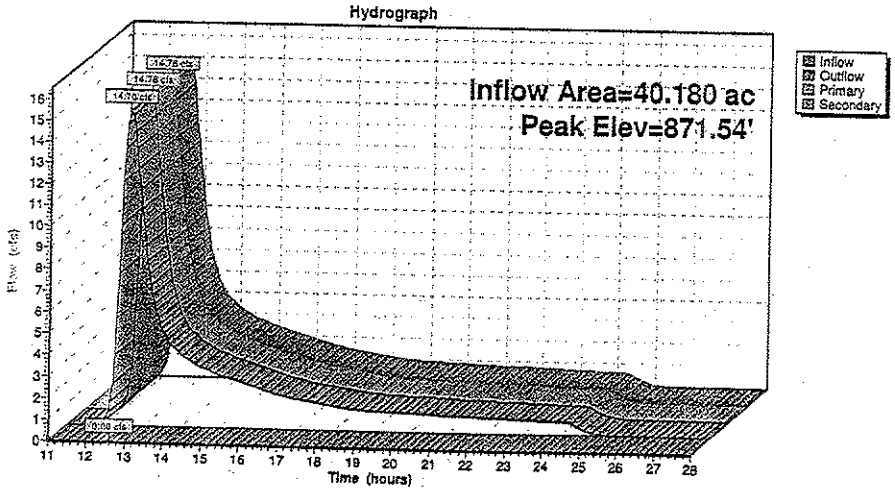
Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 871.54' @ 12.58 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	866.00'	**18.0" x 40.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 864.00' S= 0.0500 '/' n= 0.013 Cc= 0.900
2	Secondary	868.00'	**18.0" x 100.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 862.00' S= 0.0600 '/' n= 0.013 Cc= 0.900
3	Device 2	871.50'	**4.0' long x 3.8' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

Primary OutFlow Max=14.67 cfs @ 12.58 hrs HW=871.52' (Free Discharge)
└─1=**Culvert** (Inlet Controls 14.67 cfs @ 8.3 fps)

Secondary OutFlow Max=0.05 cfs @ 12.59 hrs HW=871.52' (Free Discharge)
└─2=**Culvert** (Passes 0.05 cfs of 11.19 cfs potential flow)
└─3=**Sharp-Crested Rectangular Weir** (Weir Controls 0.05 cfs @ 0.5 fps)

Pond 5P: Bypass Catch Basin (Prop.)



Pond 6P: Sawmill River

[57] Hint: Peaked at 855.32' (Flood elevation advised)
[61] Hint: Submerged 90% of Reach 4R bottom
[81] Warning: Exceeded Pond 9P by 0.19' @ 13.75 hrs

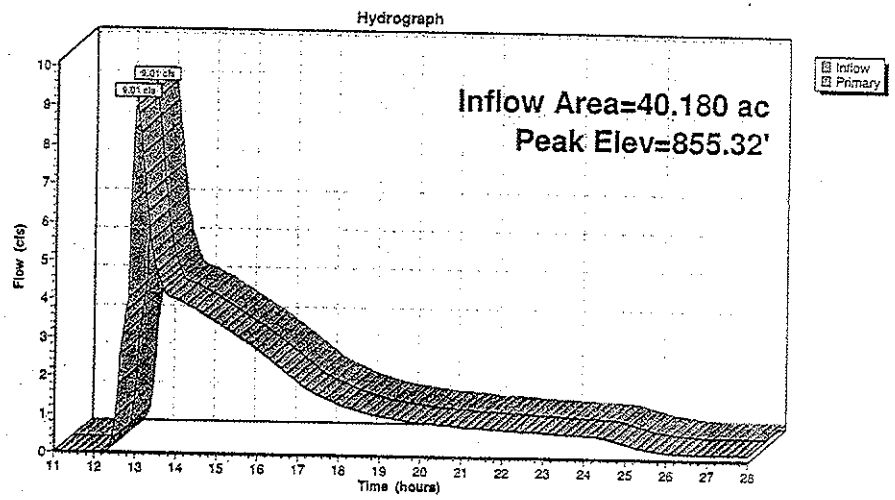
Inflow Area =	40.180 ac,	Inflow Depth =	0.61"	for	2YR EVENT event
Inflow =	9.01 cfs @	12.96 hrs,	Volume=	2.033 af	
Outflow =	9.01 cfs @	12.96 hrs,	Volume=	2.033 af,	Atten= 0%, Lag= 0.0 min
Primary =	9.01 cfs @	12.96 hrs,	Volume=	2.033 af	

Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 855.32' @ 12.96 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	855.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=8.94 cfs @ 12.96 hrs HW=855.31' (Free Discharge)
└─1=**Broad-Crested Rectangular Weir** (Weir Controls 8.94 cfs @ 1.4 fps)

Pond 6P: Sawmill River



Pond 8P: Ext. Det. Basin1B (Prop.)

1] Warning: Submerged Pond 5P Primary device # 1 OUTLET by 0.18'

low Area = 40.180 ac, Inflow Depth = 0.67" for 2YR EVENT event
low = 14.70 cfs @ 12.58 hrs, Volume= 2.242 af
tflow = 9.21 cfs @ 12.96 hrs, Volume= 2.142 af, Atten= 37%, Lag= 23.0 min
scarded = 0.19 cfs @ 12.96 hrs, Volume= 0.109 af
mary = 4.32 cfs @ 12.96 hrs, Volume= 1.881 af
condary = 4.70 cfs @ 12.96 hrs, Volume= 0.153 af

uting by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
ak Elev= 864.18' @ 12.96 hrs Surf.Area= 9,296 sf Storage= 23,601 cf
g-Flow detention time= 93.5 min calculated for 2.142 af (96% of inflow)
nter-of-Mass det. time= 70.1 min (984.7 - 914.6)

#	Invert	Avail.Storage	Storage Description
1	861.00'	31,661 cf	**Custom Stage Data (Prismatic)** Listed below

evation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
861.00	5,740	0	0
862.00	6,663	6,202	6,202
863.00	7,779	7,221	13,423
864.00	8,967	8,373	21,796
865.00	10,764	9,866	31,661

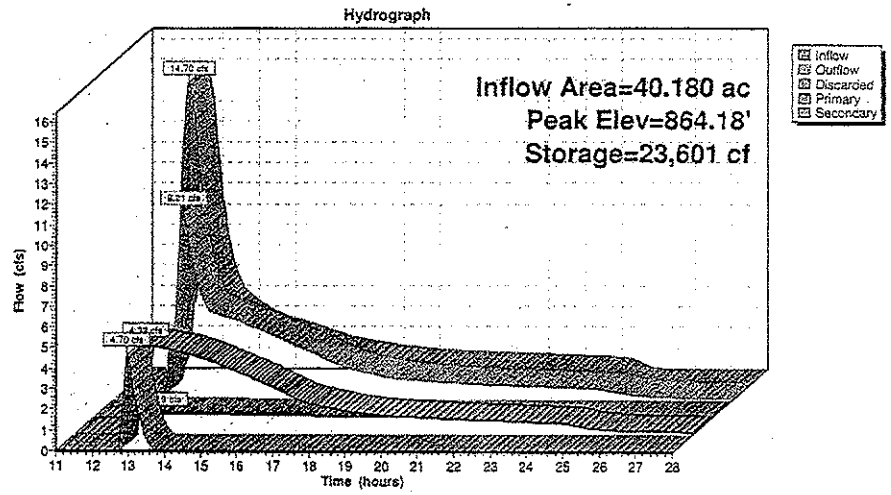
#	Routing	Invert	Outlet Devices
1	Primary	861.00'	**3.0" x 30.0' long Culvert** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 860.00' S= 0.0333 '/' n= 0.013 Cc= 0.900
2	Primary	861.85'	**12.0" x 30.0' long Culvert** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 860.85' S= 0.0333 '/' n= 0.013 Cc= 0.900
3	Secondary	864.00'	**6.0' long x 0.6' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 Coef. (English) 2.78 2.87 3.00 3.20 3.25 3.27 3.30 3.31 3.32
4	Discarded	861.00'	**0.003200 fpm Exfiltration over Surface area above Invert**
5	Secondary	861.25'	**15.0" x 20.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 860.85' S= 0.0200 '/' n= 0.013 Cc= 0.900
6	Device 5	864.00'	**12.6' long x 0.5' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

