NEW JERSEY GEOLOGICAL & WATER SURVEY

Open-File Report OFR 13-1

History of Passing Flows in New Jersey, with Contemporary and Future Applications

New Jersey Department of Environmental Protection

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At the same time, it is crucial to understand how actions of this agency can impact the State's economic growth, to recognize the interconnection of the health of New Jersey's environment and its economy, and to appreciate that environmental stewardship and positive economic growth are not mutually exclusive goals: we will continue to protect the environment while playing a key role in positively impacting the economic growth of the state.

NEW JERSEY GEOLOGICAL & WATER SURVEY

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On the cover: Outlet of the Round Valley Reservoir to South Rockaway Creek (ID pf057 in appendix B).

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History of Passing Flows in New Jersey, with Contemporary and Future Applications

by

Jeffrey L. Hoffman and Steven E. Domber

New Jersey Geological & Water Survey

New Jersey Department of Environmental Protection
Water Resources Management
Division of Water Supply & Geoscience
New Jersey Geological & Water Survey
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2013

Conversion Factors

Multiply inch-pound units	by	to obtain metric (SI) units	Multiply inch-pound units	by	to obtain metric (SI) units
VOLUME			**FLOW RATE**		
cubic inches (in^3)	16.39	cubic centimeters (cm^3)	million gallons/day (mgd)	0.04381	cubic meters/second (m^3/s)
cubic feet (ft^3)	0.02832	cubic meters (m^3)	cubic feet per second (cfs)	2,447	cubic meters/day (m^3/d)
gallons (gal)	3.785	liters (L)	million gallons/year (mgy)	3,785	cubic meters/year(m^3/y)
gallons (gal)	$3.785X10^{-3}$	cubic meters (m^3)	gallons/minute (gpm)	.06309	liters/second (L/s)

Note: In this report 1 billion = 1,000 million; 1 trillion = 1,000 billion

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“Healthy, well-functioning rivers and aquatic ecosystems are as fundamental to the workings of the natural world as arteries, veins, and the heart are to a human body. … These functions are easy to take for granted because they are rarely priced by the market, and they require virtually no investment on our part”. --- Postel, 1997

"It's always the downstream people who suffer the results of upstream negligence."
-- Prof. M. Richard Nalbandian, Temple University, quoted in the article 'In The Water's Way',
Philadelphia Inquirer, Sept. 24, 2006

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Abstract

A passing flow is a rate of water flow which either must be maintained downstream from an impoundment or must be allowed to pass a specified point in a stream. These flows are set for three reasons: (1) to protect the water privileges of downstream users; (2) to provide sufficient dilution for downstream discharges to prevent a violation of water-quality standards; and (3) to maintain sufficient flow to support the aquatic ecosystem.

New Jersey state-ordered passing flows date to 1916. In that year a passing flow was applied to the newly-approved Wanaque Reservoir in Passaic County to protect downstream water rights and prevent unsanitary conditions. Prior to that time water rights had been protected by judicial action. Water-quality passing flows were first ordered in the late 1950's for two major reservoirs in the Raritan River watershed that came online in the 1960's. The first ecological-preservation passing flows date to the 1954 U.S. Supreme Court Decree[1] which required releases from New York City's reservoirs on the Upper Delaware River to protect shellfisheries in Delaware Bay.

By 2007, the New Jersey Department of Environmental Protection (NJDEP), Division of Water Supply & Geoscience, had set more than 100 passing flows. These are conditions added to water allocation permits issued to users who can withdraw water at a rate of 100,000 gallons per day or more. Violation of the passing flows may result in monetary fines and/or permit cancellation. An additional passing flow, set by the NJDEP's Division of Parks & Forestry, governs releases from Lake Hopatcong in northern New Jersey.

Passing-flow requirements are applied to three general types of water-supply facilities in New Jersey: surface-water intakes, reservoirs, and water-table wells. A passing-flow requirement must specify two locations, an 'action point' where streamflow is modified and a 'monitoring point,' where streamflow is measured.

Passing flows have been set using a variety of methods. The first passing flows were based either on water needs of downstream users or on the estimated dry-weather flow from the watershed upstream of the withdrawal point. Other methods now in use include estimation of the flow needed to dilute a discharge, an estimate of the flow needed to sustain a specific aquatic species, or a statistical analysis of low flows. The annual 7Q10 flow is the basis for many passing-flow requirements in New Jersey. This is the lowest annual 7-day flow which occurs on average once a decade and is an example of a statisti-

[1] U.S. Supreme Court, State Of New Jersey v. State Of New York, 347 U.S. 995 (1954).

cal analysis of low flows. The 7Q10 flow is also commonly used in estimating the impact of a treated-effluent discharge on water quality.

Estimating the flows needed to protect aquatic ecology is complex. In New Jersey, the most common approach has been to assume that preserving the annual 7Q10 flow is sufficient for such protection. However this is a statistical analysis of low flows. The 7Q10's ubiquity is based on its ease of calculation, not any proven ecological significance. Also, the 7Q10 flow is a constant value that does not vary during the year. It cannot protect the natural variability in stream flows. The New England and Tennent methods are based on statistical analyses of monthly low flows and do produce estimates of ecologically-sustaining flows that vary from month-to-month or season-to-season. However, the NJDEP has not yet applied these methods in setting any passing flows.

During water-supply droughts, the NJDEP has relaxed passing flows downstream from major reservoirs and surface water intakes. This helps preserve storage in the reservoirs, thus saving the water for public-supply needs. During New Jersey's 2002 drought, special monitoring of surface water quality downstream of reservoirs showed that the reductions in passing flows did not result in any violations of surface-water-quality standards.

Introduction

Water is essential for human survival. In New Jersey, streams and aquifers provide as much as 1 trillion gallons of water a year for domestic, agricultural, non-agricultural irrigation, commercial, industrial, mining, and power-generation needs (Domber and others, 2007). Surface-water and unconfined groundwater withdrawals to meet these needs may significantly reduce streamflows. Passing flows are a way to limit the impacts of withdrawals to protect downstream users, surface-water quality, and the aquatic ecosystem.

This report 1) summarizes the types of passing flows used in New Jersey, 2) presents a history of selected passing flows in the State, and 3) discusses methods of setting these flows. It is intended for water-resource professionals trying to implement a consistent and effective approach to protecting the water resources of the State, and for those interested in how the State's approach to setting passing flows developed.

There are two general types of surface-water facilities - intakes and reservoirs. An intake is, at its simplest, a pipe that withdraws water from a flowing stream. Pumping at intakes reduces the amount of water available downstream.

A reservoir consists of a dam and a trapped pool of water. Water is stored behind the dam during wet periods, thus reducing stream flow. The water can be released during dry periods to meet the needs of downstream users. Both of these actions alter streamflow from what it would have been had the reservoir not been there. There are two types of reservoirs, on-stream and off-stream. An on-stream reservoir impounds a river or stream; filling during wet periods and draining during dry periods. An off-stream reservoir is built at a site with appropriate topography but an insufficient water supply. It is intended to store water mainly withdrawn by an intake on a nearby water source.

Actions at intakes or reservoirs which reduce flows may leave less water in the steam than is needed by downstream intakes. Flow may also be insufficient for adequate dilution of downstream treated effluent discharges. Low flows that are lower than normal, more frequent than normal, or longer in duration than normal, may also damage the aquatic ecosystem.

Groundwater withdrawals from the water-table aquifer may also affect streamflow by causing leakage out of the stream or by intercepting groundwater that would have discharged to the stream (Heath, 1983; Winter and others, 1998). Large-capacity water-table pumps near small streams may significantly reduce streamflow. In extreme cases, small streams may dry up during peak pumping periods.

One method to protect downstream water needs is to establish minimum passing flows. In general, a passing flow sets a rate at which water must be released from a reservoir or pass an intake or well. An intake's passing-flow requirement may specify that its withdrawals must not reduce streamflow below a set flow rate. This requires that the intake cease pumping if streamflow drops to or below the passing flow.

The term 'passing flow' is unique to New Jersey. Elsewhere, these flows are referred to as flow-by, pass-by flows, minimum by-pass, residual streamflow, or compensation flows. Passing flows intended to sustain the aquatic ecosystem are also called instream flows, conservation releases, or environmental flows.

Until the early 20th century, downstream water rights in New Jersey were enforced by court-ordered limits on upstream intakes. These limits grew out of lawsuits filed by threatened downstream users. In the early 20th century, the New Jersey state government became more involved in planning and permitting water-supply facilities as well as refereeing disputes (New Jersey Water Supply Commission, 1909). This involvement developed to protect the State's water supply and to deal with conflicts associated with the building of New Jersey's first major water-supply reservoirs in the late 19th century. The State's oversight role was performed by the Water Supply Commission, as mandated by the Water Supply Management Act of 1907 (Goldshore, 1983).

The New Jersey Department of Environmental Protection, Division of Water Supply & Geoscience (DWSG), is the lead agency in the State for regulating withdrawals. The DWSG requires major water users, defined as those who have the ability to withdraw more than 100,000 gallons per day (gpd), to obtain permit before withdrawing water. Permits include explicit limits on instantaneous, daily, monthly and annual withdrawals. Many permits, but not all, impose a passing-flow limitation.

The NJDEP's Division of Parks & Forestry also implements a passing flow. This Division controls flow over the dam forming Lake Hopatcong in northern New Jersey. The lake's operating schedule includes a required release to the Musconetcong River that is not part of any water-allocation permit condition.

Measurement Units

Passing flows are specified as a flow with units of volume per time. In New Jersey, the flow rate is generally expressed in units of million gallons per day (mgd), gallons per minute (gpm), or cubic feet per second (cfs) (table 1). Throughout this report, the original units given in the permit or reference are reproduced. The reader may convert units as desired, using the conversion factors in table 1. For example, if a passing flow is given in gallons per minute, multiply by 0.00144 to convert to million gallons per day or by 0.00223 to convert to cubic feet per second.

Acknowledgements

The authors are very grateful to Scott Tyrrell, formerly of the Division of Water Supply & Geoscience, for his computerized summaries of contemporary passing-flow permit conditions. The authors also wish to thank the numerous water-supply professionals who have shared their institutional knowledge of New Jersey's water allocation program. These include Jan Gheen, Asghar Hasan, Chris Hoffman, Don Kroeck, and Jennifer Myers. This report also benefited from the able review of Amy Shallcross (Delaware River Basin Commission), Tom Baxter (N.J. Water Supply Authority, retired) and Steve Nieswand (U.S. Geological Survey, NJ Water Science Center, retired).

Table 1. Conversion factors for passing flows

	gallons per minute (gpm)	million gallons per day (mgd)	cubic feet per second (cfs)
gallons per minute (gpm)	--	0.00144	0.00223
million gallons per day (mgd)	694.	--	1.547
cubic feet per second (cfs)	449.	0.646	--

Passing-Flow Specifications

Passing flows protect downstream water users. In this context a downstream user may be a purveyor authorized to withdraw water, a discharger dependent on streamflow dilution, or the aquatic community. A well-written passing-flow specification will specify which of these users is the intended beneficiary. Also, a passing-flow condition may be constructed to protect more than one downstream user.

Passing flows are applied to three different types of water-supply infrastructures: surface-water intakes, reservoirs, and groundwater wells. The different infrastructure types require slightly different approaches for setting an appropriate passing flow. These types are discussed below, with examples from New Jersey. Also, each passing flow must specify two locations, an action point and a monitoring point and this is briefly covered below. The following sections then address a series of related concerns.

Surface-Water-Intake Passing Flows

An intake is a pipe or other structure on a stream that withdraws water. A large intake may have the ability to significantly lower streamflow, perhaps even dry up the stream during low-flow periods. An intake passing flow is designed to limit potential impacts on streamflow.

In July 2008 there were 1,679 active surface-water intakes in New Jersey. Of the 104 passing flows listed in Appendix B, 71 apply to surface-water intakes. This low number is misleading. Passing flows tend to be preferentially assigned to the largest withdrawals. Some 698 billion gallons of surface water was withdrawn in New Jersey in 1999. Of this volume, 232 billion gallons (33%) was withdrawn under permits which had passing-flow conditions.

Many surface-water intake facilities on a stream are equipped with a weir that creates a slightly deeper pool from which the water is withdrawn. These weirs are not intended to provide storage of water but rather to assist in operational efficiency. Additionally these weirs tend to lack outlet structures capable of controlling the volume of water released over the dam. Therefore, water-withdrawal structures equipped with weirs are considered to be part of an intake rather than a reservoir.

There are two types of surface-water-intake passing flows, minimum-instream and excess-diversion.

… Minimum-Instream Passing Flow

A minimum-instream passing flow is a set value. An intake may not withdraw water when streamflow is below the set value, nor may it cause streamflow to decline below the set value. For example, the Forest Hill Field Club (ID pf027 in appendix B) withdraws water from the Third River in Essex County. The permit conditions state "Diversion from the Third River shall not cause the river flow measured at the intake to be < 1.5 cfs." The clear intent is that when flow is less than 1.5 cfs, the diversion must cease. When the intake is operating it may not reduce streamflow to less than 1.5 cfs.

All passing flows imposed on intakes that produce water for non-potable uses are of this type.

… Excess-Diversion Passing Flow

The second type of surface-water intake passing flow is an excess-diversion passing flow. This applies to a subset of potable-water purveyors who are explicitly listed in New Jersey's regulations at N.J.A.C. 7:19-4.6(e) *et. seq.* When streamflow drops below the excess-diversion passing flow, the purveyor may continue to withdraw water but must pay an 'excess diversion fee.' This fee is directly proportional to the volume of water withdrawn and to how far the diversion causes flow to fall below the excess-diversion passing flow. The procedure for calculating this fee is given in the regulations. Table 2 lists the surface-water purveyors affected by the excess-diversion section of the regulations.

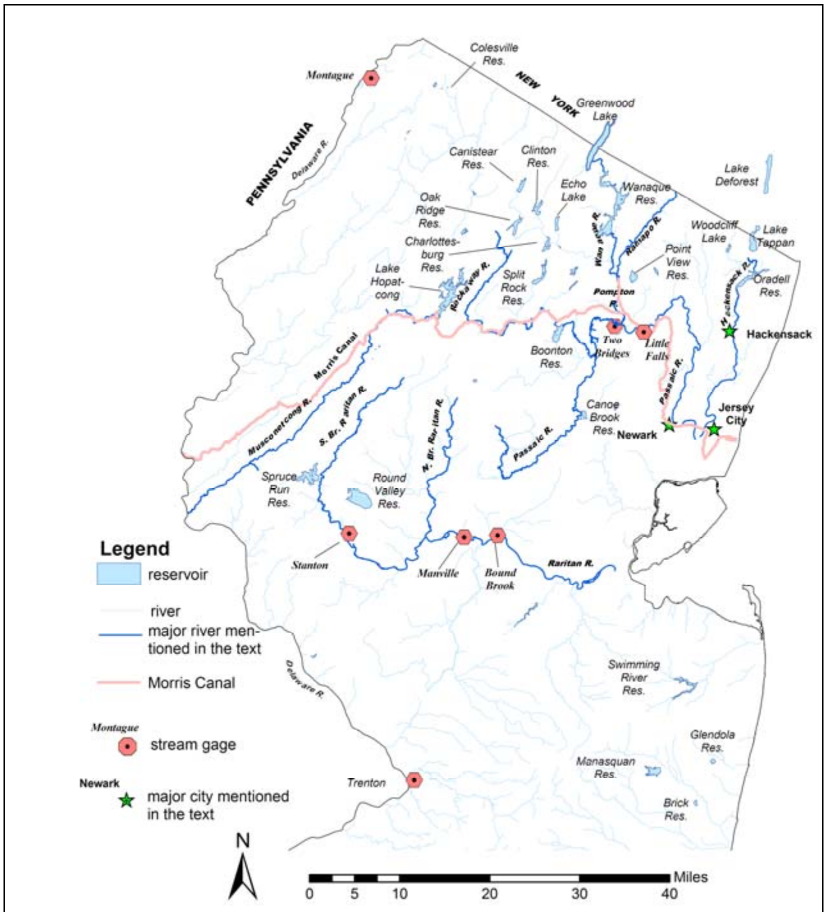

Figure 1. Selected reservoirs, rivers, locations, and streamflow gages in northern and central New Jersey.