scarded OutFlow Max=0.19 cfs @ 12.96 hrs HW=864.18' (Free Discharge)
4=Exfiltration (Exfiltration Controls 0.19 cfs)

mary OutFlow Max=4.32 cfs @ 12.96 hrs HW=864.18' (Free Discharge)
1=Culvert (Barrel Controls 0.28 cfs @ 5.7 fps)
2=Culvert (Inlet Controls 4.04 cfs @ 5.1 fps)

condary OutFlow Max=4.61 cfs @ 12.96 hrs HW=864.18' (Free Discharge)
3=Broad-Crested Rectangular Weir (Weir Controls 1.29 cfs @ 1.2 fps)
5=Culvert (Passes 3.32 cfs of 8.97 cfs potential flow)
6=Sharp-Crested Rectangular Weir (Weir Controls 3.32 cfs @ 1.5 fps)

Pond 8P: Ext. Det. Basin1B (Prop.)



Pond 9P: Overflow Catch Basin

[57] Hint: Peaked at 855.93' (Flood elevation advised)

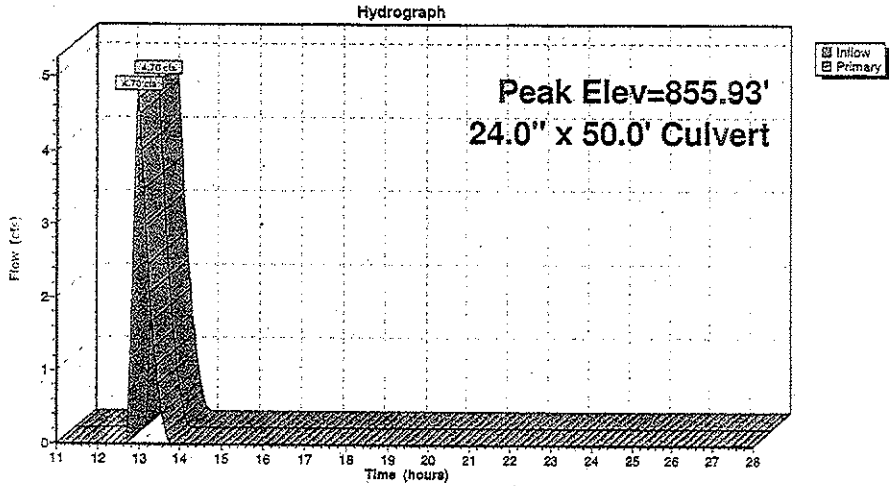
Inflow	=	4.70 cfs @	12.96 hrs,	Volume=	0.153 af
Outflow	=	4.70 cfs @	12.96 hrs,	Volume=	0.153 af, Atten= 0%, Lag= 0.0 min
Primary	=	4.70 cfs @	12.96 hrs,	Volume=	0.153 af

Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 855.93' @ 12.96 hrs
Plug-Flow detention time= (not calculated)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	855.00'	**24.0" x 50.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 852.00' S= 0.0600 '/' n= 0.013 Cc= 0.900

Primary OutFlow Max=4.63 cfs @ 12.96 hrs HW=855.92' (Free Discharge)
└1=**Culvert** (Inlet Controls 4.63 cfs @ 3.3 fps)

Pond 9P: Overflow Catch Basin



Pond 10P: High Flow Catch Basin

[57] Hint: Peaked at 875.77' (Flood elevation advised)
[61] Hint: Submerged 10% of Reach 3R bottom

Inflow Area =		40.180 ac,	Inflow Depth =	0.67"	for 2YR EVENT event
Inflow	=	14.78 cfs @	12.58 hrs,	Volume=	2.242 af
Outflow	=	14.78 cfs @	12.58 hrs,	Volume=	2.242 af, Atten= 0%, Lag= 0.0 min
Primary	=	14.78 cfs @	12.58 hrs,	Volume=	2.242 af
Secondary	=	0.00 cfs @	11.00 hrs,	Volume=	0.000 af

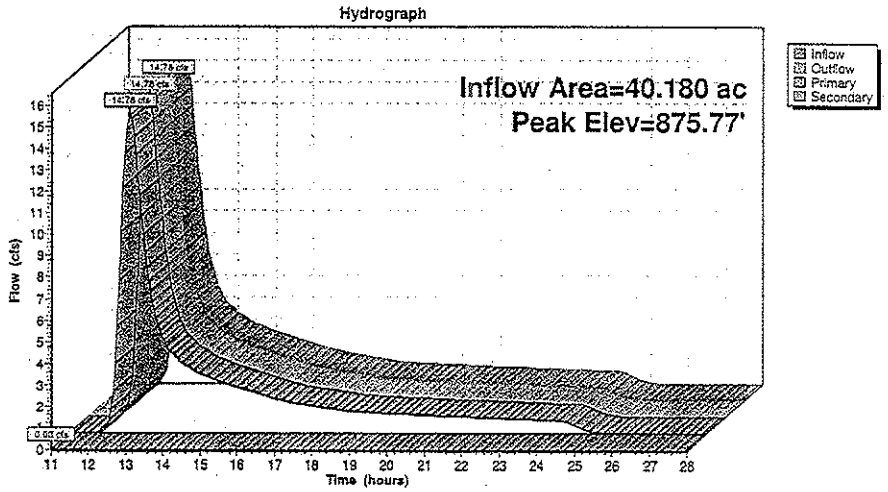
Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 875.77' @ 12.58 hrs
Plug-Flow detention time= 0.0 min calculated for 2.242 af (100% of inflow)
Center-of-Mass det. time= 0.0 min (914.6 - 914.6)

#	Routing	Invert	Outlet Devices
1	Primary	872.00'	**18.0" x 50.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 869.00' S= 0.0600 '/' n= 0.013 Cc= 0.900
2	Secondary	876.00'	**12.6' long x 0.5' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

Primary OutFlow Max=14.73 cfs @ 12.58 hrs HW=875.75' (Free Discharge)
└1=**Culvert** (Inlet Controls 14.73 cfs @ 8.3 fps)

Secondary OutFlow Max=0.00 cfs @ 11.00 hrs HW=872.00' (Free Discharge)
└2=**Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 10P: High Flow Catch Basin



Time span=11.00-28.00 hrs, dt=0.05 hrs, 341 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

ubcatchment 1S: Morse Hill Subcatchment Runoff Area=40.180 ac Runoff Depth=1.53"
Flow Length=2,745' Tc=31.4 min CN=69 Runoff=38.25 cfs 5.131 af

each 3R: Roadside Ditch (Exist.) Peak Depth=1.13' Max Vel=8.7 fps Inflow=38.25 cfs 5.131 af
n=0.030 L=1,000.0' S=0.0600 '/' Capacity=18.41 cfs Outflow=37.94 cfs 5.130 af

each 4R: Prop TRM Channel (lower) Peak Depth=0.72' Max Vel=7.4 fps Inflow=22.23 cfs 3.718 af
n=0.034 L=340.0' S=0.0824 '/' Capacity=24.26 cfs Outflow=22.14 cfs 3.717 af

each 9R: Prop TRM Channel (upper) Peak Depth=0.73' Max Vel=6.7 fps Inflow=21.27 cfs 0.869 af
n=0.034 L=340.0' S=0.0600 '/' Capacity=39.46 cfs Outflow=21.14 cfs 0.869 af

ond 5P: Bypass Catch Basin (Prop.) Peak Elev=875.70' Inflow=37.81 cfs 5.130 af
Primary=20.10 cfs 4.320 af Secondary=17.71 cfs 0.810 af Outflow=37.81 cfs 5.130 af

ond 6P: Sawmill River Peak Elev=855.76' Inflow=35.77 cfs 4.879 af
Outflow=35.77 cfs 4.879 af

ond 8P: Ext. Det. Basin1B (Prop.) Peak Elev=864.41' Storage=25,855 cf Inflow=20.10 cfs 4.320 af
Discarded=0.21 cfs 0.143 af Primary=4.57 cfs 2.907 af Secondary=13.97 cfs 1.162 af Outflow=18.76 cfs 4.213 af

ond 9P: Overflow Catch Basin (lower) Peak Elev=856.84' Inflow=13.97 cfs 1.162 af
24.0" x 50.0' Culvert Outflow=13.97 cfs 1.162 af

ond 10P: High Flow Catch Basin (upper) Peak Elev=876.59' Inflow=37.94 cfs 5.130 af
Primary=16.67 cfs 4.261 af Secondary=21.27 cfs 0.869 af Outflow=37.94 cfs 5.130 af

Total Runoff Area = 40.180 ac Runoff Volume = 5.131 af Average Runoff Depth = 1.53"

Subcatchment 1S: Morse Hill Subcatchment

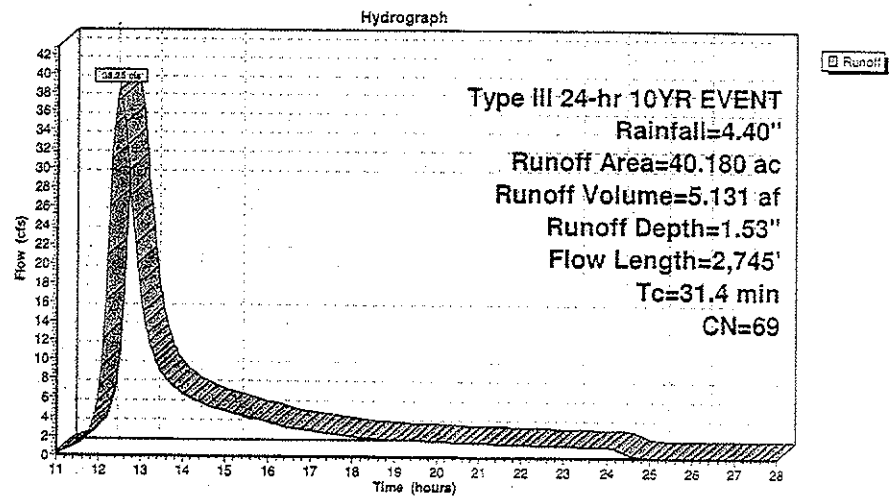
Runoff = 38.25 cfs @ 12.47 hrs, Volume= 5.131 af, Depth= 1.53"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Type III 24-hr 10YR EVENT Rainfall=4.40"

Area (ac)	CN	Description
39.000	68	Composite Woods - Good Cond.
1.180	90	Roadway
40.180	69	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.9	30	0.0500	0.1		Sheet Flow, Sheet Flow Woods: Light underbrush n= 0.400 P2= 3.00"
21.1	1,600	0.0900	1.3		Lag/CN Method, Woods
4.4	1,115	0.0600	4.3	12.78	Channel Flow, Channel Flow Area= 3.0 sf Perim= 6.7' r= 0.45' n= 0.050
31.4	2,745	Total			

Subcatchment 1S: Morse Hill Subcatchment



Reach 3R: Roadside Ditch (Exist.)

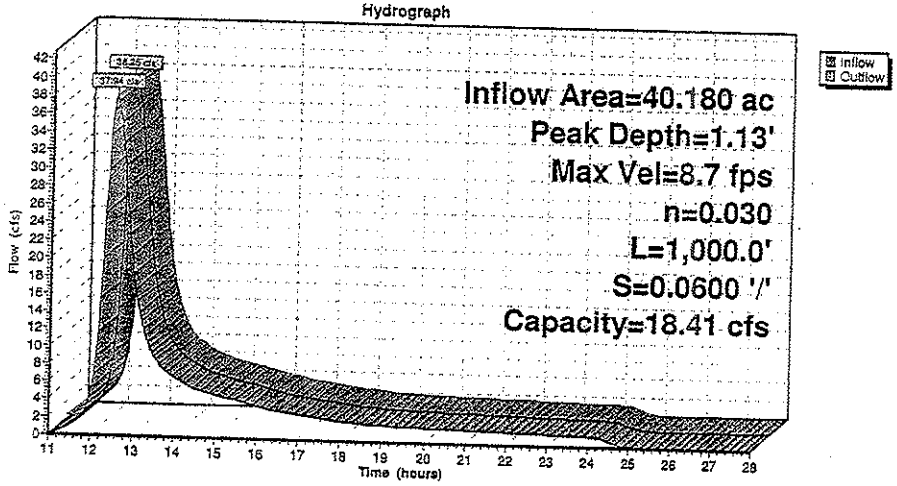
[82] Warning: Early inflow requires earlier time span
[91] Warning: Storage range exceeded by 0.38'
[55] Hint: Peak inflow is 208% of Manning's capacity ← CAPACITY EXCEEDED!

Inflow Area = 40.180 ac, Inflow Depth = 1.53" for 10YR EVENT event
Inflow = 38.25 cfs @ 12.47 hrs, Volume= 5.131 af
Outflow = 37.94 cfs @ 12.53 hrs, Volume= 5.130 af, Atten= 1%, Lag= 3.6 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.7 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 3.5 fps, Avg. Travel Time= 4.7 min

Peak Depth= 1.13' @ 12.50 hrs
Capacity at bank full= 18.41 cfs
Inlet Invert= 930.00', Outlet Invert= 870.00'
5.00' x 0.75' deep Parabolic Channel, n= 0.030 Length= 1,000.0' Slope= 0.0600 '/'

Reach 3R: Roadside Ditch (Exist.)



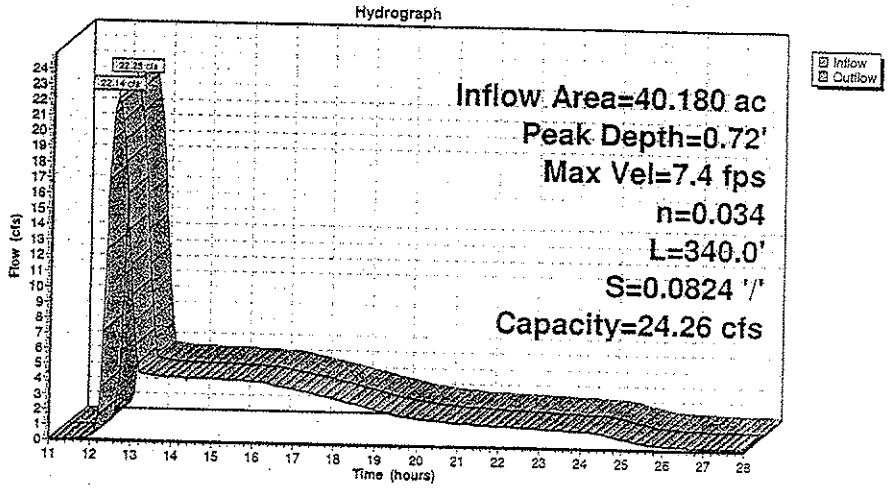
Reach 4R: Prop TRM Channel

Inflow Area = 40.180 ac, Inflow Depth = 1.11" for 10YR EVENT event
Inflow = 22.23 cfs @ 12.56 hrs, Volume= 3.718 af
Outflow = 22.14 cfs @ 12.58 hrs, Volume= 3.717 af, Atten= 0%, Lag= 1.4 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.4 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 3.5 fps, Avg. Travel Time= 1.6 min