Reservoir Passing Flows

A reservoir impounds surface water. All or some of the water is held back for use during drier times. If the reservoir is full, all of the water that enters it is discharged to the river downstream (assuming evaporation is negligible and that no water is removed from the reservoir for other uses). If the reservoir is less than full, it may retain some or all of the water flowing into it thus decreasing or even drying up downstream streamflow. To ameliorate these effects, a reservoir passing flow requires that water be released from the reservoir to the stream below the dam.

As applied in New Jersey, there are four types of reservoir passing flows: minimum release, minimum instream, variable release, and excess diversion. Each is discussed below. Reservoir locations are shown in figure 1.

… Minimum-Release Passing Flow

A minimum-release passing flow sets the minimum rate at which the reservoir must release water under all conditions. A major benefit of this type of passing flow is that it requires only an estimate of water flowing out of the reservoir. A drawback is that it results in a decline in the reservoir's water storage during dry periods when inflow is less than the constant-release passing flow. For example, the Spruce Run Reservoir, operated by the New Jersey Water Supply Authority, is required to release at least 7.75 cfs (ID pf053 in appendix B). This release must occur regardless of how much water is flowing into the reservoir from the upstream watershed. When inflows to the reservoir exceed 7.75 cfs, some of the inflow water can be stored in the reservoir for later use. However, when the inflow rate is less than 7.75 cfs, water must be released from storage to meet the required constant-release passing flow.

… Minimum-Instream Passing Flow

The second type of reservoir passing flow is the minimum-instream passing flow. Enough water must be released from the reservoir so that a minimum streamflow at a downstream monitoring location is maintained. The downstream site, commonly a stream gage, may be directly downstream, or father away. The farther away the gage is, the greater the chance that additional tributaries to the river may contribute to the measured flow, thus decreasing the amount of water that must be released from the reservoir. Most reservoir passing flows active in New Jersey are either minimum-instream or minimum-release passing flows. In some cases, a minimum-instream passing flow is downstream of several reservoirs and intakes. This requires the coordination of multiple purveyors and reservoirs to meet the requirements.

… Variable-Release Passing Flow

The third type of reservoir passing flow is the variable-release passing flow. This requires releasing all inflows to the reservoir during low flows, and a minimum rate during high flows. For example, in 1967 the McGraw-Hill Company was given permission to withdraw water from a pond on a tributary to the Millstone River in Mercer County.[2] A passing flow of 62 gallons per minute (gpm) was placed on the pond during times when inflow to the pond exceeded 62 gpm. When inflow was less than 62 gpm, the lower inflow rate was to be released over the dam. The result is that the volume of water stored in the pond did not decrease during low-flow periods. This permit is no longer active.

[2] Unpublished data on file with the Bureau of Water Allocation, NJDEP, permit PS-99.

Implementation of a variable-release passing flow requires monitoring all inflows to the reservoir. This expense may be significant, especially if more than one stream flows into a reservoir. However, reservoir storage is affected less during dry periods by a variable-release passing flow than by a constant-release passing flow. Also, by better simulating natural flows during dry periods, downstream low flows are not artificially raised and the aquatic ecosystem is less strongly affected.

Only one contemporary reservoir has a variable-release passing flow. The passing flow from the Raymond Dam on the Wanaque River (ID pf 020 in appendix B) is governed by releases from upstream Greenwood Lake. If flows out of Greenwood Lake are less than 4.64 cfs, the passing flow from Raymond Dam is set at 10.8 cfs. If flows out of Greenwood Lake exceed 4.64 cfs, and the release is for use by downstream purveyors other than the North Jersey District Water Supply, Raymond Dam's passing flow increases to 15.47 cfs.

… Excess-Diversion Passing Flow

The fourth type of passing flow affecting reservoir releases is the excess-diversion passing flow. Some of the purveyors mentioned in the excess-diversion regulation (table 2) operate reservoirs where releases may fall below the indicated passing flow if the excess diversion fee is paid. For example, the Boonton Reservoir on the Rockaway River in Morris County, which supplies water to Jersey City, has a required release of 10.83 cfs. If releases are lower, the City must pay an excess diversion fee that is proportional to the volume of water withdrawn and the volume by which releases fell below 10.83 cfs.

Table 2. Excess-diversion passing flows[1]

Purveyor	Gaging station[2]	Passing flow (cfs)	Reservoir or intake[3]
Brick Township M.U.A.	Metedeconk River near Lakewood (01408120)	13.0	Intake
Hackensack Water Company	Hackensack River at New Milford (01378570)	12.9	Reservoir
	Saddle River at Lodi (01391500)	13.9	Intake
	Passaic River at Two Bridges (01389005)	143.3*	Intake
City of Jersey City	To be released from Boonton Dam to the Rockaway River (01381000)	10.83**	Reservoir
Middlesex Water Company	Rahway River at Rahway (01395000)	4.2	Reservoir
New Jersey-American Water Company	Passaic River at Chatham (01379500)	116	Intake
	Canoe Brook near Summit (01379530)	2.12	Intake
	Passaic River near Millington (01379000)	10.7	Intake
	Swimming River near Red Bank (01407500)	9.4	Intake
	Jumping Brook near Neptune (01407760)	1.16	Intake
	Shark River near Neptune (01407705)	1.9	Intake
Newark Water Department	Pequannock River at Macopin (01382500)	12.3	Reservoir
City of New Brunswick	Lawrence Brook at Westons Mill (01405030)	8.7	Intake
North Jersey District Water Supply Commission	Wanaque River at Wanaque (01386000)	15.5***	Reservoir
	Ramapo River at Pompton Lakes (01388000)	61.9	Intake
	Passaic River at Two Bridges (01389005)	143.3 *	Intake
Passaic Valley Water Commission	Pompton River at Pompton Plains (01388500)	92.8	Intake
	Passaic River at Little Falls (01389500)	89.0	Intake
	Passaic River at Two Bridges (01389005)	27.2	Intake
Rahway Water Department	Rahway River at Rahway (01395000)	7.9	Intake
Sayreville Borough	at Duhernal Dam, Dec.-April (none)	61.88	Reservoir
	at Duhernal Dam, May-Nov. (none)	123.78	Reservoir
City of Trenton	Delaware River at Trenton (01463500)	1,131.1	Intake

1. Specified in N.J.A.C. 7:19-4.6(e)
2. Gage name and USGS Gage ID
3. Information added by authors and not contained in N.J.A.C. 7:19-4.6(e) table.

* Except when Passaic Valley Water Commission is diverting at Two Bridges, in which case passing flow will be 27.2 cfs.

** Subject to adjustment when flow in Beaver Brook at the outlet of Split Rock Pond are less than 1.5 cfs.

*** Subject to reduction if flows into reservoir at Awosting are less than 4.6 cfs.

Because the constant-release passing flow is always present, streamflow downstream of the reservoir may be greater in dry periods than it was before the reservoir was built. This effect is enhanced if the reservoir releases water for downstream intakes. This is the case for the South Branch Raritan River. The Round Valley and Spruce Run reservoirs fill during high-flow periods and release water during low-flow periods for downstream users. The reservoirs are also affected by a series of legally mandated passing flows on the Raritan River -- 62 cfs at Stanton, 108 cfs at Manville, and 139 cfs at Bound Brook (table 3).

Table 3. Passing flows on the Raritan River associated with Spruce Run and Round Valley Reservoirs

Gage	Drainage area (mi^2)	Passing flow		
		cfs	mgd	mgd/mi^2
Stanton	147	62	40	0.272
Manville	490	108	70	0.143
Bound Brook	785	139	90	0.115

Figure 2 and table 4 show a frequency analysis of the monthly low flows observed at the Manville stream gage on the South Branch Raritan River for two periods, 1904-1960 (before the Round Valley and Spruce Run reservoirs were constructed) and 1970-2002 (after construction). The frequency analysis is based on the lowest flow recorded in each calendar month in each period. Each month's frequency analysis yields the median annual minimum monthly flow (50-percent frequency) and the 25-percent and 75-percent frequencies. For example, during the pre-reservoir period the median observed low flow in September was 126 cfs. Of the Septembers in the pre-reservoir period, 25-percent had a minimum low flow less than 62 cfs whereas 25-percent had a minimum low flow exceeding 158 cfs. After the reservoirs were built, the median observed lowest September flow was 206 cfs, whereas the 25-percent-to-75-percent range was 175-223 cfs. Summer low flows are generally higher and less variable now than before the reservoirs were built. During summer months, the reservoir operators are very successful at meeting the required passing flow of 108 cfs at Manville, while retaining any higher flows in the reservoirs. Winter low flows show less of an effect of reservoir operation because the reservoir is commonly full during the winter and no flows are retained at these times.

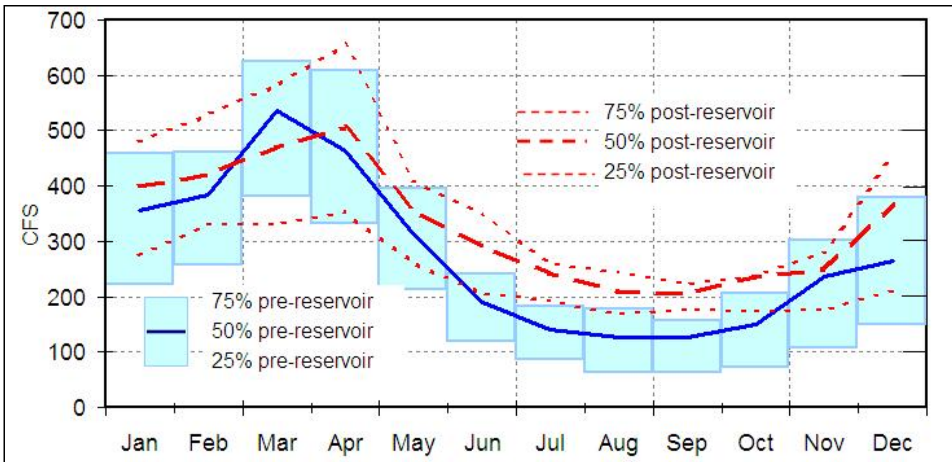

Figure 2. South Branch Raritan River at Manville, 25-50-75-percent frequency distribution of annual monthly minimum flows for pre-reservoir construction years (1904-1960) and post-reservoir construction years (1970-2002).

Table 4. South Branch Raritan River at Manville, 25-50-75-percent frequency distribution of annual monthly minimum flows for pre-reservoir and post-reservoir years

Month	Annual monthly minimum flows, cfs					
	pre-reservoir (1904-1960)			post-reservoir (1970-2002)		
	25%	50% (median)	75%	25%	50% (median)	75%
Jan	220	356	460	274	401	480
Feb	255	384	462	330	421	528
Mar	380	535	626	330	471	582
Apr	330	464	608	353	505	656
May	210	312	395	262	356	411
Jun	118	189	241	207	293	349
Jul	85	139	182	193	242	260
Aug	61	128	179	170	212	243
Sep	62	126	158	175	206	223
Oct	70	150	207	174	236	236
Nov	105	235	301	176	249	282
Dec	147	264	380	211	366	454

Groundwater-Withdrawal Passing Flows

The concept underlying application of passing flows to water-table withdrawals is similar to that used for surface-water intakes. Wells do not withdraw directly from a stream. But they may impact streamflow by either intercepting groundwater that would have otherwise discharged to the stream or by inducing leakage (Galloway and others, 2003; Winter and others, 1998; Heath, 1983). Numerous cases in New Jersey illustrate streamflow reductions caused by nearby withdrawals from an unconfined aquifer (Cauller and Carleton, 2006; Gordon 2002; Nicholson and others, 1996).

The NJDEP has applied minimum-instream passing flows to water-table wells and well fields that may affect streamflow. For example, the Ramsey Water Department's wells no. 15 and no. 16 withdraw water from the valley-fill water-table aquifer near the Ramapo River. These wells are required to cease pumping when flow in the river, as measured at a nearby stream gage, drops below 12.32 cfs (ID pf002 in appendix B).

Applying passing flows to groundwater withdrawals assumes that the withdrawals cause an immediate effect on stream flow. This may or may not be valid, depending on the distance from the well to the stream, the quantity of water stored in the aquifer, the volume of water pumped, the duration of pumping, and the hydraulic connection between the stream and the aquifer. However, assuming an immediate one-to-one connection between well withdrawals and a reduction in streamflow in most cases is the more conservative assumption and the simplest to regulate.

The NJDEP is becoming more aware of the effect of unconfined-aquifer withdrawals on surface-water ecology. Ten of the now-existing passing flows set in New Jersey apply to wells. The NJDEP anticipates imposing more passing flows on groundwater withdrawals in the future. (Jennifer Myers, NJDEP, DWSG, oral communication, 2008).

Passing-Flow Locations

Each passing-flow requirement must specify two locations. The first is termed the 'action point' and is the site where the streamflow is modified. The second is termed the 'monitoring point' and is where streamflow is measured. Measurements at the monitoring point determine whether the withdrawal at the action point can continue at its full rate, at a lesser rate, or must cease. The monitoring point need not be at the action point but may be upstream or downstream from the action point, or even on a nearby stream. The specific permit conditions relating the action point to the monitoring point govern the intake’s ability to withdraw water at low-flow conditions.

Additional Concerns

… *Intent of Ecological Passing Flows*

A passing flow set to protect the aquatic ecosystem is intended to provide protection downstream of the action point. Flow is measured at the monitoring point to insure that sufficient water is passing the action point. Some purveyors have the ability to increase streamflow upstream of a monitoring point by discharging additional water to the stream. In this case, excessive withdrawals at the action point that create flows lower than the passing flow may be compensated for by downstream discharges, thus meeting the passing flow at the monitoring point. This results in lower flows than desired between the action point and where water is added to the stream and violates the spirit of the passing flow requirement while meeting legal requirements.

In some cases, a significant tributary may enter the stream between an upstream action point and a downstream monitoring point. Flow at the monitoring point is thus dependent on streamflow at both the action point and in the tributary. When tributary flows are very high the purveyor may have the ability to allow very little water to pass the action point but still meet the passing flow conditions at the monitoring point. This also may be harmful if the aquatic ecosystem immediately downstream of the action point is adversely affected.

… Modification Of Dilution Passing Flows

Assimilative capacity is the ability of a natural body of water to receive wastewaters or toxic materials without harmful effects. Some passing flows are set based on the need for sufficient assimilative capacity at a downstream point to meet a set standard. If the waste load increases or the water-quality standard becomes stricter, the passing flow may have to be increased. If the waste load decreases, or the water-quality standard is relaxed, the passing flow may be reduced without causing a violation of the standard. This highlights the interdependence of water quantity and quality.

… Relaxation of Reservoir Passing Flows During Droughts

A reservoir system's safe yield is that volume of water it can reliably deliver during a repeat of the most stressful conditions yet experienced. Reservoirs with a minimum-release or minimum-instream passing flow must release water to the stream and this can decrease storage during a drought. As an additional safety factor, some reservoir passing flows are reduced during a drought, providing an additional margin of safety.

History of Passing Flows in New Jersey

The application of passing flows in New Jersey has evolved with time. The history of passing flows starts in 1907 when the Water Supply Management Act formed the New Jersey Water Supply Commission (NJWSC) (New Jersey Water Supply Commission, 1908). Before 1907, the State was not involved in regulating withdrawals other than by issuing charters to water companies. These water companies, and industrial users, protected their water rights by means of the legal system. After 1907, in response to drought, water-quality issues, the need for regional water-supply systems, and water-use conflicts, the State became more and more involved in regulating water withdrawals and establishing passing flows.

The NJWSC has been succeeded by a series of State water supply agencies -- the State Water Supply Commission in 1929, the Water Policy and Supply Council in 1947, then the Department of Environmental Protection (NJDEP) in 1981 (Goldshore, 1983). Currently water allocation permits are issued by the Division of Water Supply & Geosciences within the NJDEP. Contemporary regulations go into more detail about how to set passing flows, calculate excess diversion fees, and how passing flows apply to different types of water uses (appendix C).