Peak Depth= 0.72' @ 12.57 hrs
Capacity at bank full= 24.26 cfs
Inlet Invert= 858.00', Outlet Invert= 830.00'
2.00' x 0.75' deep channel, n= 0.034 Length= 340.0' Slope= 0.0824 '/'
Side Slope Z-value= 3.0 '/'

Reach 4R: Prop TRM Channel



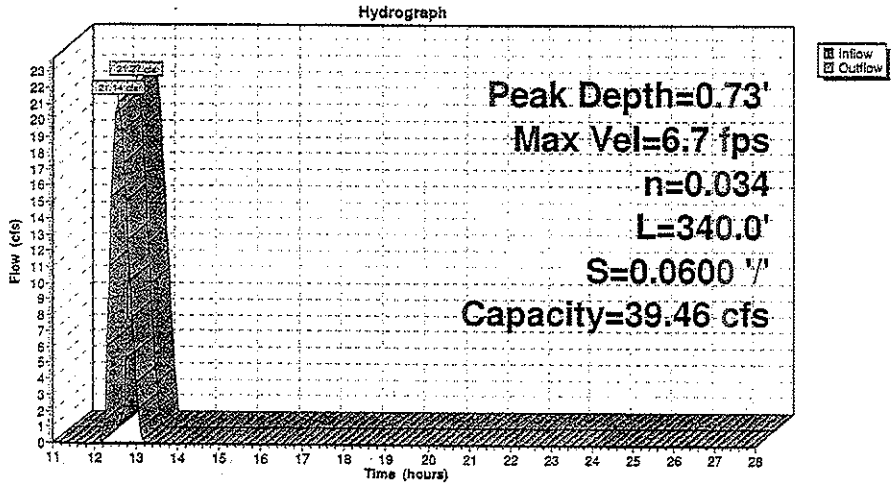
Reach 9R: Prop TRM Channel (Upper)

nflow = 21.27 cfs @ 12.53 hrs, Volume= 0.869 af
Outflow = 21.14 cfs @ 12.56 hrs, Volume= 0.869 af, Atten= 1%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.7 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 2.5 fps, Avg. Travel Time= 2.3 min

Peak Depth= 0.73' @ 12.54 hrs
Capacity at bank full= 39.46 cfs
Inlet Invert= 858.00', Outlet Invert= 837.60'
4.50' x 1.00' deep channel, n= 0.034 Length= 340.0' Slope= 0.0600 '/'
Side Slope Z-value= 2.0 3.0 '/'

Reach 9R: Prop TRM Channel



Pond 5P: Bypass Catch Basin (Prop.)

[57] Hint: Peaked at 875.70' (Flood elevation advised)
[63] Warning: Exceeded Reach 9R inflow depth by 16.96' @ 12.55 hrs
[79] Warning: Submerged Pond 10P Primary device # 1 INLET by 3.70'

Inflow Area = 40.180 ac, Inflow Depth = 1.53" for 10YR EVENT event
Inflow = 37.81 cfs @ 12.56 hrs, Volume= 5.130 af
Outflow = 37.81 cfs @ 12.56 hrs, Volume= 5.130 af, Atten= 0%, Lag= 0.0 min
Primary = 20.10 cfs @ 12.56 hrs, Volume= 4.320 af
Secondary = 17.71 cfs @ 12.56 hrs, Volume= 0.810 af

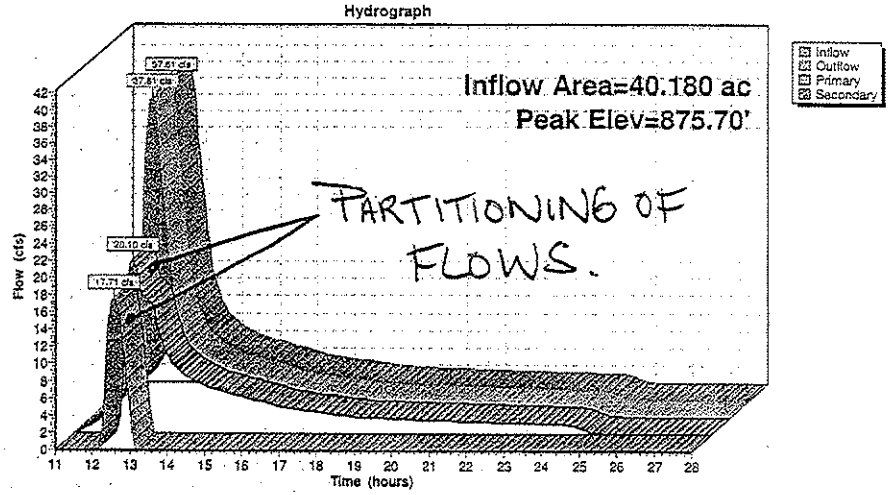
Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 875.70' @ 12.56 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	866.00'	**18.0" x 40.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 864.00' S= 0.0500 '/' n= 0.013 Cc= 0.900
2	Secondary	868.00'	**18.0" x 100.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 862.00' S= 0.0600 '/' n= 0.013 Cc= 0.900
3	Device 2	871.50'	**4.0' long x 3.8' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

Primary OutFlow Max=20.07 cfs @ 12.56 hrs HW=875.68' (Free Discharge)
└─1=**Culvert** (Inlet Controls 20.07 cfs @ 11.4 fps)

Secondary OutFlow Max=17.68 cfs @ 12.56 hrs HW=875.68' (Free Discharge)
└─2=**Culvert** (Inlet Controls 17.68 cfs @ 10.0 fps)
└─3=**Sharp-Crested Rectangular Weir** (Passes 17.68 cfs of 126.74 cfs potential flow)

Pond 5P: Bypass Catch Basin (Prop.)



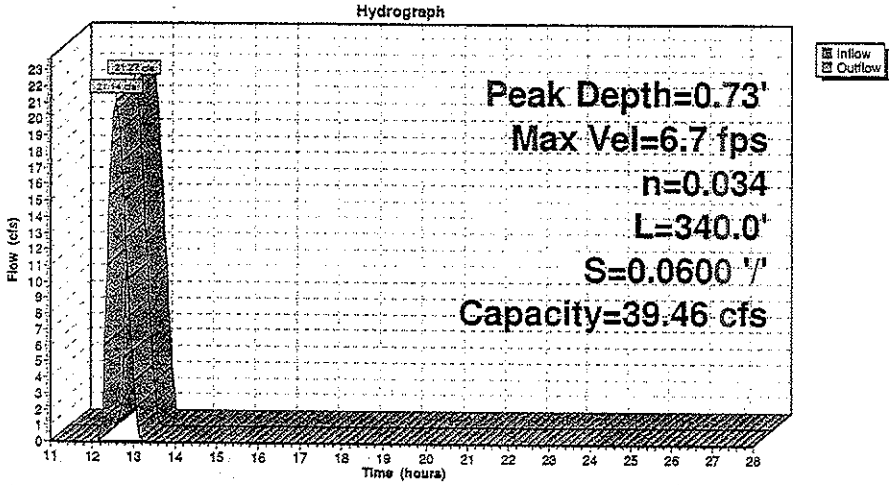
Reach 9R: Prop TRM Channel (Upper)

nflow = 21.27 cfs @ 12.53 hrs, Volume= 0.869 af
Outflow = 21.14 cfs @ 12.56 hrs, Volume= 0.869 af, Atten= 1%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.7 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 2.5 fps, Avg. Travel Time= 2.3 min

Peak Depth= 0.73' @ 12.54 hrs
Capacity at bank full= 39.46 cfs
Inlet Invert= 858.00', Outlet Invert= 837.60'
.50' x 1.00' deep channel, n= 0.034 Length= 340.0' Slope= 0.0600 '/'
Side Slope Z-value= 2.0 3.0 '/'

Reach 9R: Prop TRM Channel



Pond 5P: Bypass Catch Basin (Prop.)

[57] Hint: Peaked at 875.70' (Flood elevation advised)
[63] Warning: Exceeded Reach 9R inflow depth by 16.96' @ 12.55 hrs
[79] Warning: Submerged Pond 10P Primary device # 1 INLET by 3.70'

Inflow Area = 40.180 ac, Inflow Depth = 1.53" for 10YR EVENT event
Inflow = 37.81 cfs @ 12.56 hrs, Volume= 5.130 af
Outflow = 37.81 cfs @ 12.56 hrs, Volume= 5.130 af, Atten= 0%, Lag= 0.0 min
Primary = 20.10 cfs @ 12.56 hrs, Volume= 4.320 af
Secondary = 17.71 cfs @ 12.56 hrs, Volume= 0.810 af

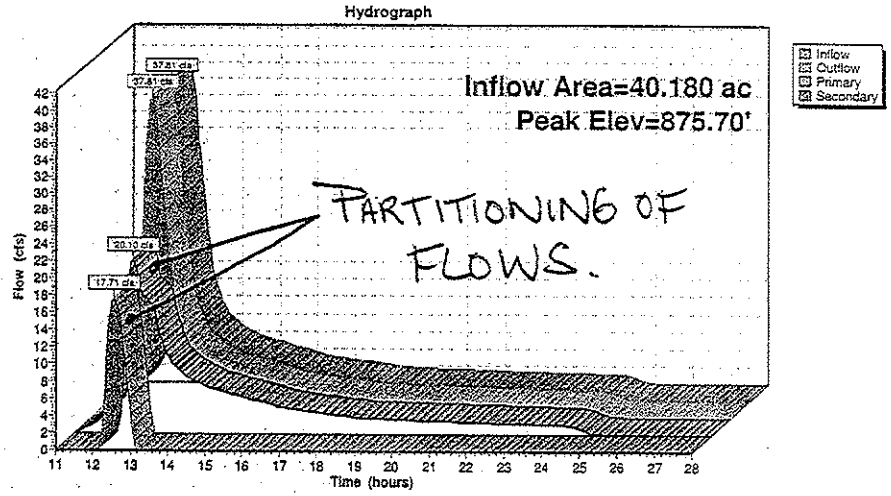
Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 875.70' @ 12.56 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	866.00'	**18.0" x 40.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 864.00' S= 0.0500 '/' n= 0.013 Cc= 0.900
2	Secondary	868.00'	**18.0" x 100.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 862.00' S= 0.0600 '/' n= 0.013 Cc= 0.900
3	Device 2	871.50'	**4.0' long x 3.8' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

Primary OutFlow Max=20.07 cfs @ 12.56 hrs HW=875.68' (Free Discharge)
└1=Culvert (Inlet Controls 20.07 cfs @ 11.4 fps)

Secondary OutFlow Max=17.68 cfs @ 12.56 hrs HW=875.68' (Free Discharge)
└2=Culvert (Inlet Controls 17.68 cfs @ 10.0 fps)
└3=Sharp-Crested Rectangular Weir (Passes 17.68 cfs of 126.74 cfs potential flow)

Pond 5P: Bypass Catch Basin (Prop.)



Pond 6P: Sawmill River

[57] Hint: Peaked at 855.76' (Flood elevation advised)
[61] Hint: Submerged 92% of Reach 4R bottom
[81] Warning: Exceeded Pond 9P by 0.47' @ 12.40 hrs

Inflow Area =	40.180 ac,	Inflow Depth =	1.46"	for	10YR EVENT event
Inflow =	35.77 cfs @	12.62 hrs,	Volume=	4.879 af	
Outflow =	35.77 cfs @	12.62 hrs,	Volume=	4.879 af,	Atten= 0%, Lag= 0.0 min
Primary =	35.77 cfs @	12.62 hrs,	Volume=	4.879 af	

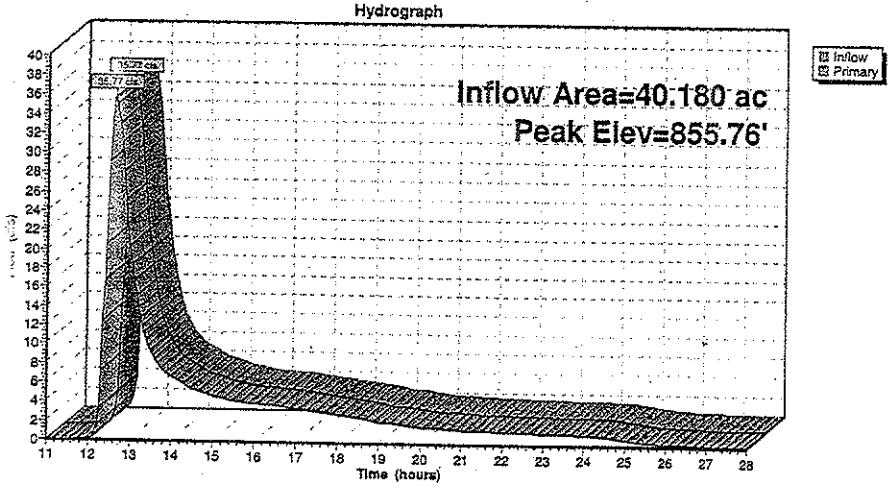
Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 855.76' @ 12.62 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	855.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=35.62 cfs @ 12.62 hrs HW=855.76' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 35.62 cfs @ 2.3 fps)

Pond 6P: Sawmill River

Hydrograph



Pond 8P: Ext. Det. Basin1B (Prop.)

[79] Warning: Submerged Pond 5P Primary device # 1 OUTLET by 0.41'

Inflow Area =	40.180 ac,	Inflow Depth =	1.29"	for	10YR EVENT event
Inflow =	20.10 cfs @	12.56 hrs,	Volume=	4.326 af	
Outflow =	18.76 cfs @	12.68 hrs,	Volume=	4.213 af,	Atten= 7%, Lag= 7.3 min
Discarded =	0.21 cfs @	12.68 hrs,	Volume=	0.143 af	
Primary =	4.57 cfs @	12.68 hrs,	Volume=	2.907 af	
Secondary =	13.97 cfs @	12.68 hrs,	Volume=	1.162 af	

Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 864.41' @ 12.68 hrs Surf.Area= 9,706 sf Storage= 25,855 cf
Plug-Flow detention time= 64.1 min calculated for 4.201 af (97% of inflow)
Center-of-Mass det. time= 51.2 min (962.2 - 910.9)

#	Invert	Avail.Storage	Storage Description
1	861.00'	31,661 cf	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
861.00	5,740	0	0
862.00	6,663	6,202	6,202
863.00	7,779	7,221	13,423
864.00	8,967	8,373	21,796
865.00	10,764	9,866	31,661