As the State's understanding of the aquatic ecosystem has increased, and the streams have become increasingly heavily used, the approaches to setting passing flows have become more sophisticated. However, some of the oldest passing flows requirements have been incorporated into contemporary permits and enabling statutes and thus are still applied. The following sections present a brief history of selected passing flows in New Jersey.

Pre-New Jersey Water Supply Commission

New Jersey's large water-supply reservoirs date from the late 19th and early 20th centuries. The East Jersey Water Company built the Oak Ridge, Clinton and Macopin reservoirs in pristine areas in northeast New Jersey to capture water from the Pequannock watershed for use by the City of Newark. These reservoirs, and the required 21-mile-long pipeline to deliver the water, were completed in 1892 (Cunningham, 1994). They supplied clean water that replaced polluted supplies closer to Newark. No passing flows were placed on these reservoirs at that time.

The Hackensack Water Company (subsequently the Spring Valley Water Company) deepened a mill pond on the Hackensack River to create the Oradell Reservoir in 1902. It was expanded in 1912 by installation of a taller wooden dam, and then expanded again in 1923 by installation of a 22-foot high concrete dam (Leiby and Wichman, 1969). Passing flows were not required downstream of the reservoirs, possibly because by the time they were built, the Hackensack Water Company had acquired all downstream water rights on the Hackensack River.

The first argument for passing flows appears to have been in the 1893 State Geologist's report (New Jersey Geological Survey, 1894). It discussed the threat to human health posed by the poor water quality of the Passaic River below Little Falls. It suggested building small water-storage facilities on the upper Passaic and lower Whippany Rivers (which were judged to be unsuitable for large reservoirs due to topography) and using controlled releases to increase dry-season flow in the lower Passaic. Had this plan been implemented, the increased dry-season flows would have provided more dilution of the untreated wastewater and industrial waste that entered the Passaic River at that time, thus improving water quality.

New Jersey Water Supply Commission

The State's involvement with regulating water withdrawals dates to the founding of the New Jersey Water Supply Commission (NJWSC) in 1907 (New Jersey Water Supply Commission, 1908; Goldshore, 1983). The NJWSC was established in response to a proposal to export water from Hudson County to Staten Island, New York (Sackett, 1914). This proposal met with opposition in the State Legislature but was not finally rejected until after a decision by the U.S. Supreme Court.[3]

The NJWSC's enabling legislation spells out payment rates for excess diversion fees (appendix D) and includes the concept of a passing flow based on low streamflow. Its rules of procedure explicitly called for "protection of lower riparian owners in low flow seasons" as part of analyzing a new withdrawal request (New Jersey Water Supply Commission, 1909).

Wanaque Reservoir

The first mention of a specific passing flow in the NJWSC's records occurs in connection with the Wanaque Reservoir, on the Wanaque River in Passaic County[4]. This reservoir was constructed by the North Jersey District Water Supply Commission, a consortium of

[3] U.S. Supreme Court, HUDSON COUNTY WATER CO. v. MCCARTER, 209 U.S. 349 (1908). This judgment is also notable for the following:

> "We are of opinion, further, that the constitutional power of the state to insist that its natural advantages shall remain [209 U.S. 349, 357] unimpaired by its citizens is not dependent upon any nice estimate of the extent of present use or speculation as to future needs. The legal conception of the necessary is apt to be confined to somewhat rudimentary wants, and there are benefits from a great river that might escape a lawyer's view. But the state is not required to submit even to an aesthetic analysis. Any analysis may be inadequate. It finds itself in possession of what all admit to be a great public good, and what it has it may keep and give no one a reason for its will."

[4] From records of the NJWSC on file with the NJDEP, microfiche #91, 'North Jersey District Water Supply Commission.'

several northeastern municipalities searching for a dependable water supply (Goldshore, 1983). Several downstream water users objected to the proposed increased water use, including the Dundee Water Power & Land Co., East Jersey Water Co, Acquackanonk Water Co., and the Society for Establishing Useful Manufactures. To protect these downstream water rights, the permit, issued December 19, 1916, required that "The dry-season flow of the Wanaque River below the dam must at all times be maintained at a minimum of 12,000,000 gallons per diem." (North Jersey District Water Supply Commission, 1926)

This constant-release passing flow was criticized by the North Jersey District Water Supply Commission as being too great of a discharge. In response, the NJWSC modified the Wanaque reservoir's constant-release passing flow to be equal to the dry-season flow above the reservoir, exclusive of the watershed above Greenwood Lake.

The lowered passing flow was criticized by the owners of the Morris Canal - the Morris Canal & Banking Co. and the Lehigh Valley Railroad Co. The Morris Canal carried barges from the Hudson River to the Delaware River across northern New Jersey. Commercial traffic on the canal began in 1832.[5] Water was fed into the canal at several locations, including a feeder canal that diverted water from the Wanaque River. To assure a supply of water during dry seasons, the Morris Canal & Banking Company built a dam on the Wanaque River in 1837 to create Greenwood Lake.[6] Water was stored in the lake during high flows and released during dry times to supply the downstream intake for the Morris Canal. While barge traffic had stopped by the late 1800's, the canal's owners retained the water rights to withdraw water for the canal.

The Wanaque Reservoir is situated between Greenwood Lake and the Morris Canal's Wanaque River intake. The canal owners felt that the reservoir would not pass a sufficient volume of water to enable canal operation and so sued to obtain more water. A judge agreed, and ruled in 1922 that the operation of the dam must not lessen natural flow below 77 cubic feet per second, which is equivalent to 49.8 million gallons per day.[7] The court also imposed a variable-release flow on the reservoir that tied releases from the Wanaque Reservoir to inflows into the reservoir.

By 1929, the North Jersey District Water Supply Commission had obtained the Morris Canal's water rights. With those objections negated, it then applied to the NJWSC to increase the height of the dam and to withdraw more water from nearby Post Brook. The NJWSC gave approval with two revised passing flows. A variable-release passing flow was applied linking releases from the reservoir to water being released by the upstream Greenwood Lake. An additional constant passing flow of 350,000 gpd was applied to the

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[5] Canal Society of New Jersey web page (http://www.canalsocietynj.org/njcanals.html) accessed July 12, 2007.

[6] Greenwood Lake Chamber of Commerce web page (http://www.greenwoodlakeny.org/about.htm) accessed July 11, 2007.

[7] Court order by his Honor Edwin Robert Walker, Chancellor of the State of New Jersey, in the case of Lehigh Valley RR Co. and Morris Canal. & Banking Co. vs. North Jersey District Water Supply Commission, September 25, 1922.

new intake pipe on Post Brook. These two passing flows are still in effect (pf 020 and pf021 in Appendix B).

The lands of the Morris Canal passed into State ownership in the 1920s, including Lake Hopatcong, constructed on the Musconetcong River in western New Jersey to supply water to the canal. The contemporary constant-release passing flow of 7.5 mgd (ID pf101 in appendix B) on releases from the lake's dam appears to be a direct descendent of flows originally imposed as part of the Canal's operation.[8] The contemporary releases from the dam are intended to maintain aquatic habitat, dilute treated effluent discharged from a sewage treatment plant, and to run water-powered mills at Waterloo Village (NJDEP, 2011).

Selected Passaic Basin Locations

In the 1930's, the Passaic Valley Water Commission received a permit to withdraw water from the Pompton and Passaic Rivers to supply a planned off-stream reservoir (Point View Reservoir). This diversion was subject to a passing-flow requirement that no withdrawals were allowed when streamflow in the Passaic River at Little Falls was less than 800 cfs (517 mgd) (Tippetts-Abbett-McCarthy-Stratton Engineers, 1955). This large passing flow was probably due to the need for high water flows by hydropower generators at Little Falls. Since the 1930's the demands of water supply have taken precedence over power generation and the passing flows have been reduced. The Passaic Valley Water Commission now has a passing flow of 27.2 cfs (17.6 mgd) in the Passaic River at Little Falls for withdrawals at Two Bridges (pf099 in Appendix B). It also has a passing flow of 88 mgd on the Pompton River for its Jackson Avenue intake which pumps water to the off-stream Point View Reservoir (pf098 in Appendix B).

In the 1950s NJDWSC built the Ramapo pump station on the Ramapo River in Pompton Lakes. The intakes are located in Pompton Lake just upstream of the dam and were built to increase the safe yield of the Wanaque Reservoir system. The water can be pumped to either the Wanaque Reservoir (NJDWSC) or Oradell Reservoir (UWNJ) via a network of large-diameter water mains. The 100 mgd pump station was expanded to 150 mgd in the 1980's as part of the Wanaque South project to augment the Wanaque Reservoir system's safe yield. This intake has a passing flow of 40 mgd measured at the USGS gaging station 01388000 located just below the Pompton Lake dam on the Ramapo River (pf019).

In the 1980's, NJDWSC and UWNJ built the Two Bridges pump station as part of the Wanaque South project. This intake is located on the Pompton River directly upstream of the confluence of the Pompton and Passaic Rivers in Wayne. It was designed to augment and further increase the safe yield of the Wanaque system. The 300 mgd pumps can send water to the Wanaque Reservoir (NJDWSC) or Oradell Reservoir (UWNJ) via the same

[8] Unpublished letter from Oliver Hartwell, U.S. Geological Survey district engineer to H.T. Critchlow, NJ. Dept of Conservation and Development, dated March 1, 1923, on file with the U.S.Geological Survey's New Jersey Water Science Center.

network of water mains (pf018). The actual passing flow varies depending on PVWC pumping. PVWC can withdraw water from the Passaic River at Little Falls or the Pompton River at Two Bridges (the same location as NJDWSC's intake) (pf099). If PVWC is taking water from Two Bridges the passing flow is 27.2 cfs, but if PVWC is taking its water from Little Falls the passing flow is 143.3 cfs. This complex arrangement is partly the result of water-quality differences between the two locations, the absence of other existing USGS gaging stations on the Passaic River below Two Bridges, and historic water-use requirements.

Jersey City constructed the Boonton Reservoir on the Rockaway River in 1904. During the drought of 1917 all incoming streamflow was diverted to Jersey City to satisfy its demands. The only water in the Rockaway River directly downstream of the reservoir came from inadvertent leakage through the dam[9]. During this drought the primary consideration was construction of a new supply pipe from the reservoir to Jersey City. A passing flow was first imposed on the Boonton Reservoir in 1969. That year a sewage treatment plant on the Rockaway River directly downstream of the Boonton Reservoir encountered operational difficulties; poorly-treated effluent created a significant water-quality problem in the Rockaway River. A court imposed a constant-release passing flow from the Boonton Reservoir of 7 mgd to improve water quality in the river (Steve Nieswand, retired USGS and NJDEP employee, written communication, 2007). This passing flow is still in effect but has been increased to 23 cfs (14.87 mgd). This is based on a flow of 125,000 gpd-per-square mile for the reservoir's 119 square-mile watershed (ID pf009 in appendix B). This release is also subject to an excess-diversion passing flow of 10.83 cfs (table 2).

The Jersey City Water Department built the Split Rock Reservoir in the 1940's to hold back flood water on Beaver Brook, a tributary of the Rockaway River upstream of the Boonton Reservoir, for release during dry times. The NJWSC placed a constant-release passing flow of 1 mgd on Split Rock Reservoir when it was constructed.[10] In the 1965 drought this passing flow was temporarily suspended as an emergency measure. Beaver Brook dried up, causing complaints by local residents about the need for water for fire protection. A constant-release passing flow of 250,000 gpd was reimposed, then raised to 800,000 gpd in 1966. After the drought, the 1-mgd (1.55 cfs) constant-release passing flow was reinstated and is still in effect (ID pf010 in appendix B).

In 1926, the Commonwealth Water Company (now New Jersey-American Water) applied to the Water Supply Commission to withdraw water from Canoe Brook in Millburn Township, Essex County.[11] The permit was granted with a modified constant passing flow. No withdrawals were allowed when flow in Canoe Brook directly upstream of the intake was equal to or less than 3.5 mgd. However, when upstream flows exceeded this

[9] From records of the NJWSC on file with the NJDEP, microfiche #140,'Jersey City.'

[10] From records of the NJWSC on file with the NJDEP, microfiche #140, 'City of Jersey City Split Rock Pond Application.'

[11] From records of the NJWSC on file with the NJDEP, microfiche #250, 'Commonwealth Water Company.'

rate, the withdrawal was allowed to reduce streamflow to 1.375 mgd, but no lower. This passing flow is still in effect but has been modified to a constant passing flow of 1.37 mgd (ID pf086 in appendix B).

In 1954, the Commonwealth Water Company applied to the NJWSC to withdraw water from the Passaic River.[12] This was granted, subject to the conditions that there would be no withdrawals between June 1 and September 30, and subject to a constant passing flow of 75 mgd in the Passaic River. This constant passing flow is still in effect (ID pf087, appendix B).

Selected Raritan Basin Locations

The Spruce Run and Round Valley Reservoirs in the Raritan Basin are operated by the N.J. Water Supply Authority (NJWSA). The Spruce Run Reservoir is an on-stream reservoir; it dams Spruce Run and Mulhockaway Creek. The Round Valley Reservoir is an off-stream reservoir; it was formed by closing off a large valley. The reservoir's small watershed (5.7 mi^2) does not supply sufficient water to make it a reliable water source without augmentation. Water from the South Branch Raritan River at Hamden is pumped to fill the reservoir. Water can be released to augment flow in the South Branch Raritan River, or it can be released to the South Branch Rockaway Creek.

These reservoirs are subject to constant-release passing flows set directly below the impoundments. The NJWSA is also required to operate the reservoirs to release sufficient water to maintain constant passing flows at three downstream flow gages: 40 mgd at Stanton; 70 mgd at Manville; and 90 mgd at Bound Brook (fig. 2, table 3). These passing flows are written into the enabling legislation that authorized and funded the reservoirs (Shanklin, 1974). These passing flows are also higher, in general, than low flows observed on a significant number of summer days before the reservoirs were built (fig. 2, table 4).

It appears that these three major passing flows are based on different methodologies. At Stanton, the 40-mgd passing flow is equivalent to 0.272 mgd/mi^2. This is consistent with the recommendation of a passing flow made by the Tippetts-Abbett-McCarthy-Stratton Engineers study (1955) of the volume of water needed to meet future water requirements, provide adequate dilution, and prevent salt-water intrusion in the Raritan Basin. The 70-mgd passing flow at Manville is equivalent to 0.143 mgd/mi^2. This number is consistent with Vermeule's (1894) estimate of average daily flow during the driest flow in the Passaic River basin of 0.125 mgd/mi^2. The 90-mgd passing flow at Bound Brook was based on the volume of water needed at that time to dilute treated effluent from a sewage treatment plant to acceptable standards (Don Kroeck, retired NJDEP employee, oral communication, 2004).

[12] From records of the NJWSC on file with the NJDEP, microfiche #816, 'Commonwealth Water Company, Summit, Union Co.'

Methods of Setting Passing Flows

Passing flows can be set using a variety of methods. The methods can be divided roughly into three general categories: preservation of flows, preservation of water quality, and preservation of the aquatic ecosystem. Each general category includes several methods.

Preservation of Flows

Preservation of flows has historically been accomplished by analyzing low flows. The rationale behind preservation of low flows is that these occur naturally and downstream users have adapted to occasional flows at this level. These low flows have historically been used in the safe-yield evaluation of downstream water supplies.

New approaches are beginning to look at preserving average and high flows. These approaches assume that the natural ecosystem requires a range of flows, so in order to preserve the ecosystem it is necessary to preserve more than only summer low flows. This approach is incorporated into the Tennant, Aquatic Base Flow, and Natural Flow Paradigm methods described in the following section on preservation of the aquatic ecosystem.

… Vermeule's dry-weather flows

The amount of water available during dry periods is a limiting factor for both water supply and hydropower. C.C. Vermeule (1894) analyzed streamflow and developed estimates of natural low flows, including average for the driest month and driest day (table 5). These estimates, expressed as flow per square mile of watershed area, were based on a geographic grouping of streams. The range in natural low flows is a function of the ability of aquifers in the watershed to hold and release water to the streams during rainless periods. Passing flows based on these values are a way to ensure that downstream users always have the water flow that can be expected dry periods.