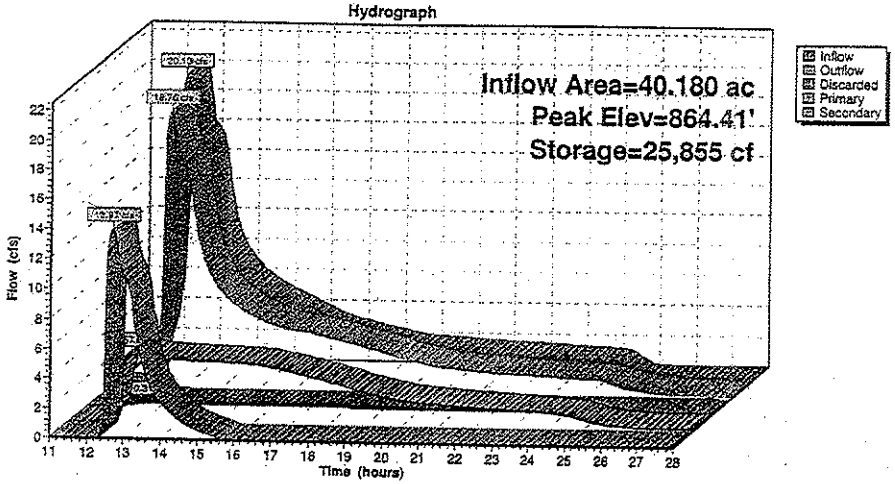
#	Routing	Invert	Outlet Devices
1	Primary	861.00'	**3.0" x 30.0' long Culvert** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 860.00' S= 0.0333 '/' n= 0.013 Cc= 0.900
2	Primary	861.85'	**12.0" x 30.0' long Culvert** CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 860.85' S= 0.0333 '/' n= 0.013 Cc= 0.900
3	Secondary	864.00'	**6.0' long x 0.6' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 Coef. (English) 2.78 2.87 3.00 3.20 3.25 3.27 3.30 3.31 3.32
4	Discarded	861.00'	**0.003200 fpm Exfiltration over Surface area above Invert**
5	Secondary	861.25'	**15.0" x 20.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 860.85' S= 0.0200 '/' n= 0.013 Cc= 0.900
6	Device 5	864.00'	**12.6' long x 0.5' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

Discarded OutFlow Max=0.21 cfs @ 12.68 hrs HW=864.41' (Free Discharge)
└**4=Exfiltration** (Exfiltration Controls 0.21 cfs)

Primary OutFlow Max=4.57 cfs @ 12.68 hrs HW=864.41' (Free Discharge)
├**1=Culvert** (Barrel Controls 0.29 cfs @ 5.8 fps)
└**2=Culvert** (Inlet Controls 4.28 cfs @ 5.5 fps)

Secondary OutFlow Max=13.93 cfs @ 12.68 hrs HW=864.41' (Free Discharge)
├**3=Broad-Crested Rectangular Weir** (Weir Controls 4.52 cfs @ 1.8 fps)
└**5=Culvert** (Inlet Controls 9.41 cfs @ 7.7 fps)
└**6=Sharp-Crested Rectangular Weir** (Passes 9.41 cfs of 11.88 cfs potential flow)

Pond 8P: Ext. Det. Basin1B (Prop.)



Pond 9P: Overflow Catch Basin

[57] Hint: Peaked at 856.84' (Flood elevation advised)

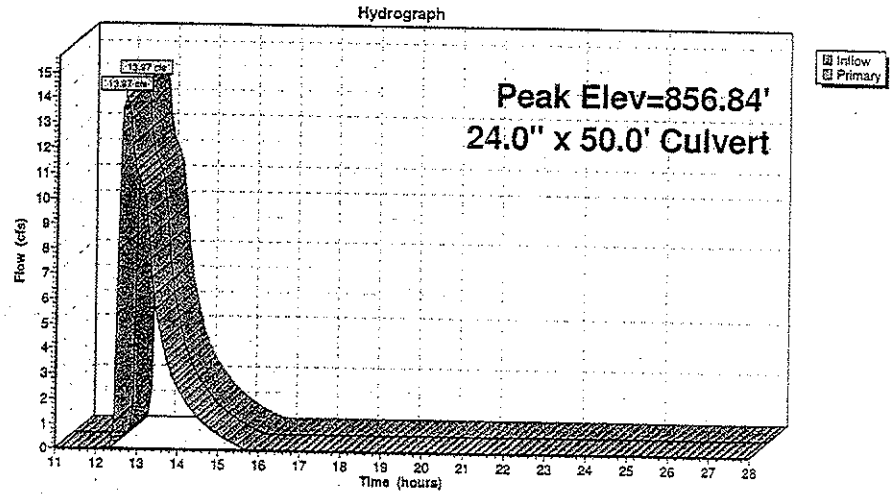
Inflow	=	13.97 cfs @	12.68 hrs,	Volume=	1.162 af
Outflow	=	13.97 cfs @	12.68 hrs,	Volume=	1.162 af, Atten= 0%, Lag= 0.0 min
Primary	=	13.97 cfs @	12.68 hrs,	Volume=	1.162 af

Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 856.84' @ 12.68 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	855.00'	**24.0" x 50.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 852.00' S= 0.0600 '/' n= 0.013 Cc= 0.900

Primary OutFlow Max=13.93 cfs @ 12.68 hrs HW=856.84' (Free Discharge)
└─**1=Culvert** (Inlet Controls 13.93 cfs @ 4.6 fps)

Pond 9P: Overflow Catch Basin



Pond 10P: High Flow Catch Basin

[57] Hint: Peaked at 876.59' (Flood elevation advised)
[61] Hint: Submerged 11% of Reach 3R bottom

Inflow Area = 40.180 ac, Inflow Depth = 1.53" for 10YR EVENT event
Inflow = 37.94 cfs @ 12.53 hrs, Volume= 5.130 af
Outflow = 37.94 cfs @ 12.53 hrs, Volume= 5.130 af, Atten= 0%, Lag= 0.0 min
Primary = 16.67 cfs @ 12.53 hrs, Volume= 4.261 af
Secondary = 21.27 cfs @ 12.53 hrs, Volume= 0.869 af

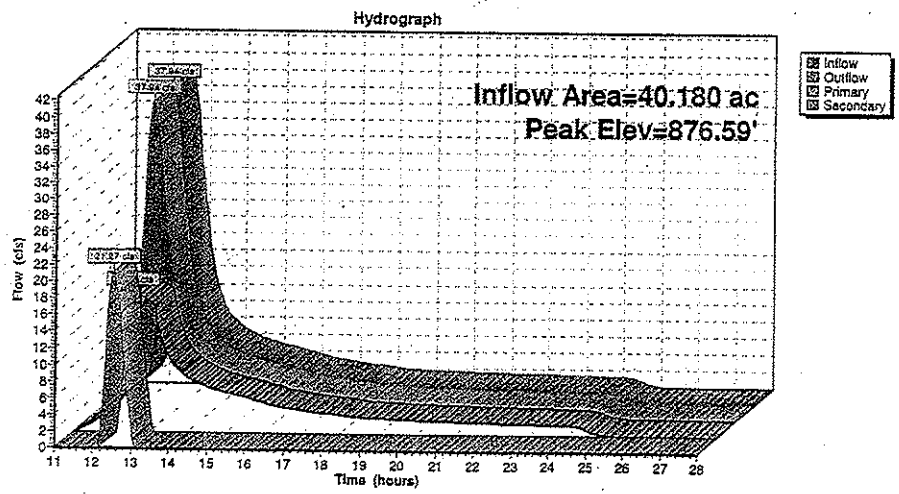
Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 876.59' @ 12.53 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	872.00'	**18.0" x 50.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 869.00' S= 0.0600 '/' n= 0.013 Cc= 0.900
2	Secondary	876.00'	**12.6' long x 0.5' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

Primary OutFlow Max=16.66 cfs @ 12.53 hrs HW=876.59' (Free Discharge)
└1=**Culvert** (Inlet Controls 16.66 cfs @ 9.4 fps)

Secondary OutFlow Max=21.13 cfs @ 12.53 hrs HW=876.59' (Free Discharge)
└2=**Sharp-Crested Rectangular Weir** (Weir Controls 21.13 cfs @ 2.9 fps)

Pond 10P: High Flow Catch Basin



Time span=11.00-28.00 hrs, dt=0.05 hrs, 341 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Morse Hill Subcatchment Runoff Area=40.180 ac Runoff Depth=2.09"
Flow Length=2,745' Tc=31.4 min CN=69 Runoff=53.62 cfs 7.005 af

Reach 3R: Roadside Ditch (Exist.) Peak Depth=1.42' Max Vel=9.1 fps Inflow=53.62 cfs 7.005 af
n=0.030 L=1,000.0' S=0.0600 '/' Capacity=18.41 cfs Outflow=53.20 cfs 7.002 af