The first passing flows were applied in the Passaic River watershed. The Wanaque Reservoir has a watershed area of 90.4 square miles. It has a constant-release passing flow of 10 mgd. This represents 111,000 gallons per day per square mile (gpd/mi^2). This estimate appears to be based on Vermeule's estimate of driest daily flow in the Passaic River watershed of 110,000 gpd/mi^2 (equivalent to 9.94 mgd). The available records do not explicitly state how the passing flow for the Wanaque Reservoir was set but this is a reasonable assumption.

Vermeule (1894) estimated an average flow in the driest month of 127,000 gpd/mi^2 in the Passaic River watershed. This number appears to be the source of the default passing-flow standard specified in the Water Supply Allocation Rules at 7:19-4.6(f) (Paul Schorr, NJDEP, DWSG, oral communication, 2006):

> "Where the passing flow is not specified above, it shall be fixed by the Department based on an amount equal to the average daily flow for the driest month, as shown on existing records or in lieu thereof, 125,000 gallons for each square mile of unappropriated watershed above the point of diversion."

If the flow rate of 125,000 gpd/mi^2 is meant to be an estimate the average daily flow for the driest month, then it will overestimate the actual dry-weather flow in some basins, such as the Raritan, which generally have lower dry-weather flows. Also, 125,000 gpd/mi^2 underestimates the flows in other basins, such as those in the coastal plain, where dry weather flows are generally higher (table 5).

Table 5. Vermeule (1894) estimates of dry-weather streamflow

Location	Class of Streams	Streamflow (gallons per day per square mile)	
		average for driest month	driest day
Kittatinny Valley and Highlands watersheds	ordinary watersheds	81,000	81,000
	streams with large groundwater contribution	140,000	110,000
Delaware River above Trenton		127,000	110,000
Passaic River		127,000	110,000
streams on watersheds of red sandstone	Hackensack River	123,000	122,000
	Raritan River	84,000	84,000
	small streams	22,000	5,000
watersheds of the Delaware River	Trenton to Camden	168,000	120,000
	Camden to Bridgeton	168,000	120,000
coastal stream watersheds	streams with moderate groundwater contribution	168,000	120,000
	streams with large groundwater contribution	168,000	168,000

… Downstream water rights

The first passing flows were established to prevent negative impacts to existing downstream water withdrawals. These passing flows are set to insure that newer, upstream withdrawals do not interfere with older, downstream withdrawals, even during low-flow periods. These flows were mainly applied to large upstream infrastructures, such as reservoirs, that have the capability to significantly alter streamflow. Under the contemporary system of regulations, new water withdrawals may not have a significant adverse impact on pre-existing users. The NJDEP may set a passing flow to allow sufficient water to pass by a new intake point to supply downstream users. During the permitting process, established users have the right to comment on any new withdrawal that they believe may adversely impact their ability to withdraw a sufficient volume of water.

Preservation of Water Quality

Treated wastewater is routinely discharged into the surface waters of New Jersey. This activity is highly regulated by the U. S. Environmental Protection Agency (USEPA) and NJDEP. The discharges may not cause a violation of surface-water-quality standards. The allowable waste loads are calculated as a function of streamflow volumes, quality of the effluent and the receiving water, and the surface-water-quality standards. The allowable load is usually calculated assuming a representative low flow. If flows decline below the design flow then the discharge may cause a violation of water-quality standards.

...Annual 7Q10 flows

The Federal Clean Water Act, (33 U.S.C. § 1251, *et seq*.) specifies water-quality criteria that discharges to streams must meet. Many of the quality calculations are based on low streamflow so that the discharge does not cause a violation at these flows. One of the most common flows used in calculating allowable discharges is the annual 7Q10 flow (U.S. Environmental Protection Agency, 1991). This is the average 7-day flow that has a 10-percent chance of occurring each year. This is roughly equivalent to the flow expected to occur in only one year out of ten and, in New Jersey, is roughly equivalent to summer drought flows. This water-quality approach has been used to establish passing flows. The justification is that if a withdrawal is not allowed to reduce streamflow below the annual 7Q10 flow then streamflow should be sufficient to dilute any downstream discharges to acceptable quality. Using the annual 7Q10 flow as a passing flow has become very common as it is supported in Federal regulations and for most streams is relatively easy to calculate.

The annual 7Q10 flow is not designed to be an estimate of low flows during a 'pristine' period in the past. If streamflow changes, due either to upstream withdrawals and discharges or to the effect of land-use changes, then the annual 7Q10 flow changes. The U.S. Geological Survey periodically recalculates annual 7Q10 values and makes them available to the public over the internet at http://nj.usgs.gov/flowstatistics/ (Reiser and others, 2002). Changes in annual 7Q10 flows with time can provide information on trends in low flows but do not identify the causes of the changes (Watson and others, 2005).

The annual 7Q10 is frequently misinterpreted as a flow that is intended to be protective of stream ecology. However, there are no ecological data supporting this position. Recent research shows that the annual 7Q10 flow represents a significant stress on the natural aquatic ecosystem. The foreword in Annear and others (2004) says:

> "There is adequate warning and justification against the use of a single-flow recommendation, like 7Q10, for fishery and riverine management."

The Massachusetts Department of Fish and Game concludes:

> "Although such a low streamflow value, roughly equivalent to a ten-year drought, is appropriately used in the context of limiting pollution discharges, the 7Q10 flow statistic is sometimes inappropriately claimed to represent an adequate streamflow for maintaining a healthy aquatic ecosystem, when in fact much higher streamflow levels are required."[13]

The annual 7Q10 flow can be expressed on an areal basis. Reiser and others (2002) provide annual 7Q10 flows and watershed area for many stream gages in New Jersey. Of the 387 gages for which calculations of the areal 7Q10 flow is possible, at 218 gages the areal annual 7Q10 flows are less than 100,000 gpd/mi^2. At 124 gages the areal annual 7Q10 flow is in the range of 100,000 to 250,000 gpd/mi^2. At 45 gages the areal annual 7Q10 flows exceed 250,000 gpd/mi^2. Figure 3 shows the areal distribution of these rates. Figure 4 shows the calculated annual 7Q10 flow per watershed area plotted against watershed area. This analysis shows that the default average daily flow for the driest-month value of 125,000 gpd/mi^2 is not an appropriate approximation of the

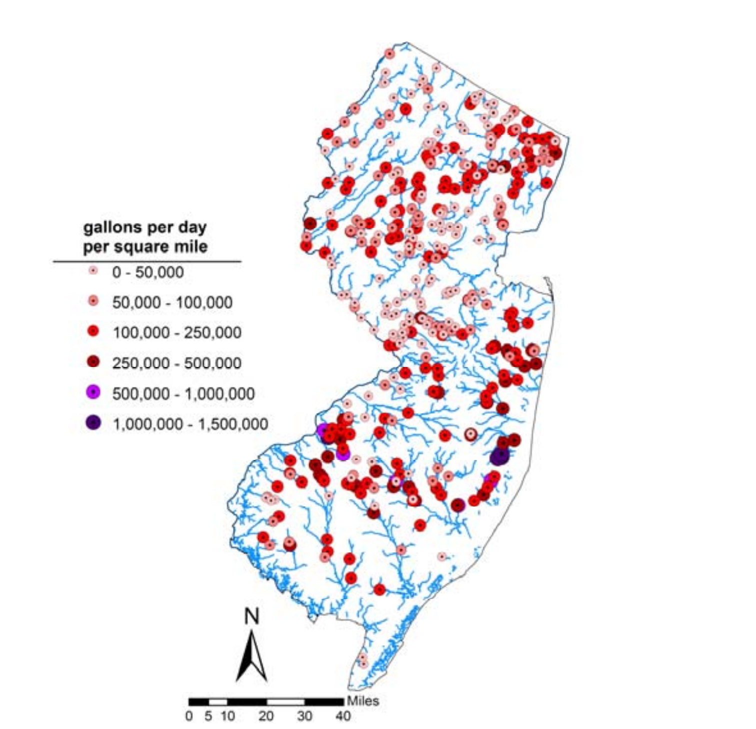

Figure 3. Annual 7Q10 flows per unit watershed area in New Jersey

[13] MA Dept. of Fish and Game, Riverways Program, 7Q10 fact sheet. Accessed at http://www.mass.gov/dfwele/river/programs/rifls/lf_7q10.htm on 6/11/07.

annual 7Q10 flow at most gages in New Jersey.

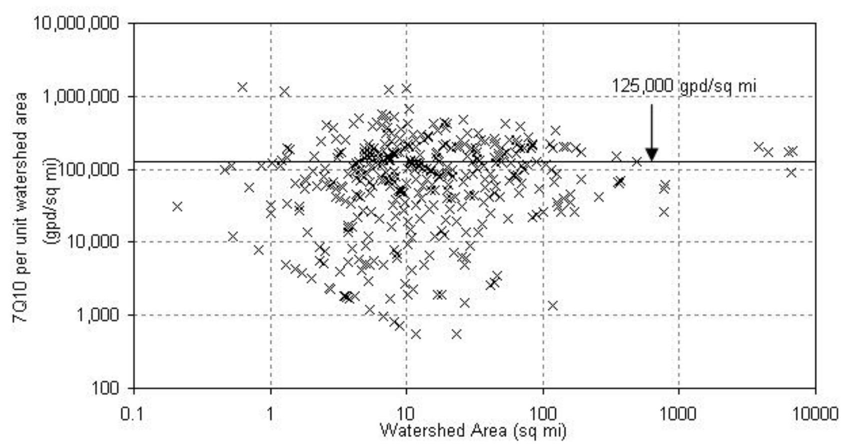

Figure 4. Annual 7Q10 flows per unit watershed area vs. watershed area

The variability in annual 7Q10 flow per unit watershed area may be due to three factors: geology, subsurface drainage areas, and water transfers. Each is discussed below.

First, the geology of New Jersey is varied. Those formations consisting of water-bearing sand, such as most of those in the southern part of the Sate or those in the glacial valley-filled regions in northern part of the State, supply greater base flows during dry periods. This is due to the greater storage capacity of sand as compared to rock. Areas of bare rock, such as those in parts of northern New Jersey, cannot supply as much water to streams during dry periods because their capacity to store and transmit water is limited. This greatly affects annual 7Q10 values inasmuch as these flow are sustained by groundwater discharged from aquifer storage.

Second, surface-water drainage basins are defined as watersheds. Groundwater drainage areas may or may not coincide with surface watersheds. Streams which receive groundwater from a drainage area much greater than their surface watershed may have a disproportionally greater 7Q10 flow.

Third, humans transfer water into and out of some watersheds. These alterations may significantly affect low flows. Watersheds that lose water to exports are expected to have lower annual 7Q10 flows. Watersheds that gain water from imports or have reservoirs that release water at low-flow times have increased annual 7Q10 values.

...Monthly 7Q10 flows

Monthly 7Q10 flows are calculated the same way as annual 7Q10 flows, but use only the values from one calendar month. Thus a January 7Q10 flow is that average 7-day flow that has a 10-percent chance of occurring each January. It may be interpreted as a flow that is characteristic of a January drought. Monthly and annual 7Q10 flows at several stream gages in New Jersey are in figure 5.

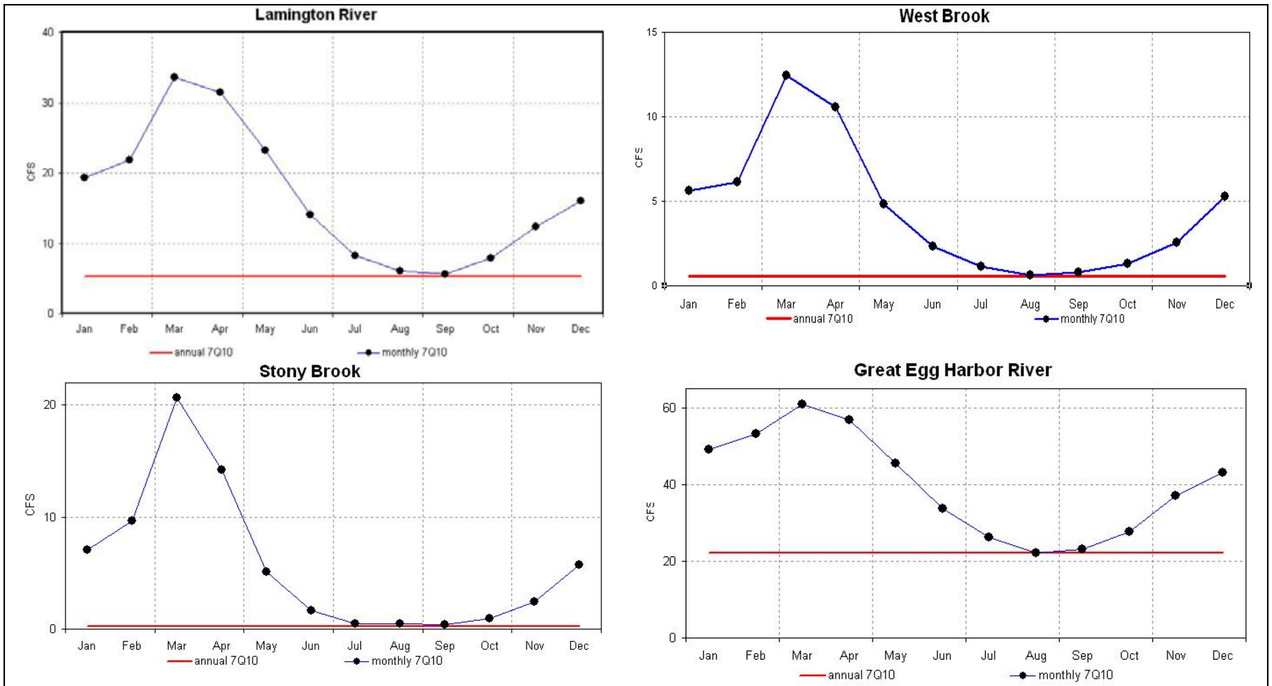

Figure 5. Monthly and annual 7Q10 flows at selected streamflow gages.

Monthly 7Q10 flows could be the basis for setting passing flows. In Georgia, monthly 7Q10s are now one option for setting regulatory instream flows (Georgia Board of Natural Resources, 2001; Caldwell, 2005).

…Other dilution considerations

In the late 1950s, passing flows were set for the Raritan River to guide operation of the Spruce Run and Round Valley Reservoirs. A passing flow of 90 million gallons per day (mgd) was set at the Bound Brook gage. This volume was selected in part to provide sufficient dilution of treated effluent discharges at that time on the lower Raritan River (Don Kroeck, retired NJDEP employee, oral communication, 2004).

<u>Preservation of the aquatic ecosystem</u>

Passing flows set to protect the natural aquatic ecosystem are commonly referred to as instream flows or environmental flows. Calculating instream flows is complicated as it requires the integration of the numerical, engineering approach of hydrologists with the descriptive, environmental approach of aquatic biologists. A successful instream flow requirement builds on the strengths of both parties.

Methods of setting instream flow are based either on a statistical analysis of streamflow (such as the Tennant method, Aquatic Base Flow, or natural flow paradigm) or on a species-centric analysis of habitat needs. Each of these is discussed below. In general, a statistical approach produces one or more evaluation criteria that are used to compare flows before and after a withdrawal. If the criteria do not change too much, the assumption is that the withdrawal will not significantly impact the aquatic ecosystem. This is easier to implement as a permit condition in a regulatory setting. A species-centric analysis requires analyzing the complex relations between flows and species integrity, and setting appropriate ecosystem-integrity assessments to guide flow-management decisions. These complex relationships must then be converted into standards that can be written into a permit condition in order to be useful in a regulatory setting.

…Tennant method

The Tennant (or Montana) method is based on a relation between a percentage of the average annual flow (QAA) and assumed habitat quality during two periods of the year (Tennant, 1976). It assumes that 10-percent of QAA must be retained in the stream year-round to support a 'poor' habitat and to prevent severe degradation. Streamflow must be maintained at 30-percent of the QAA during the period April-September and 10-percent October-March in order to support a 'fair' habitat. To support a 'good' aquatic habitat, 40-percent of the QAA is needed April-September and 20-percent October-March. The NJDEP has not applied the Tennant method to any streams in New Jersey in order to set permit conditions.

… Aquatic Base Flow

The aquatic base flow (ABF) method, also known as the New England method, uses the median of selected annual monthly flows to determine required passing flows during different seasons (U. S. Fish and Wildlife Service, 1981). The median annual August monthly flow is used to estimate necessary summer flows. Summer is defined as mid-June to mid-October. The fall and winter period is mid-October to March, and required flows defined as the median of annual February flows. Spring is April to mid-June, and required flows defined as the median of annual April and May flows. This method was developed using data from 48 gaging stations in New England, each with more than 25 years of satisfactory flow records and a watershed of at least 50 square miles. The NJDEP has not applied the aquatic base flow method to any streams in New Jersey in order to set permit conditions.

…Natural Flow Paradigm

Another statistical approach is the natural flow paradigm (Poff and others, 1997; Ricter and others, 1998). The natural flow paradigm recognizes that streamflow is a master variable that governs the aquatic ecosystem and that the full range of flows are critical for sustaining a stream's ecology. The natural flow paradigm comes from recent work in the field of fluvial ecology. Bencala and others (2006) summarize this approach as a

> "more holistic view that the science is incapable of understanding the complexity of ecosystems, so management strategies must focus on restoring the fundamental drivers of ecosystem function rather than incrementally managing pieces."

The natural flow paradigm is the foundation of the Indicators of Hydrologic Alteration (IHA) method (Ricter and others, 1996, 1997, 1998). This approach has not yet been implemented in New Jersey in a regulatory application. Recent research, however, has shown its potential usefulness (Kennen and others, 2007). In particular, Hoffman and Rancan (2009) investigate using the natural flow paradigm to set monthly instream flows in New Jersey streams. This approach is being used as one tool to assess the water supply of watersheds as part of the ongoing update of the New Jersey Water Supply Master Plan.

…Habitat analysis

A habit analysis involves linking flows to habitat and/or health for one or more aquatic species. The goal is to identify a low flow that supports an acceptable level of ecological health. This type of analysis is most advanced in regard to the water needs of trout (Stone, 1877; Crisp, 2000).

In the 1940's, New York City began operating reservoirs on the Upper Delaware River in New York State. As part of an interstate agreement ordered by the U.S. Supreme Court in 1931 and amended in 1954, constant-release passing flows were imposed on these reservoirs. The City was given flexibility in reservoir operation as long as passing flows were maintained at two downstream monitoring points in New Jersey -- Montague and Trenton. These passing flows were based in part on work done in 1952 by Professor Harold Haskin of Rutgers University on the effect of changing salinity in Delaware Bay on oysters (Ford, 2003). Thus, one goal of the passing flows is to protect the oyster harvests over 300 river miles downstream of the reservoirs.

Habitat analysis has also been extensively applied to trout production. Reservoirs which consistently discharge cool water may support a significant downstream trout population. Passing flows may be set to insure discharge of enough cool water to maintain appropriate temperatures in downstream sections of the river during the summer. Cool-water reservoir releases from New York City's reservoirs on the Upper Delaware River support a significant trout population, much larger than the one before the reservoirs were built. The 1954 Supreme Court Decree has been modified by unanimous consent of the Decree Parties several times partially in order to better maintain trout habitat immediately downstream of the reservoirs. Bovee and others (2007) present a habitat analysis designed to better understand how changes in releases from these reservoirs might affect trout habitat.

Optimizing streamflow for the benefit of one species may have detrimental effects on other species (Sparks, 1995). It is time-consuming and expensive to ascertain the relationships that link ecological health to flows . Thus it is tempting to focus on a charismatic species (trout, for example), an economically-important species (oysters), or an endangered species (dwarf wedgemussels), and assume that if that species is thriving all others species are also. Unfortunately, multi-species ecological models are rarely, if ever, used (Pilkey and Pilkey-Jarvis, 2007).

Contemporary New Jersey regulations

In calculating excess-diversion passing flows, NJDEP regulations allow using the average daily flow for the driest month or, if this is not available, 125,000 gpd/mi^2 flows (N.J.A.C. 7:19-4.6(f)). This value is probably based on Vermeule's estimate of average daily flow in the driest month in the Passaic watershed (127,000 gpd/mi^2). (Paul Schorr, DWSG, NJDEP oral communication, 2006).

Passing flows calculated for public water supplies can also be set using the same approaches as those for the excess-diversion passing flows (N.J.A.C. 7:19-1.6(e)1). Passing flows calculated for non-public water supplies commonly use a 7Q10 approach (N.J.A.C. 7:19-1.6(e)2).

NJDEP regulations also require that new withdrawals not adversely impact current users. Documented downstream water needs can provide the justification for setting passing flows that exceed either 125,000 gpd/mi^2 or estimated 7Q10 flows.

Contemporary Passing-Flow Locations and Standards

The NJDEP's water-allocation regulations call for a passing flow to be imposed on any surface-water or groundwater diversion that impacts a surface-water source (N.J.A.C. 7:19-1.6(e)). As of early 2007, there were 103 passing flow standards set in New Jersey (fig. 6, appendix B). These are set as a permit condition on water that can be withdrawn at a rate of 100,000 gallons per day or greater for a month or longer.

Some large purveyors must meet multiple passing flows. For example, the New Jersey Water Supply Authority (NJWSA) must meet a passing flow of 7.75 cfs downstream of the dam of the Spruce Run Reservoir (ID pf053 in appendix B). It must also meet two passing flows related to the Round Valley Reservoir -- 0.17 mgd into the South Branch of Rockaway Creek and 0.83 mgd into Prescott Brook (IDs pf057 and pf058 in appendix B, respectively). In addition, the NJWSA must operate the reservoirs to meet passing flows at three downstream stream gages on the Raritan River -- 40 mgd at Stanton, 70 mgd at Manville, and 90 mgd at Bound Brook, (IDs pf056, pf055, and pf054 in appendix B, respectively). This sequence of passing flows attempts to mitigate the impacts of reservoir operation upstream of the gages.

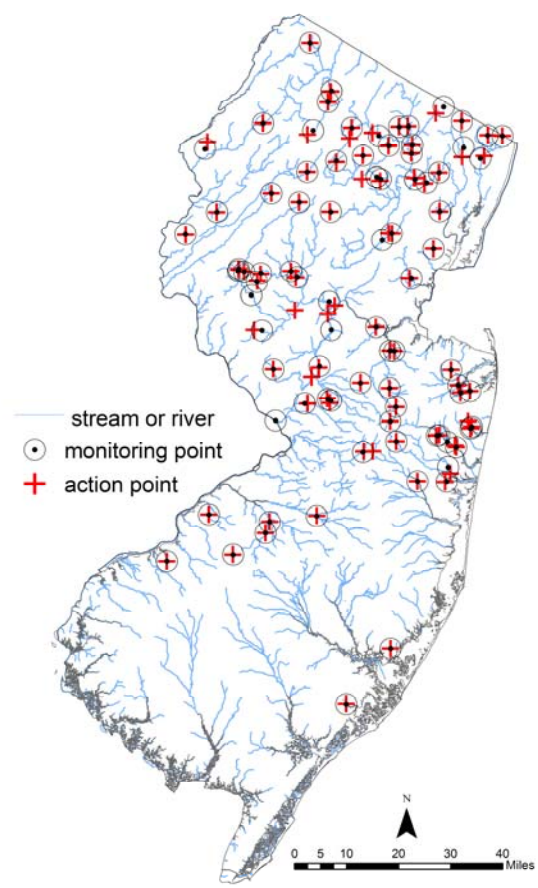

Figure 6. Passing-flow monitoring and action points, January 2008

Implementation of Passing Flows

A review of the contemporary passing-flow requirements in New Jersey (Appendix B) shows a wide range in language and terms. Some may be open to interpretation.

For example, the New Brunswick City Water Department withdraws water from Weston's Pond on Lawrence Brook under allocation permit 5337. The passing flow imposed on this permit (ID pf022) is:

> "Diversion from Weston's Pond shall not cause the river flow measured at USGS gauging station at Weston's Mill Dam on Lawrence Brook to be <8.7 cfs."

This permit is clear that if the river flow exceeds 8.7 cfs, then the diversion may not cause the flow to fall below that value. But the permit condition is unclear on whether or not the diversion must cease if the natural flow is less than 8.7 cfs. In practice this is interpreted as requiring all withdrawals to cease when natural flow falls below 8.7 cfs.

In contrast the Spring Meadow Golf Course has a passing-flow permit condition that clearly defines the relationship between withdrawals and the passing flow. This facility withdraws water from the Manasquan River under allocation permit 4035PS. The passing flow imposed on this permit (ID pf066) is:

> "Diversion from the intake shall not cause the river flow measured at USGS gauging station at Squankum to be < 21.5 cfs. Pumping shall cease when flow is at or below passing flow 21.5 cfs."

Another practical difficulty occurs when multiple passing-flow permit conditions are based on the same monitoring point. If two different intakes (action points) have the same monitoring point, it may be difficult to assign responsibility when streamflow declines below the passing flow. This may not be an issue where the same purveyor owns both intakes. But if different purveyors have withdrawals that are tied to the same monitoring point, they must cooperate to insure an equitable use of the stream.

Some permit conditions are tied to conditions other than streamflow. For example, the Sayreville Borough Water Department withdraws water from the South River under allocation permit 5313. Its passing flow condition (ID pf015) is tied to flow in the South River and to chloride concentration in the diverted water.

It is not necessary for the monitoring point to be located downstream of the action point. If streamflow at the action point can be correlated to an upstream or nearby stream gage then the permit condition can be written to account for this relationship. For example, the Brick Township MUA withdraws water from the North Branch Metedeconk River under allocation permit 5172. Its withdrawals are governed by observed flow in the stream gage 01408120, which is upstream of the action point. The permit condition says:

> "Diversion shall cease when the river flow at USGS gaging station 01408120 is < 14 cfs. Diversion of over 16 MGD may only occur if the flow at the gage is in excess of 31.6 cfs". (ID pf008)

As flow at the upstream gage increases from 14 to 31.6 cfs, Brick's withdrawals are allowed to increase linearly according to a condition in the permit.

The stream gage may also be in a different, but close, watershed. In this case, the assumption is that streamflow at the monitoring point is affected by the same hydrologic conditions that govern streamflow at the action point. There are currently no examples of this in New Jersey.

These examples show the ambiguity that may arise if a passing flow condition is not worded precisely. A clear statement of the passing-flow conditions should be unambiguous and applicable in a regulatory/enforcement setting. This would assist both the Department and the permitted party.

In an attempt to promote clear and consistent permit conditions, table 6 presents suggested wording for permit conditions for each type of passing flow and a range of action-point/monitoring-point relationships. Each relationship is given a type code that is used to characterize each passing flow in Appendix B. This characterization is based on an interpretation of the current permit conditions.

Table 6. Suggested wording for passing-flow permit conditions

Type code	Goal of passing flow	Proposed wording
	-----*Diversions:*	*Intake Passing Flows* -----
I1	Diversion is not to reduce streamflow downstream below the passing flow.	Diversion from *{action point}* is to cease whenever streamflow at *{monitoring point}* is equal to or less than *{PF}*. Diversion at *{action point}* is never to cause streamflow at *{monitoring point}* to fall below *{PF}*.
I2	Diversion is to cease when streamflow upstream or nearby falls below a specified value.	Diversion from *{action point}* is to cease whenever streamflow at *{monitoring point}* is equal to or less than *{value}*.
I3	Diversion is to lessen when streamflow falls below a specified value.	Diversion from *{action point}* must be reduced whenever streamflow at *{monitoring point}* is equal to or less than *{value}* according to the following set of rules …
I4	Diversion is to cease based on a metric other than streamflow.	Diversion from *{action point}* is to cease based on *{other metric}* at *{monitoring point}* according to the following rules …
	----- *Releases: On-Stream Reservoir Passing Flows* -----	
R1	Minimum-release passing flow.	Releases from the *{action point}* shall equal or be greater than *{PF}* at all times.
R2	Minimum-instream passing flow.	Releases from the *{action point}* shall maintain streamflow at *{monitoring point}* at or greater than *{PF}* at all times.
R3	Variable-release passing flow.	Releases from the *{action point}* shall equal or be greater than *{PF}* whenever inflows to the reservoir are equal to or greater than *{PF}*. Releases from the reservoir shall be equal to or greater than inflows to the reservoir whenever the inflows are less than *{PF}*.
R4	Variable-release passing flow based on monitoring point upstream or nearby.	Releases from the *{action point}* shall equal or be greater than *{PF}* whenever streamflow at *{monitoring point}* is equal to or greater then *{value}*. When streamflow at *{monitoring point}* is less than *{value}* then releases from the *{action point}* shall be governed by the following rules …
R5	Releases based on a metric other than streamflow.	Releases from the *{action point}* are governed by *{other metric}* at *{monitoring point}* according to the following rules…

Notes:

(1) Off-stream reservoirs may have a passing flow that applies to the intake pipe that supplies the reservoir and another passing flow governing discharges from the dam.

(2) Small dams built to provide a deeper pool as part of a surface-water intake facility are not considered to be part of a reservoir system.

(3) Definitions:

Action Point - where purveyor can take an action to modify stream flow

Monitoring Point - where streamflow or another appropriate metric is measured

PF - passing flow

Relaxation of Passing Flows

Passing flows on potable intakes and reservoirs are commonly relaxed during declared drought emergencies in order to protect the State's water supply. Passing flows can decrease the storage in a reservoir if the required release rate exceeds the inflow rate. Reducing these passing flows slows the rate of water-storage decline during dry periods, retaining water for later use. Purveyors commonly request relaxation of passing flows during the early stages of a drought to ensure that adequate supplies will be available later if conditions continue to worsen.

During the 2002 drought, NJDEP reduced 17 passing flows in order to protect water-supply sources (table 7). The intent was to reduce those passing flows that were set higher than the flows used for calculating effluent-discharge limits at downstream discharge points. Thus, reducing the reservoir passing flows to the discharge-design flows need not create a water-quality violation. The initial reduction of passing flows was followed by a more thorough review of discharges and design flows. This resulted in a modification of some of the passing flows. During this review process there were insufficient data available to allow an evaluation of biological impacts of these passing-flow reductions. (Joe Mattle, NJDEP, written communication, 2007). NJDEP monitored water quality to insure that water-quality criteria were not violated. Test results showed that the reduced passing flows did not cause any violations of NJDPES discharge permits during the drought.

Table 7. Reductions in passing flows during the 2002 drought[a]

Stream	Location	Affected Purveyors[b]	Passing Flow (million gallons/day)		
			original	AO2002-03[a]	Revised[c]
----- Reservoirs and Lakes -----					
Wanaque River	Wanaque Reservoir	NJDWSC	10	5.0	2.6
	Point View Reservoir	PVWC	0.4	0.2	0.2
Rockaway River	Boonton Reservoir	Jersey City	10	5.0	5.2
Swimming River	Swimming River Reservoir	NJAWC	6.1	3.0	3.0
Musconetcong River[d]	Lake Hopatcong	---[e]	7.5	4.4	4.4
Raritan River	Spruce Run Reservoir	NJWSA	5.0	--[f]	1.9
----- Streams -----					
Ramapo River	Pompton Lakes	NJDWSC	40	10	10.
Pompton River	Pompton Plains	NJDWSC	88	68	29.0
Passaic River	Two Bridges	NJDWSC, PVWC	92.6	72.6	46.9
	Chatham	NJAWC	75	55	36.5
	Little Falls	PVWC	17.6	13.6	13.6
Saddle River	Hohokus Brook	United Water	9.0	4.0	4.0
Shark River	Neptune City	NJAWC	1.2	0.8	0.8
Jumping Brook	Neptune City	NJAWC	0.8	0.5	0.5
Manasquan River	NJWSA intake	NJWSA	8.0	6.0	6.0
Metedeconk River	N.B. Metedeconk R. gage	Brick Twp.	9.0	7.0	7.0
Raritan River	Bound Brook	NJWSA	90	70	90.
	Stanton	NJWSA	40	30	21.5

a. Relaxation of passing flows set in Administrative Order 2002-03, issued by Commissioner Shinn, NJDEP, January 24, 2002. Normal passing flows reinstated by Governor McGreevy's Executive Order 44 issued on January 8, 2003.

b. NJDWSC - North Jersey District Water Supply Commission
PVWC - Passaic Valley Water Commission
NJWSA - New Jersey Water Supply Authority

c. Recommendation of the NJDEP Drought Passing Flow Work Group, in memorandum addressed to Administrator Dennis Hart, Water Supply Administration titled 'Recommendations for revising passing flows for several drought regions' and dated May 20, 2002.

d. The Lake Hopatcong release reduction was set in Administrative Order 2002-07, issued by Commissioner Bradley, NJDEP, March 15, 2002.

e. Lake Hopatcong is not normally a water-supply source but can be used in a drought emergency.

f. The passing flow directly out of the Spruce Run Reservoir was not addressed in Administrative Order 2002-03.