Reach 4R: Prop TRM Channel (Lower) Peak Depth=0.84' Max Vel=8.0 fps Inflow=30.46 cfs 4.687 af
n=0.034 L=340.0' S=0.0824 '/' Capacity=24.26 cfs Outflow=30.38 cfs 4.686 af

Reach 9R: Prop TRM Channel (Upper) Peak Depth=0.96' Max Vel=7.7 fps Inflow=36.05 cfs 1.714 af
n=0.034 L=340.0' S=0.0600 '/' Capacity=39.46 cfs Outflow=35.86 cfs 1.714 af

Pond 5P: Bypass Catch Basin (Prop.) Peak Elev=883.33' Inflow=53.00 cfs 7.002 af
Primary=27.35 cfs 5.672 af Secondary=25.65 cfs 1.330 af Outflow=53.00 cfs 7.002 af

Pond 6P: Sawmill River Peak Elev=855.96' Inflow=50.67 cfs 6.732 af
Outflow=50.67 cfs 6.732 af

Pond 8P: Ext. Det. Basin1B (Prop.) Floor El. 861.0 Peak Elev=864.70' Storage=26,682 cf Inflow=27.35 cfs 5.672 af
Discarded=0.24 cfs 0.160 af Primary=4.87 cfs 3.357 af Secondary=20.77 cfs 2.046 af Outflow=25.86 cfs 5.563 af

Pond 9P: Overflow Catch Basin (Lower) Peak Elev=857.89' Inflow=20.77 cfs 2.046 af
24.0" x 50.0' Culvert Outflow=20.77 cfs 2.046 af

Pond 10P: High Flow Catch Basin (Upper) Peak Elev=876.81' Inflow=53.20 cfs 7.002 af
Primary=17.15 cfs 5.288 af Secondary=36.05 cfs 1.714 af Outflow=53.20 cfs 7.002 af

Total Runoff Area = 40.180 ac Runoff Volume = 7.005 af Average Runoff Depth = 2.09"

Subcatchment 1S: Morse Hill Subcatchment

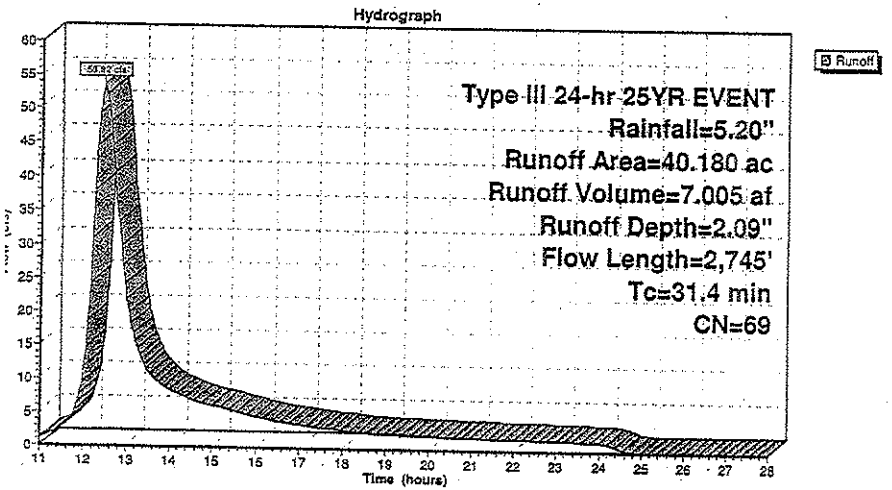
:off = 53.62 cfs @ 12.46 hrs, Volume= 7.005 af, Depth= 2.09"

:off by SCS TR-20 method, UH=SCS, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
:e III 24-hr 25YR EVENT Rainfall=5.20"

Area (ac)	CN	Description
39.000	68	Composite Woods - Good Cond.
1.180	90	Roadway
40.180	69	Weighted Average

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.9	30	0.0500	0.1		**Sheet Flow, Sheet Flow**
					Woods: Light underbrush n= 0.400 P2= 3.00"
21.1	1,600	0.0900	1.3		**Lag/CN Method, Woods**
4.4	1,115	0.0600	4.3	12.78	**Channel Flow, Channel Flow**
					Area= 3.0 sf Perim= 6.7' r= 0.45' n= 0.050
31.4	2,745	Total			

Subcatchment 1S: Morse Hill Subcatchment



Reach 3R: Roadside Ditch (Exist.)

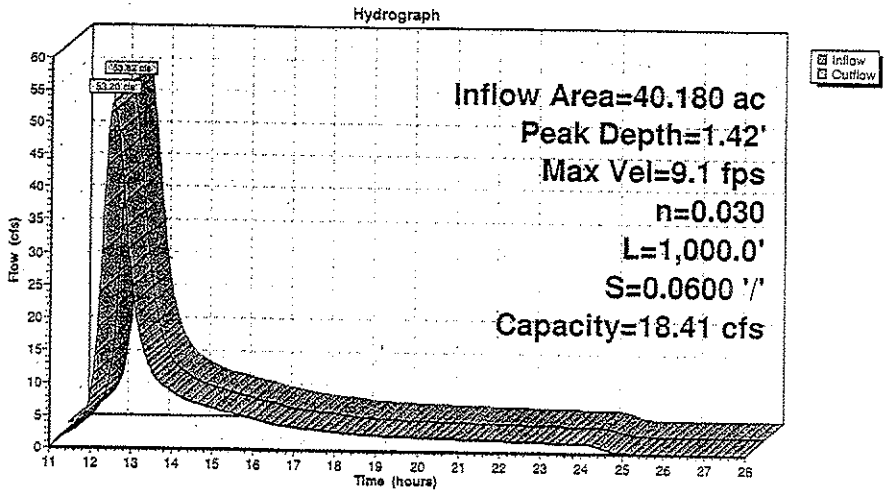
[82] Warning: Early inflow requires earlier time span
[91] Warning: Storage range exceeded by 0.67'
[55] Hint: Peak inflow is 291% of Manning's capacity

Inflow Area = 40.180 ac, Inflow Depth = 2.09" for 25YR EVENT event
Inflow = 53.62 cfs @ 12.46 hrs, Volume= 7.005 af
Outflow = 53.20 cfs @ 12.52 hrs, Volume= 7.002 af, Atten= 1%, Lag= 3.5 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.1 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 3.9 fps, Avg. Travel Time= 4.3 min

Peak Depth= 1.42' @ 12.49 hrs
Capacity at bank full= 18.41 cfs
Inlet Invert= 930.00', Outlet Invert= 870.00'
5.00' x 0.75' deep Parabolic Channel, n= 0.030 Length= 1,000.0' Slope= 0.0600 '/'

Reach 3R: Roadside Ditch (Exist.)