Conclusion

Passing flows are an integral part of New Jersey's water-resource management-strategy. They are defined as either the rate at which a reservoir must discharge water or a streamflow that must be allowed to pass by an intake or monitoring point. The first state-mandated passing flow in New Jersey dates back to 1916 on the Wanaque Reservoir and was established to protect downstream water rights. Passing flows have since been established throughout the State to protect downstream users, water quality, and the aquatic ecosystem. The Division of Water Supply and Geoscience in the New Jersey Department of Environmental Protection is responsible for implementing passing flows as part of its water-allocation and agricultural-certification permitting processes.

A passing-flow requirement must specify both an action point and a monitoring point. The action point is the site where the streamflow is modified, such as an intake or dam. The monitoring point is the site where streamflow is measured and may be at, upstream or downstream of the action point. Appendix B lists the monitoring and action points for the 103 passing-flow requirements in effect in 2007.

This report divides passing flows into three types, surface-water intake, reservoir, and groundwater withdrawal. Surface-water-intake passing flows are subdivided into minimum-instream or excess-diversion passing flows. Reservoir passing flows are subdivided into minimum-release, minimum-instream, variable-release and excess-diversion passing flows. A groundwater passing flow is essentially equivalent to a surface-water intake minimum-instream passing flow.

Passing flows are set using a variety of methods. The methods can be divided roughly into three general categories: preservation of flows, preservation of water quality, and preservation of the aquatic ecosystem. Preservation of flows is based on typical seasonal low flow or the flow necessary to protect downstream water rights. Preservation of water quality involves the dilution needed by a downstream discharger to meet water-quality criteria. The annual seven-day average 10-year low flow (annual 7Q10) is the most commonly applied flow statistic used in New Jersey. The annual 7Q10 has been misinterpreted as being protective of the aquatic ecosystem. Passing flows designed to protect the aquatic ecosystem are referred to as instream flows or environmental flows. They are typically based on a statistical analysis of streamflow, such as the Tennant, Aquatic Base Flow or Natural Flow Paradigm, or on a species-centric analysis of habitat needs.

Passing flows are periodically reduced during droughts to provide an additional margin-of-safety to a reservoir system's safe yield. During the 2002 drought, NJDEP measurements showed no water-quality-criteria violations as a result of these reductions.

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Glossary

Annual 7Q10 - The annual-minimum 7-day-average flow that has a recurrence interval of 10 percent (or once in ten years). This is commonly considered to be representative of a drought flow.

Aquatic Base Flow method - A methodology developed in New England to estimate in-stream flow needs (U.S. Fish & Wildlife Service, 1981).

Assimilative Capacity - The capacity of a natural body of water to receive wastewaters or toxic materials without deleterious effects and without damage to aquatic life or humans who consume the water. (U.S. EPA, 1997).

Environmental Flows - Passing flows that are set to protect the aquatic ecosystem.

Gaging station - A location on a stream where flow is measured. The U.S. Geological Survey maintains a national network of gaging stations.

Hydroecological Integrity - A term that refers to maintaining those processes which sustain a water-based ecological system in a natural or unimpacted state.

Instream Flows - Passing flows that are set to protect the aquatic ecosystem.

Off-stream Reservoir - A reservoir that is built behind a dam in a valley with a small stream but is filled primarily by a diversion on a different stream or river that is piped into this reservoir. Releases may be over the dam or through a pipe. The Round Valley Reservoir is an example in New Jersey.

On-stream Reservoir - A reservoir that is built on a stream. A dam is built on a stream and a reservoir fills behind the dam. The reservoir is filled by runoff from the watershed upstream of the reservoir. Releases from the reservoir may be over the dam or through a discharge pipe. This is also called a run-of-the-river reservoir. The Spruce Run Reservoir is an example in New Jersey.

Passing Flows - The volume of water that must remain in a stream. This is required of water-intake and storage infrastructures by a regulatory authority in order to support downstream water needs.

Tennnant method - A method developed in Montana by Tennant to estimate instream flow needs (Tennant, 1976).

Watershed - All the area which drains to a defined point, usually on along a stream. Also called a drainage basin.

Appendix A. Acronyms and abbreviations

Acronym	Stands For
7Q10	7-Day mean low-flow that occurs, on average, once in 10 years
ABF	Aquatic Base Flow
BWA	Bureau of Water Allocation, DWSG, NJDEP
cfs	cubic feet per second
DWSG	Division of Water Supply & Geosciences, NJDEP
GIS	Geographic Information System
gpd	gallons per day
mgd	million gallons per day
MUA	Municipal Utilities Authority
NJDEP	New Jersey Department of Environmental Protection
NJGWS	New Jersey Geological & Water Survey
QAA	average annual flow
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WD	Water Department

Appendix B. Details of contemporary passing flow locations in New Jersey[1]

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf001	Perth Amboy MUA, Runyon Watershed	5006	Deep Run Reservoir	intake - Deep Run Reservoir	outlet - Deep Run Reservoir	R1	Diversion from the intake shall not cause the river flow measured at the gauge which shall be located at the sluice gate at the Deep Run dam spillway, to be ≤ 2.2 cfs (1.42 mgd)
pf002	Ramsey Water Dept	5076	wells 15 & 16	wells 15 & 16	Ramapo River near Mahwah gage (USGS 01387500)	I2	Diversion from Well Nos. 15 and 16 to stop when the passing flow in the river, as measured at the USGS gauging station in Mahwah, to be < 12.32 cfs
pf003	Lakewood Twp MUA	5079	Cohansey Aquifer - Well Nos. 5, 6a, 8, 9, 10, 11, 12, 13, 14, 15, 16, & 17.	wells - Cohansey & Kettle Creek well-fields	Lake Riveria proposed USGS gage	I1	Diversion from the proposed Cohansey well field and existing Kettle Creek well field, shall not cause the passing flow (at the gauging station to be installed near the head of Lake Riveria) to be ≤ 1.5 cfs
pf004	Newark City Water Dept	5123	Charlotteburg Reservoir	intake - Pequannock R, Charlotteburg Reservoir	Pequannock R at Macopin intake gage (USGS 01382500)	R2	Diversion (overall) shall not cause the passing flow at USGS gaging station number 01382500 below the Macopin Dam to be < 12.3 cfs .
pf005	Newark City Water Dept	5123	Oak Ridge Reservoir Pequannock River	intake - Pequannock River, Oak Ridge Reservoir	Pequannock R just downstream of Oak Ridge Reservoir	R1	Releases (by City of Newark) from Oak Ridge Reservoir so the passing flow immediately downstream is never < 5 cfs
pf006	Butler Borough WD	5128	Kakeout Reservoir	intake - Kakeout Reservoir on Stone Brook	Stone Brook just downstream of Kakeout Reservoir	R1	Diversion from the reservoir shall not cause the river flow measured below the Dam to be < 0.261 cfs
pf007	Hackettstown MUA	5145	Lower Mine Hill Reservoir	intake - Lower Mine Hill Reservoir on Mine Brook	Mine Brook just downstream of Lower Mine Hill reservoir	R1	Diversion from the Lower Mine Hill Reservoir shall not cause the streamflow measured below the dam to be < 0.2 cfs
pf008	Brick Twp MUA	5172	N. Br. Metedeconk River intakes 1, 2a, 2b	intakes - N. Br. Metedeconk River	N. Br. Metedeconk River near Lakewood (USGS 01408120)	I1	Diversion shall cease when the river flow at USGS gaging station 01408120 is < 14 cfs. Diversion of over 16 mgd may only occur if the flow at the gage is in excess of 31.6 cfs.
pf009	City of Jersey City	5268	Boonton Reservoir	intake - Boonton Reservoir on Rockaway R.	Rockaway R. below Boonton Reservoir gage (USGS 01381000)	R2	Diversion from the intake shall not cause the river flow measured below Boonton Reservoir at USGS gauging station 01381000 to be < 23. cfs

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Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf010	City of Jersey City	5268	Split Rock Reservoir	intake - Split Rock Reservoir on Beaver Brook	Beaver Brook below Split Rock Reservoir Dam	R2	The river flow measured below Split Rock Reservoir Dam at USGS gauging station 01380000 shall not fall below < 1.55 cfs.
pf011	United Water NJ Matchaponix	5270	Matchaponix Brook, intake 1	intake - Matchaponix Brook	intake - Matchaponix Brook	I1	Diversion from the intake shall cease when the streamflow measured at the intake is < 7.3 cfs.
pf012	Sussex Borough WD	5292	Colesville Reservoir, Clove Brook	intake - Colesville Dam on Clove Brook (trib to Papakating)	Clove Brook just downstream of Colevsille Dam	R1	Permittee shall maintain a residual streamflow, at the spillway of the Colesville dam of at least 0.1 cfs.
pf013	US Army Training Ctenter at Ft Dix	5303	Greenwood Branch	intake - Greenwood Branch	intake - Greenwood Branch	I2	Diversion from the Greenwood Branch shall not cause the river flow measured at the gauging station downstream of the point of the diversion to be < 23 cfs.
pf014	Atlantic City MUA	5306	Doughty Pond	intake - Doughty Pond on Absecon Creek	Absecon Creek just downstream of Doughty Pond	I1	Diversion from Absecon Creek shall not cause the streamflow measured below the intake to be < 3.2 cfs.
pf015	Sayreville Borough WD	5313	South River	intake - South River	intake - South River	I1 & I4	Diversion from the river shall take place only when the net residual flow below the point of diversion is > 61.88 cfs (40 mgd) during the months of December through April, based on measurements at the USGS stream gaging station at the Duhernal Dam located immediately upstream, and only when the chloride concentration of the water diverted is 60 parts per million or less.
pf016	Sayreville Borough WD	5313	South River	intake - South River	intake - South River	I1 & I4	Diversion from the river shall take place only when the net residual flow below the point of diversion is > 123.78 cfs (80 mgd) during the months of May through November, based on measurements at the USGS stream gaging station at the Duhernal Dam located immediately upstream, and only when the chloride concentration of the water diverted is 60 parts per million or less.
pf017	Medford Leas Estaugh Corp	5323	SW Branch Of Rancocas Creek	intake - Southwest Branch of the Rancocas Creek	intake - Southwest Branch of the Rancocas Creek	I1	Diversion from the intake shall cease when the river flow measured at the point of diversion (the Southwest Branch of the Rancocas Creek) is < 11.3 cfs.
pf018	North Jersey Dist WSC, Wanaque North	5329	Two Bridges Pumping Site	intake-Pompton River at Two Bridges	confluence of the Passaic and Pompton Rivers	I2	Diversion from the Two Bridges Pump Station shall not cause the river flow calculated at the USGS gaging station number 01389005 at confluence of the Pompton and Passaic Rivers to be < 143.3 cubic feet per second (92.6 mgd) or 27.2 cfs (17.6 mgd) when PVWC is diverting from the Two Bridges Pump Station. The river flow at the confluence of the Pompton and Passaic Rivers is calculated from USGS gaging station number 01389500 at Little Falls. [N.J.A.C. 7:19- 2].
pf019	North Jersey Dist WSC, Wanaque North	5329	Ramapo River	intake - Ramapo River	intake - Ramapo River	I1	Diversion from the intake shall not cause the river flow measured immediately downstream of the intake to be < 61.9 cfs.

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Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf020	North Jersey Dist WSC Wanaque North	5329	Raymond Dam, Wanaque River	intake - Raymond Dam on the Wanaque R.	Wanaque R. just downstream of Raymond Dam	R2	Diversion from the intake shall not cause the flow of the Wanaque River measured below the Raymond Dam to be < 10.8 cfs as long as 4.64 cfs is discharged during the same time from Greenwood Lake. If a quantity in excess of 4.64 cfs is released from Greenwood Lake for use other than the use of the NJDWSC, an amount equal to the amount discharged from Greenwood Lake shall be released from the Wanaque Reservoir, and in addition thereto, such amount as shall be required to make the total discharge from the reservoir at least 15.47 cfs.
pf021	North Jersey Dist WSC Wanaque North	5329	Post Brook	intake - Post Brook	intake - Post Brook	I1	Diversion from the intake shall not cause the river flow measured below the point of diversion to be < 0.54 cfs.
pf022	New Brunswick City WD	5337	Weston's Pond on Lawrence Brook intakes 1d, 1c, 1b, 1a	intake - Weston's Pond on Lawrence Brook	Lawrence Brook at Weston's Mill Dam gage (USGS 01405030)	I1	Diversion from Weston's Pond shall not cause the river flow measured at USGS gauging station at Weston's Mill Dam on Lawrence Brook to be < 8.7 cfs.
pf023	Rahway City WD	5339	Rahway River	intake - Rahway R.	Rahway River at Rahway gage (USGS 01395000)	I1	Diversion from the Rahway River shall not cause the river flow measured at USGS gauging station No. 01395000 to be < 7.9 cfs.
pf024	Franklin Boro WD	5359	Franklin Pond	intake - Franklin Pond on Wallkill River	Wallkill R. Downstream of Franklin Pond (USGS partial gaging station 01367700)	I1	Diversion from the Franklin Pond intake shall not cause the Wallkill River flow measured at the partial gauging station downstream of the dam to be < 2. cfs.
pf025	Bamm Hollow Country Club	2151p	Nut Swamp Brook	intake - Nut Swamp Brook	intake - Nut Swamp Brook	I1	Diversion from the intake at Nut Swamp Brook shall not cause the river flow measured at the intake to be < 0.19 cfs.
pf026	Westwood Golf Club	2257p	Matthews Branch	intake #1 - Matthews Branch	Matthews Branch culvert beneath Route 551	I1	Diversion from the Matthews Branch though Intake No. 1 shall not cause streamflow in the culvert beneath Route 551 (measured at a time midway between high and low tide) during the current or next outgoing tide to be < 0.2 cfs.
pf027	Forest Hill Field Club	2268p	Third River	intake - Third River	intake - Third River	I1	Diversion from the Third River shall not cause the river flow measured at the intake to be < 1.5 cfs.
pf028	Ocean County Parks at Atlantis	2322p	Willis Creek , Intake 2	intake - Willis Pond on Willis Creek	spillway - Willis Pond	I1	Diversion from the Willis Creek intake shall not cause the streamflow measured the spillway, located below Willis Pond to be < 0.4 cfs.
pf029	Battleground Country Club	2327p	Pond 6, Intake 2	intake - Manalapan Brook tributary	spillway - downstream of intake #1	I1	Diversion from the Manalapan Brook tributary shall not cause the streamflow over the dam, immediately downstream from Intake No.1, to be < 0.3 cfs.
pf030	Fiddlers Elbow Golf & Country Club	2329p	Lamington River	intake - Lamington River	intake - Lamington River	I1	Diversion from the intake shall cease when the river flow measured at the intake is < 8. cfs.

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Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf031	Fox Hollow Golf Club	2334p	Lamington River	intake - Lamington River	Lamington Road Bridge, Lamington R.	I1	Diversion from the intake shall not cause the river flow measured at the Lamington Road Bridge to be < 13 cfs. The permittee shall measure the flow in the Lamington River in the vicinity of the Lamington Road Bridge prior to diverting water from the stream, in accordance with the August 2, 1991 monitoring plan. The flow measuring device shall be used to monitor the residual flow to ensure that the river flow does not fall below 13 cfs due to the permittee's diversion. If the streamflow falls below 13 cfs, the diversion shall cease.
pf032	Cranbury Golf Club	2335p	Big Bear Brook, Intake 2	intake - Big Bear Brook	Big Bear Brook proposed gauging station at Cranbury-Dutch Neck Road Bridge	I1	Diversion from the river shall not cause the river flow measured at USGS gauging station at Cranbury-Dutch Neck Road Bridge to be < 0.3 cfs. [Note: gage not installed]
pf033	Flanders Valley Golf Course	2338p	Lower Lake, Drakes Brook	intake - Drakes Brook	Drakes Brook weir	I1	Diversion from the intake shall not cause the river flow measured at the weir to be < 0.5 cfs.
pf034	Princeton University	2393p	Lake Carnegie	intake - Carnegie Lake	Millstone R. gaging station	I1	Diversion from Carnegie Lake shall not cause the river flow measured at U.S.G.S. gaging station at Millstone River at Carnegie Lake to be < 8.5 cfs. [Note: gaging station discontinued]
pf035	US Army Armament Research Dev	2403p	All Diversion Sources	all intakes & wells	Green Pond Brook below Picatinny Lake gaging station (USGS 01379780	I1	The permittee shall operate the surface intakes and groundwater production wells listed in this permit in such a manner as not to reduce the passing flow measured at USGS gaging station # 01379780 at Picatinny Arsenal in Green Pond Brook, below Picatinny Lake to ≤ 1.8 cfs.
pf036	Rossmoor Community Assoc. Inc	2422p	Cedar Brook, Pond 3	intake - Cedar Brook pond 3	weir at the outlet of Pond 3 on Cedar Brook	I1	Diversion from Cedar Brook(Pond 3) shall not cause the streamflow measured at the weir at the outlet of Pond 3 on Cedar Brook to be < 0.18 cfs.
pf037	Due Process Golf Course	2426p	Pine Brook	intake - Pine Brook	intake - Pine Brook	I1	Diversion from Pine Brook shall not cause the river flow immediately below the point of diversion to be < 5. cfs.
pf038	Royce Brook Golf Course	2449p	Millstone River	intake - Millstone R.	Millstone R. gauging station (USGS 01402000) at Blackwells Mills	I1	Diversion from the intake shall not cause the river flow measured at the USGS gauging station at Blackwells Mills to be < 40. cfs.
pf039	Charleston Springs Golf Club	2480p	Manalapan Brook	intake - Manalapan Brook	intake - Manalapan Brook	I1	Diversion from the intake shall not cause the river flow measured at the intake to be < 0.785 cfs.
pf040	Fort Monmouth Golf Course	2486p	Irrigation Pond, Wampum Brook tributary	intake - tributary of Wampum Brook	discharge from pond on Wampum Brook	I1	Diversion from the tributary of Wampum Brook shall not cause the tributary flow measured below the pond to be < 0.4 cfs.
pf041	Six Flags Great Adventure	2504p	Lahaway Creek	intake - Lahaway Creek	Lahaway Creek Check Dam	I1	Diversion from the Lahaway Creek intake shall not cause the flow measured at Lahaway Creek Check Dam to be < 0.5 cfs , which is the minimum passing flow.
pf042	Six Flags Great Adventure	2504p	Well IR-1	Well IR-1	Lahaway Creek Check Dam	I1	Diversion from Well IR-1 shall cease if flow in Lahaway Creek (measured at the Check Dam) is ≤.5 cfs.

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Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf043	Village Grande at Bear Creek	2505p	All diversion Sources	all intakes & wells	Bear Brook gaging station (USGS 01400775) at Old Trenton Road	I1	The overall diversion shall not cause the passing flow of Bear Brook to be < 0.8 cfs at USGS gaging station number 01400775 located at Old Trenton Road. [Note: gaging station discontinued.]
pf044	Beaver Brook Country Club	2514p	Beaver Brook - on-stream Pond	intake - Beaver Brook	intake - Beaver Brook	I1	Diversion from the on stream pond shall not cause the Beaver Brook flow measured at the intake to be < 3.5 cfs.
pf045	Heron Glen Golf Course	2515p	Irrigation wells F & M	all intakes & wells	Neshanic River gaging station (USGS 01398000) near Reaville	I3	Diversion from the irrigation wells shall cease when the river flow measured at the USGS Reaville gauging station, number 01398000, on the Neshanic River is ≤0.21 cfs .When the flow at the Reaville Gage is between 0.2 and 0.65 cfs the maximum allowable pumping from the wells for irrigation purposes shall not exceed the daily values as identified on the graph titled, "Neshanic River at Reaville Flow vs. Allowable Pumping from Hunterdon County Golf Course Well".
pf046	Jumping Brook Golf & Country Club	2517p	Jumping Brook	intake - Jumping Brook	Jumping Brook gaging station (USGS 01407760) near Neptune	I1	Diversion from the Jumping Brook intake shall cease when the Brook flow measured at USGS gaging station 01407760 near Neptune is < 1.75 cfs (minimum passing flow) or the flow at the Jumping Brook Country Club's intake is ≤ 1.3 cfs.
pf047	Berkshire Valley Golf Course	2520p	Valley-fill aquifer, wells IRR-1, IRR-2, HH, CH	Wells IRR-1, IRR-2, HH, CH	Rockaway River gaging station (USGS) upstream of the Boonton Reservoir	I1	The diversion wells shall not cause the passing flow at USGS gauging station upstream of the Boonton Reservoir to be < 28.8 cfs.
pf048	Yards Creek Generating Station, Jersey Central Power & Light	4004ps	All Diversion Sources	all intakes & wells	Yards Creek gaging station (USGS 01443900) near Blairstown	R2	The downstream discharge monitored at the existing USGS gaging station on Yards Creek (No. 01443900) shall never be < 0.875 cfs. Daily releases shall be considered to be equivalent to the measured flows at USGS Gage No. 01443900 on Yards Creek. The permittee must release enough water to maintain a minimum passing flow of 0.875 cfs at the USGS gage.
pf049	Dundee Water Power & Land Co	4006ps	Dundee Lake on Passaic River	intake - Dundee Lake on Passaic River	Passaic River gaging station (USGS 01389500) at Little Falls	R5	Diversion may take place when the drawdown in Dundee Lake is ≤ 2 Feet Value from the top of the dam, providing that during low flow periods the passing flow through the turbines or other flow release structures need not be greater than the lake's incoming streamflow as monitored at the USGS gaging station at Little Falls.
pf050	NJ Water Supply Authority	4007ps	Spruce Run and Round Valley Reservoirs	Spruce Run and Round Valley Reservoirs	Raritan River gaging station at Bound Brook (USGS 01403060)	R2	Water shall be released from the Spruce Run Reservoir, supplemented by the natural runoff, such that minimum flow at the USGS gauging station at Bound Brook on the Raritan River is not < 90. mgd.
pf051	NJ Water Supply Authority	4007ps	Spruce Run and Round Valley Reservoirs	Spruce Run and Round Valley Reservoirs	Raritan River gaging station at Manville (USGS 01400500)	R2	Water shall be released from the Spruce Run Reservoir, supplemented by the natural runoff, such that minimum flow at the USGS gauging station at Manville on the Raritan River is not < 70. mgd.
pf052	NJ Water Supply Authority	4007ps	Spruce Run and Round Valley Reservoirs	Spruce Run and Round Valley Reservoirs	S. Br. Raritan River gaging station at Stanton (USGS 01397000)	R2	Water shall be released from the Spruce Run Reservoir, supplemented by the natural runoff, such that minimum flow at the U.S.G.S. gauging station at Stanton on South Branch Raritan River is not < 40. mgd.

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Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf053	NJ Water Supply Authority	4007ps	Spruce Run Reservoir	Spruce Run Reservoir dam	Spruce Run Reservoir dam	R1	Water shall be released into Spruce Run immediately below the dam at a continuous rate such that the rate is not < 7.75 cfs.
pf054	NJ Water Supply Authority	4008ps	Spruce Run and Round Valley Reservoirs	Spruce Run and Round Valley Reservoirs	Raritan River gaging station at Bound Brook (USGS 01403060)	R2	The diversion shall not cause the streamflow of the South Branch of Raritan River, measured at the USGS Bound Brook gage, to be < 90. mgd.
pf055	NJ Water Supply Authority	4008ps	Spruce Run and Round Valley Reservoirs	Spruce Run and Round Valley Reservoirs	Raritan River gaging station at Manville (USGS 01400500)	R2	The diversion shall not cause the streamflow of the South Branch of Raritan River, measured at the USGS Manville gage, to be < 70. mgd.
pf056	NJ Water Supply Authority	4008ps	Spruce Run and Round Valley Reservoirs	Spruce Run and Round Valley Reservoirs	S. Br. Raritan River gaging station at Stanton (USGS 01397000)	R2	The diversion shall not cause the streamflow of the South Branch of Raritan River, measured at USGS Stanton gage, to be < 40. mgd.
pf057	NJ Water Supply Authority	4008ps	Round Valley Reservoir	Round Valley Reservoir release into Prescott Brook	South Branch of Rockaway Creek immediately below the North Dam	R2	The diversion released from the Round Valley Reservoir into Prescott Brook shall not cause the streamflow at South Branch of Rockaway Creek, measured immediately below the North Dam, to be < 170,000 gpd.
pf058	NJ Water Supply Authority	4008ps	Round Valley Reservoir	Round Valley Reservoir release into Prescott Brook	Prescott Brook immediately below the South Dam	R2	The diversion released from the Round Valley Reservoir into Prescott Brook shall not cause the streamflow, measured immediately below the South Dam, to be < 830,000 gpd.
pf059	Howell Park Golf Course	4010ps	Elsie Lake, Timber Swamp Creek	intake - Elsie Lake on Timber Swamp Creek	intake on Elsie Lake on Timber Swamp Creek	I1	Diversion from the Elsie Lake shall not cause the Timber Swamp Creek flow below the point of diversion to be < 0.8 cfs.
pf060	NJ Water Supply Authority	4011ps	Millstone River	intake - Millstone R.	Millstone River at Blackwells Mills gage (USGS 01402000)	I1	Diversion from the Millstone River shall not cause the Millstone River flow measured at USGS gauging station at Blackwells Mills to be < 50. cfs.
pf061	NJ Water Supply Authority	4012ps	Raritan &Millstone Rivers	intake - Raritan & Millstone Rivers	Raritan River at Bound Brook gage (USGS 01403060)	I1	Diversion from the intake shall not cause the river flow measured at USGS gauging station no. 01403060 at Bound Brook to be < 90. mgd.
pf062	Merrill Creek Reservoir	4023ps	Merrill Creek, Intake 2	Merrill Creek Reservoir release to Merrill Creek	Merrill Creek immediately below Merrill Creek Reservoir	R2	Releases from the Merrill Creek Reservoir shall be the runoff under all hydrologic conditions from the watershed upstream of the Main Dam so that the flow in the Merrill Creek immediately below the dam is never < 3. cfs.
pf063	Merrill Creek Reservoir	4023ps	Delaware River, Intake 2	Merrill Creek Reservoir	Delaware River at Trenton gage (USGS 01463500)	I1	Diversion from the intake shall not cause the Delaware River flow measured at the Trenton USGS gauging station to be < 3,000 cfs. [Note: Reduce diversion as needed as detailed in the paper permit Condition B.2]
pf064	NJ Water Supply Authority	4034psx	Manasquan Reservoir, Timber Swamp Brook	Manasquan Reservoir on Timber Swamp Brook	Timber Swamp Brook immediately downstream of Oak Glen Reservoir	R2	Releases from the Manasquan reservoir shall be maintained so that the flow of Timber Swamp Brook, immediately below the dam is never < 0.3 cfs.
pf065	NJ Water Supply Authority	4034psx	Manasquan River	intake - Manasquan River, proposed Allaire Intake Structure for Oak Glen Reservoir	Manasquan River immediately downstream of proposed Allaire Intake Structure for Oak Glen Reservoir	I1	Diversion from the Manasquan River at the proposed Allaire Intake Structure for storage into the proposed Oak Glen Reservoir and for water supply shall not cause the river flow immediately downstream of the diversion to be < 12. cfs.

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Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf066	Spring Meadow Golf Course	4035ps	Manasquan River	intake - Manasquan River	Manasquan River at Squankum gage (USGS 01408000)	I1	Diversion from the intake shall not cause the river flow measured at USGS gauging station at Squankum to be < 21.5 cfs. Pumping shall cease when flow is at or below passing flow of 21.5 cfs.
pf067	Paterson MUA Great Falls Hydroelectric	4037ps	Passaic River	intake - Passaic River	Passaic River at the Great Falls	I1	Diversion from the intake shall not cause the Passaic River flow over the Great Falls to be < 200. cfs.
pf068	Oxford Textile Inc	4045ps	Furnace Brook, Intake 1 & 2	intakes - Furnace Brook	Furnace Brook at Route 31 gage	I2	Diversion from Furnace Brook shall not take place when the streamflow measured at USGS gauging station at Route 31 is ≤ 1.32 cfs. [Note: gage has been discontinued.]
pf069	Metedeconk National Golf Club	4047ps	Metedeconk River, Storage pond	intake - Metedeconk River	weir - Metedeconk River	I1	Diversion from the river shall not cause the river flow measured at the weir to be < 2.1 cfs.
pf070	Hopewell Valley Golf Club	4049ps	Stony Brook	intake - Stony Brook	intake - Stony Brook	I1	Diversion from Stony Brook shall not cause the river flow measured at the intake to be < 0.1 cfs.
pf071	Great Bear Hydropower	4051ps	Paulins Kill	intake - Paulins Kill	dam - Paulins Kill	I1	Diversion shall not cause the flow over the dam to be < 15 cfs at any time.
pf072	Mercer Oaks Golf Course	4056ps	Lake Mercer, Assunpink Creek Intake 1	intake 1 - Lake Mercer/Assunpink Creek	Assunpink Creek near Clarksville gage (USGS 01463620)	I2	Diversion from the Lake Mercer/Assunpink Creek shall cease when the river flow measured at USGS gaging station at Clarksville, No. 1463620 is < 7.4 cfs.
pf073	Mercer Oaks Golf Course	4056ps	Lake Mercer, Assunpink Creek Intake 2	intake 2 - Lake Mercer/Assunpink Creek	Assunpink Creek near Clarksville gage (USGS 01463620)	I2	Diversion from the Lake Mercer/Assunpink Creek shall cease when the river flow measured at USGS gaging station at Clarksville, No. 1463620 is < 7.4 cfs.
pf074	Bellemead Golf Course	4060ps	Lamington River	intake - Lamington River	intake - Lamington R.	I1	Diversion from the River shall not cause the river flow measured at the system intake to be < 14. cfs.
pf075	Rockaway River Country Club	4065ps	Rockaway River	intake - Rockaway River	Rockaway River gaging station (USGS 01380500) upstream of the Boonton Reservoir	I1	Diversion from the Rockaway River shall not cause the river flow measured at USGS gauging station at Rockaway River above Boonton Reservoir to be < 26. cfs. If a drought warning or emergency is declared by the Department or the City of Jersey City the passing flow is automatically increased to 45. cfs.
pf076	Lake Mohawk Golf Club	4066ps	Lake Mohawk, Walkill River	intake - Wallkill R, Lake Mohawk	Wallkill R, Lake Mohawk outlet	I2	Diversion from the intake shall cease when the Wallkill River flow measured at the outlet of the lake is ≤ 1.4 cfs.
pf077	Weequahic Golf Course	4067ps	Weequahic Lake	intake, Weequahic Lake	Weequahic Lake	I4	Diversion from the intake shall cease when the lake level is < 6 feet above mean sea level.
pf078	Renaissance / Leisure Glen	4068ps	Toms River	intake - Toms River	intake - Toms River	I1	Diversion from the Toms River intake shall not cause the river flow measured at the intake to be < 23. cfs.
pf079	Pennsauken Twp Of	4070ps	South Branch Pennsauken Creek	intake - South Br of Pennsauken Creek	intake - South Br of Pennsauken Creek	I1	Diversion from the South Branch of Pennsauken Creek shall not cause the flow at Intake No. 1 to be < 5. cfs.
pf080	Golden Pheasant Golf Course	4071ps	Little Creek	intake - Little Creek	intake - Little Creek	I1	Diversion from the intake shall not cause the flow of Little Creek measured at the intake to be < 3.99 cfs.
pf081	Ballyowen Golf Club	4072ps	Wallkill River-Furnace Pond, original intake	intake, original - Furnace Pond on Wallkill R.	intake - Wallkill R., Furnace Pond	I1	Diversion from the intake shall not cause the river flow measured at the Furnace Pond Intake to be < 8.5 cfs.