Reach 4R: Prop TRM Channel

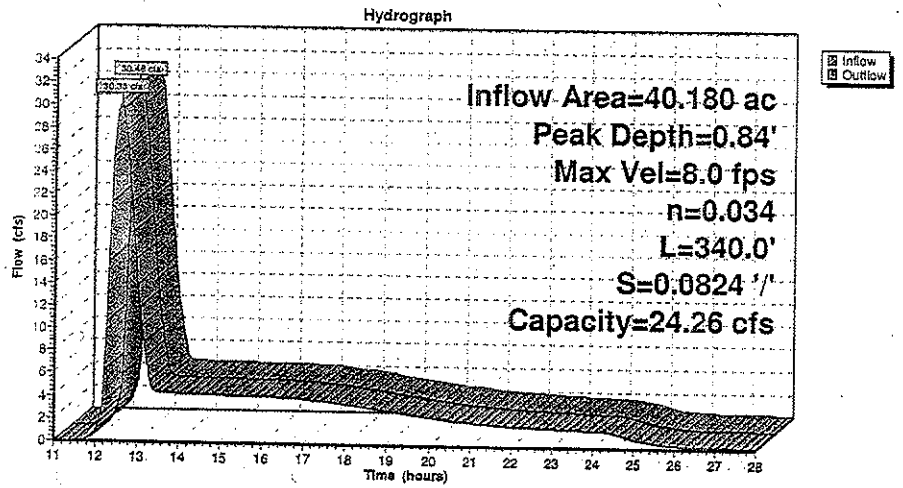
[91] Warning: Storage range exceeded by 0.09'
[55] Hint: Peak inflow is 126% of Manning's capacity

Inflow Area = 40.180 ac, Inflow Depth = 1.40" for 25YR EVENT event
Inflow = 30.46 cfs @ 12.54 hrs, Volume= 4.687 af
Outflow = 30.38 cfs @ 12.56 hrs, Volume= 4.686 af, Atten= 0%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.0 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 3.7 fps, Avg. Travel Time= 1.5 min

Peak Depth= 0.84' @ 12.55 hrs
Capacity at bank full= 24.26 cfs
Inlet Invert= 858.00', Outlet Invert= 830.00'
2.00' x 0.75' deep channel, n= 0.034 Length= 340.0' Slope= 0.0824 '/'
Side Slope Z-value= 3.0 '/'

Reach 4R: Prop TRM Channel



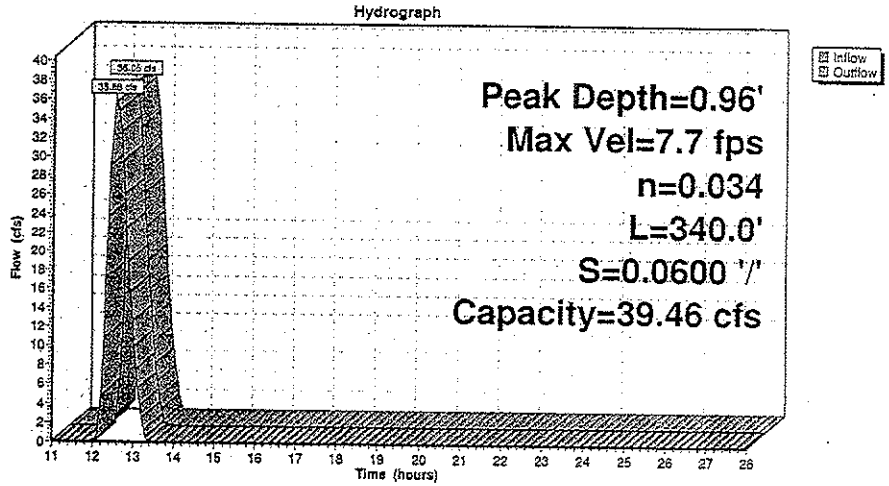
Reach 9R: Prop TRM Channel

Inflow = 36.05 cfs @ 12.52 hrs, Volume= 1.714 af
Outflow = 35.86 cfs @ 12.54 hrs, Volume= 1.714 af, Atten= 1%, Lag= 1.4 min

Routing by Stor-Ind+Trans method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.7 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 3.1 fps, Avg. Travel Time= 1.8 min

Peak Depth= 0.96' @ 12.53 hrs
Capacity at bank full= 39.46 cfs
Inlet Invert= 858.00', Outlet Invert= 837.60'
2.50' x 1.00' deep channel, n= 0.034 Length= 340.0' Slope= 0.0600 '/'
Side Slope Z-value= 2.0 3.0 '/'

Reach 9R: Prop TRM Channel



Pond 5P: Bypass Catch Basin (Prop.)

] Hint: Peaked at 883.33' (Flood elevation advised)
] Warning: Exceeded Reach 9R inflow depth by 24.36' @ 12.55 hrs
] Warning: Exceeded Pond 10P by 6.51' @ 12.55 hrs

ow Area =	40.180 ac,	Inflow Depth =	2.09"	for	25YR EVENT event
ow =	53.00 cfs @	12.54 hrs,	Volume=	7.002 af	
flow =	53.00 cfs @	12.54 hrs,	Volume=	7.002 af,	Atten= 0%, Lag= 0.0 min
nary =	27.35 cfs @	12.54 hrs,	Volume=	5.672 af	
condary =	25.65 cfs @	12.54 hrs,	Volume=	1.330 af	

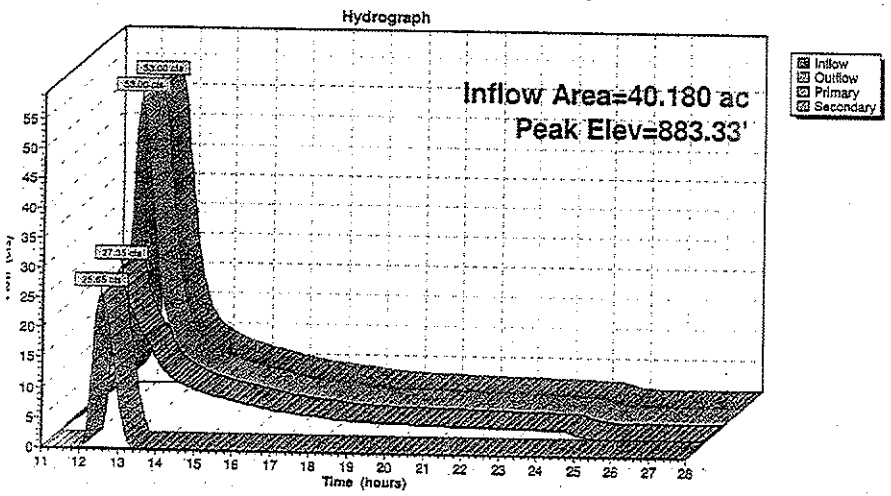
uting by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
ak Elev= 883.33' @ 12.54 hrs
g-Flow detention time= (not calculated: outflow precedes inflow)
nter-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
	Primary	866.00'	**18.0" x 40.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 864.00' S= 0.0500 '/' n= 0.013 Cc= 0.900
2	Secondary	868.00'	**18.0" x 100.0' long Culvert** CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 862.00' S= 0.0600 '/' n= 0.013 Cc= 0.900
3	Device 2	871.50'	**4.0' long x 3.8' high Sharp-Crested Rectangular Weir** 0 End Contraction(s)

nary OutFlow Max=27.29 cfs @ 12.54 hrs HW=883.26' (Free Discharge)
1=Culvert (Inlet Controls 27.29 cfs @ 15.4 fps)

condary OutFlow Max=25.59 cfs @ 12.54 hrs HW=883.26' (Free Discharge)
2=Culvert (Inlet Controls 25.59 cfs @ 14.5 fps)
3=Sharp-Crested Rectangular Weir (Passes 25.59 cfs of 726.85 cfs potential flow)

Pond 5P: Bypass Catch Basin (Prop.)



Pond 6P: Sawmill River

[57] Hint: Peaked at 855.96' (Flood elevation advised)
[61] Hint: Submerged 93% of Reach 4R bottom
[61] Warning: Exceeded Pond 9P by 0.35' @ 12.25 hrs

Inflow Area =	40.180 ac,	Inflow Depth =	2.01"	for	25YR EVENT event
Inflow =	50.67 cfs @	12.60 hrs,	Volume=	6.732 af	
Outflow =	50.67 cfs @	12.60 hrs,	Volume=	6.732 af,	Atten= 0%, Lag= 0.0 min
Primary =	50.67 cfs @	12.60 hrs,	Volume=	6.732 af	

Routing by Stor-Ind method, Time Span= 11.00-28.00 hrs, dt= 0.05 hrs
Peak Elev= 855.96' @ 12.60 hrs
Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated)

#	Routing	Invert	Outlet Devices
1	Primary	855.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=50.63 cfs @ 12.60 hrs HW=855.96' (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 50.63 cfs @ 2.6 fps)

Pond 6P: Sawmill River