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Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf082	Ballyowen Golf Club	4072ps	Wallkill River-Furnace Pond, new intake	intake, new – Furnace Pond on Wallkill River	intake - Wallkill River, Furnace Pond	I1	Diversion from the intake shall not cause the river flow measured at the Furnace Pond Intake to be < 8.5 cfs.
pf083	Ballyowen Golf Club	4072ps	well 5	well 5	intake - Wallkill R., Furnace Pond	I1	Diversion from this well is only permitted when flows measured at the Furnace Pond Intake on the Wallkill River are < 8.5 cfs
pf084	Neshanic Valley Golf Course	4075ps	South Branch of Raritan River	intake - S. Br. Raritan River	S. Br. Raritan River gaging station at Stanton (USGS 01397000)	I2	Diversion from the South Branch of Raritan River shall not occur when the river flow measured at Gauging Station No. 01397000 is < 46.75 cfs.
pf085	Kresson Golf Club	4076ps	Cedar Lake (Barton Run)	intake - Cedar Lake on Barton Run	Barton Run immediately downstream of Cedar Lake dam	I2	Diversion from the intake shall cease when the streamflow over Cedar Lake Dam falls below < 0.4 cfs.
pf086	NJ American Water Short Hills	5008x	Canoe Brook, intakes 9 & 10	intakes - Canoe Brook	Canoe Brook near Summit gage (USGS 01379530)	I1	Diversion from Canoe Brook shall not cause the river flow measured at the USGS gauging station at Canoe Brook near Summit to be < 2.12 cfs.
pf087	NJ American Water Short Hills	5008x	Passaic River, intake 2	intake - Passaic River	Passaic River at Chatham gage (USGS 01379500)	I1	Diversion from the Passaic River diversion shall not cause the river flow at the USGS gauging station at Chatham to be < 116 cfs.
pf088	NJ American Water Union Beach & Monmouth	5018x	Swimming River	intake - Swimming River	Swimming River near Red Bank gage (USGS 01407500)	I1	Diversion from the intake shall not cause the river flow, measured at USGS gaging station 01407500, to be < 9.4 cfs or the natural inflow to the reservoir, whichever is less.
pf089	NJ American Water Union Beach & Monmouth	5018x	Jumping Brook	intake - Jumping Brook	Jumping Brook near Neptune City gage (USGS 01407760)	I1	Diversion from the Jumping Brook shall not cause the streamflow measured at the USGS gaging station, No. 01407760, on Jumping Brook near Neptune City to be < 1.2 cfs.
pf090	NJ American Water Union Beach & Monmouth	5018x	Shark River	intake - Shark River	Shark River near Neptune City gage (USGS 01407705)	I1	Diversion from the Shark River shall not cause the river flow measured at the USGS gaging station, No. 01407705, on Shark River near Neptune City to be < 1.9 cfs.
pf091	United Water NJ	5082x	All Diversion Sources	wells	Saddle River gage (staff gage at withdrawal?)	I2	Diversion from both wells shall cease during periods of time when the natural passing flow of the Saddle River is < 2.32 cfs.
pf092	United Water NJ	5082x	Sparkill Creek	intake - Sparkill Creek	Sparkill Creek gage	I1	Diversion from the intake shall not cause the river to stop flowing over the dam at the Continental Can Company or the flow measured at USGS Sparkill gauging station 01376280 to be < 4.64 cfs. [Note: no such USGS gage.]
pf093	United Water NJ	5082x	Two Bridges Pump station	intake - Two Bridges	Passaic R. just downstream of confluence of the Passaic and Pompton Rivers (USGS 01389005)	I1	Diversion shall not cause the river flow measures at the confluence to the Passaic and Pompton Rivers to be < 92.6 mgd.
pf094	United Water NJ	5082x	Saddle River	intake - Saddle River	Saddle River at Ridgewood gage (USGS 01390500)	I1	Diversion from the intake shall not cause the river flow measured at the USGS gauging station at Ridgewood to be < 13.9 cfs.

All notes are at the end of the appendix.

Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

ID[2]	Purveyor	Allocation Permit	Description	Action Point[3]	Monitoring Point[3]	Type Code[4]	Requirement[5]
pf095	United Water NJ	5082x	Oradell Reservoir, Hackensack River	intake - Oradell Reservoir on Hackensack River	Hackensack River just below Oradell Reservoir	R2	Diversion from the intake shall not cause the Hackensack River flow measured at New Milford (below the Oradell Reservoir dam) to be < 12.9 cfs. Pursuant to the provision of N.J.S.A. 58:2-1 et. seq., the permitee is subject to excess diversion fees.
pf096	United Water NJ	5082x	Lake Tappan, Hackensack River	intake - Lake Tappan on Hackensack River	Hackensack River just below Lake Tappan	R2	Release shall be made from Lake Tappan so that the flow of the Hackensack River at a point below the Lake Tappan dam is not < 12.4 mgd.
pf097	United Water NJ	5082x	Ramapo River at Pompton Lakes	intake - Ramapo River at Pompton Lakes	Ramapo River just below intake (USGS Pompton Lakes gage 01388000)	I1	Diversion from the intake shall not cause the river flow measured below the intake to be < 40. mgd.
pf098	Passaic Valley Water Commission	5099x	Pompton River, Jackson Ave Intake	intake - Jackson Ave Intake	Pompton River just below intake (USGS gage at Pompton Lakes 01388500)	I1	Diversion from the intake shall not cause the flow of the Pompton River measured below the intake to be < 88. mgd.
pf099	Passaic Valley Water Commission	5099x	Pompton And Passaic Rivers, Two Bridges & Little Falls Intakes	intake - Pompton River at Two Bridges	Passaic River below Pompton River at Two Bridges gage (USGS gage 01389005)	I1	Diversion from the Two Bridges Pump Station shall not cause the river flow calculated at the USGS gaging station number 01389005 at confluence of the Pompton and Passaic Rivers to be < 27.2 cfs. The river flow at the confluence of the Pompton and Passaic Rivers is calculated from the USGS gaging station number 01389500 at Little Falls.
pf100	Southeast Morris County MUA	5264x	Clyde Potts Reservoir, Harmony Brook	intake - Clyde Potts Reservoir on Harmony Brook	Harmony Brook just downstream of Clyde Potts Brook	R2	Diversion from the Clyde Potts Reservoir shall not cause the flow of Harmony Brook measured below the reservoir to be < 0.13 cfs.
pf101	NJDEP-Parks & Forestry	--	Lake Hopatcong, Musconetcong River	Lake Hopatcong dam	Musconetcong River at outlet of Lake Hopatcong (USGS gage 01455500	R2	Unless otherwise instructed by the Director, Division of Parks and Forestry, there shall be discharged at all times through the fountain, at Hopatcong State Park, supplemented if necessary by gage opening, at Hopatcong Dam, 7.5 mgd (12. cfs).[6]
pf102	Passaic Valley Water Commission	5099x	Pompton And Passaic Rivers, Two Bridges	intake- Pompton River at Two Bridges	Passaic River at Little Falls gage (USGS gage 01389500)	I1	Diversion from the Two Bridges and Little Falls Pump Stations shall not cause the passing flow at USGS gauging station no. 01389500 at Little Falls to be < 17.6 mgd.
pf103	Passaic Valley Water Commission	5099x	Pompton And Passaic Rivers, Two Bridges	intake- Little Falls	Passaic River at Little Falls gage (USGS gage 01389500)	I1	Diversion from the Two Bridges and Little Falls Pump Stations shall not cause the passing flow at USGS gauging station no. 01389500 at Little Falls to be < 17.6 mgd.

Notes:

(1) This appendix is based on data from the files of the Bureau of Water Allocation (BWA), Division of Water Supply and Geosciences, New Jersey Department of Environmental Protection.

(2) The 'ID' field has been assigned by the authors of this report for identification purposes.

(3) The 'Action Point' and 'Monitoring Point' fields have been assigned by the authors of this report based on their interpretation of the BWA files and on reported system operation.

Appendix B. Details of Contemporary Passing Flow Locations in New Jersey[1] (cont)

(4) The 'Type Code' field is assigned based on author's interpretation of BWA permit conditions. See table 6 for details.
(5) The 'Requirement' field is copied from BWA files. Spelling is maintained from the original.
(6) "Lake Hopatcong Water Level Management Plan," unpublished manuscript on file with the New Jersey DEP, Division of Parks and Forestry, State Park Service, 16 p, ca 2001. This passing flow is not associated with a withdrawal and thus does not have an allocation permit.

Appendix C. Excerpts of Regulations, 2007, Pertaining to Passing Flows

The following is excerpted from the complete regulations. Consult the complete regulations for a fuller description of the requirements relating to water allocation in New Jersey. The referenced current water-supply laws and regulations are available at:

http://www.nj.gov/dep/watersupply/statauth.htm

N.J.S.A. 58:1A-1 et seq. (Water Supply Management Act)

58:1A-1. Short title

This act shall be known and may be cited as the "Water Supply Management Act."
L.1981, c. 262, s. 1, effective Aug. 13, 1981.

58:1A-5. Supply and diversion of water; rules and regulations

The commissioner shall have the power to adopt, enforce, amend or repeal, pursuant to the "Administrative Procedure Act," P.L.1968, c. 410 (C. 52:14B-1 et seq.) rules and regulations to control, conserve, and manage the water supply of the State and the diversions of that water supply to assure the citizens of the State an adequate supply of water under a variety of conditions and to carry out the intent of this act. These rules and regulations may apply throughout the State or in any region thereof and shall provide for the allocation or the reallocation of the waters of the State in such a manner as to provide an adequate quantity and quality of water for the needs of the citizens of the State in the present and in the future and may include, but shall not be limited to:

e. Standards and procedures to be followed to maintain the minimum water levels and flow necessary to provide adequate water quantity and quality;

N.J.A.C. 7:19 -- Water Supply Allocation Rules

7:19-1.3 Definitions

"Passing flow requirement" means the volume of water required to be maintained at a selected point in the stream to promote water quality conditions after consideration of the needs of downstream users.

7:19-1.6 Diversion source categories and requirements

(e) A permittee shall maintain each inactive, active, or emergency surface water diversion source pursuant to the requirements of (a), (b), or (c) above, as appropriate. The Department will establish a passing flow requirement for each surface water diversion source or ground water diversion that impacts a surface water source as follows:

1. In the case of a diversion source used for public water supply, the Department will establish the passing flow requirement in accordance with the criteria set forth in N.J.A.C. 7:19-4.6(f).

2. In the case of a diversion source used for a purpose other than public water supply, the Department will establish the passing flow requirement at a level that will not reduce the passing flow below the 7 day, 10 year low flow as established by the United States Geological Survey.

3. If an applicant proposes a lower passing flow requirement than that established pursuant to (e)1 or 2 above, the applicant shall submit with the permit application, pursuant to N.J.A.C. 7:19-2.2, a detailed environmental impact study which demonstrates to the satisfaction of the Department that no adverse environmental impact will occur as a result of the proposed lower passing flow requirement.

4. The Department will temporarily increase the passing flow requirement established pursuant to (e)1 or 2 above if the Department determines such an increase is warranted to preserve the water quality of the diversion source.

5. The Department will not establish a passing flow requirement for a surface water diversion source if the 7 day, 10 year low flow is zero; the streamflow is intermittent; or the size or nature of the watershed is such that a passing flow requirement is impractical.

6. The permittee shall ensure that the intake structure for the surface water diversion source is designed to maintain the passing flow requirement.

7:19-4.6 Calculation of Fees

(f) Where the passing flow is not specified above, it shall be fixed by the Department based on an amount equal to the average daily flow for the driest month, as shown on existing records or in lieu thereof, 125,000 gallons for each square mile of unappropriated watershed above the point of diversion. The flows computed on the basis of 125,000 gallons per day per square mile shall be in addition to flows from any appropriated watershed above the point of diversion.

7:19-10.2 Restrictions and requirements placed on water purveyors

(a) The restrictions and requirements placed by the Commissioner on water purveyors during a water emergency may include the following:

6. Alteration of passing flow requirements. Such alteration in passing flow requirements does not exempt the purveyor from paying appropriate excess diversion fees;

N.J.A.C. 7:20A -- Agricultural, Aquacultural, And Horticultural Water Usage Certification

7:20A-1.3 Definitions
"Passing flow" means the volume of water required to be maintained at a selected point in the stream to promote water quantity and quality conditions after consideration of downstream users and ecological needs.

7:20A-2.6 Water usage certification conditions
(a) 12. All water usage certifications that impact or have the potential to impact surface water bodies, may include a passing flow for the affected portion of the waterbody. In establishing the passing flow, the Department shall take into account the needs of other authorized, existing downstream users, existing holders of a valid water supply allocation permit or registration, water usage certification or agricultural water usage registration, aquatic and water-dependent ecological requirements, use and classification of the waterbody, natural streamflow variability (hydrograph) of the impacted waterbody, impacts to the safe yield of existing public water supply systems, and the feasibility of implementing a passing flow requirement.

i. The Department may implement the use of new passing flow assessment tools as they develop in order to protect the integrity of waterbodies;

Appendix D. Historical Laws
Excerpts Pertaining to Passing Flows

Laws, Session of 1907
Chapter 252.

An Act to establish a State Water-Supply Commission, and to define its powers and duties, and the conditions under which waters of this State may be diverted.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

8. Every municipality, corporation or private person now diverting the waters of streams or lakes without outlets for the purpose of a public water-supply shall make annual payments on the first day of May to the State Treasurer for all such water hereafter diverted in excess of the amount now being legally diverted; *provided, however,* no payment shall be required until such legal diversion shall exceed a total amount equal to one hundred (100) gallons daily, per capita for each inhabitant of the municipality or municipalities supplied, as shown by the census of one thousand nine hundred and five. And every municipality, corporate or private person not at present diverting surface waters for said purpose but who shall hereafter divert such waters, shall make annual payments on the first day of May to the State Treasurer for all waters diverted in excess of a total of one hundred (100) gallons daily for each inhabitant of the municipalities supplies, as shown by the census of one thousand nine hundred and five. Such payment shall be deemed to be a license and its amount shall be fixed by said commission at a rate of not less than one dollar ($1.00) or more than ten dollars ($10.00) per million gallons. If at all times an amount equal to the average daily flow for the driest month, as shown by existing records, or in lieu thereof one hundred and twenty-five thousand gallons daily for each square mile of unappropriated watershed above the point of diversion, shall be allowed to flow down the stream, the commission shall fix the minimum rate and may increase the rate proportionally as a less amount is allowed to flow down the stream below the point of diversion, due account being taken in fixing said increase both of the duration and amount of said deficiency, *provided, however,* the aforesaid one hundred and twenty-five thousand gallons daily for each square mile of unappropriated watershed shall be additional to the dry-season flow or any part thereof which may be allowed to flow down from any appropriated watershed or watersheds above said point of diversion. Water diverted within the corporate limits of a municipality for manufacturing and fire purposes only, and returned without pollution to the stream from which it was taken within said corporate limits shall not be reckoned in making up the aggregate amount diverted.

Approved June 17, 1907.