SUSQUEHANNA RIVER BASIN
DROUGHT COORDINATION PLAN

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The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland, New York, Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to effect coordinated planning, conservation, management, utilization, development and control of basin water resources among the government and private sectors.

**Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).*

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INTRODUCTION

The Susquehanna River Basin is a region of varied topography, geology, and climatic influences. In the northern and western portions of the basin, the climate is influenced by the Great Lakes and Midwest weather patterns, while the southern and eastern portions experience Atlantic coastal weather conditions. With the basin at the interface of these climatic influences, weather patterns can lock into extended periods of dryness, followed by violent storm events.

The basin experiences rapid runoff during and after storm events due to the steepness of the topography, particularly within the Appalachian Plateau and Ridge and Valley Provinces, and complex geology. This condition also offers little opportunity for rainfall to recharge ground-water aquifers. During periods of drought, there are extended intervals between runoff events, causing streamflows to quickly drop to and stay at baseflow levels and causing aquifer storage to steadily deplete. At these times, the basin must rely on available surface- and ground-water supplies, mainly in storage, to meet its water supply needs until Mother Nature again provides a replenishment of the resource.

One of the basic responsibilities of the Susquehanna River Basin Commission (Commission) is to coordinate the efforts of the states of Maryland and New York, the Commonwealth of Pennsylvania, and the federal government in managing the water resources of the Susquehanna River Basin. As part of its coordination responsibilities, the Commission monitors the waters of the basin and informs the public of emerging drought conditions. The Commission also coordinates activities of its signatory parties to deal with drought conditions. If conditions reach extreme proportions, the Commission has the authority to declare a drought emergency.

This report details the methodologies for monitoring hydrometeorological variables and includes recommendations, through a drought coordination plan, for relating and combining these data to indicate the onset and termination of drought and drought severity. Also included are statements of the authority, responsibilities, and drought actions of the Commission, and state agencies with drought management roles.

The drought coordination plan, as presented in this report, is a tool designed to guide the Commission in managing water supply droughts. Future report supplements will address the protection of aquatic environments during periods of drought. The plan is based on a staged approach to drought triggering, declaration, and response actions and activities. The three drought stages of watch, warning, and emergency are discussed in detail on pages 4 and 5. Sample nonessential water uses that could be subject to restriction in times of drought emergencies are presented in the Appendix.

During a drought event, the Commission relies on a multi-agency committee (Drought Coordinating Committee) as the primary vehicle for coordination among the Commission's signatory parties. The committee is made up of representatives from the Commission and each of the Commission's signatory parties who are responsible for administering that signatory's drought management program. In addition, the Committee may consult other appropriate parties. The primary

duties of the Drought Coordinating Committee are to review drought monitoring data, make recommendations to the commissioners on drought stage and coverage area, and make recommendations of appropriate drought response actions to be taken by the commissioners through resolution.

AUTHORITY

The fundamental authority empowering the Commission to plan for and coordinate drought management throughout the basin is derived from the Susquehanna River Basin Compact (Compact). Article 11, Section 11.4 of the Compact states, "In the event of a drought which may cause an actual and immediate shortage of available water supply within the basin, or within any part thereof, the Commission after public hearing…may determine and delineate the area of shortage and by unanimous vote declare a drought emergency therein." For the duration of this defined drought emergency, the Commission may direct increases or decreases in any allocations, diversions, or releases previously granted, or required, for a limited time to meet the emergency condition.

Section 11.5, Standards, stipulates that "Permits shall be granted, modified or denied…to avoid such depletion of the natural streamflows and ground waters in an emergency area as will adversely affect…the rights of their lawful users of the same source." Thus, during periods of severe drought, the Commission has broad authority to declare a drought emergency and respond to that emergency through the modification of existing permits and project approvals, including changing withdrawal amounts and downstream release requirements.

The Commission also has the authority to operate and respond to drought through releases from the Commission's allocated water storage to meet instream water needs in accordance with all applicable agreements, e.g. U.S. Army Corps of Engineers storage reallocation agreements. These releases are triggered by specified low flow conditions. This authority stems from Article 4, Section 4.2(a) of the Compact, which states, "The commission shall have the power to acquire, construct, operate and control projects and facilities for the storage and release of waters...." In addition, Article 3, Section 3.7 of the Compact states, "The commission shall promote and aid the coordination of the activities and programs of federal, state, municipal, and private agencies concerned with water resources administration in the basin." At no time is coordination and efficient management of the available water resources more essential than during a drought.

Article 3, Section 3.5(1) of the Compact charges the Commission with the responsibility of developing and effectuating water resources plans, policies, and projects and adopting, promoting, and coordinating policies and standards for water resources conservation, control, utilization and management. In addition, Article 4, Section 4.1 states, "The commission shall have the power to develop, implement, and effectuate plan…the use of the water of the basin for domestic, municipal, agricultural, and industrial water supply." Thus, drought management, including planning for the use of water, is within the purview of Commission authority. This water use planning is particularly critical during drought events when water supplies are limited and essential uses must be protected.

The authority for the Commission's responsibility to monitor hydrologic conditions and drought impacts stems from Article 3, Sections 3.4(4) and (5) and Article 5, Section 5.1 of the Compact. Here the Commission's charge is to collect, compile, coordinate, and interpret systematic surface and ground-water data, to conduct ground and surface water investigations, tests and operations, and to undertake…investigations, studies and surveys pertaining to existing water quality.

During periods of drought, the Commission's public information and education function is defined in Article 3, Section 3.4(6) of the Compact. In this section, the Commission's role is to prepare, publish, and disseminate information and reports concerning the water problems of the basin.

To better ensure that remaining supplies are adequate for the duration of a drought event, drought management must begin well before the drought emergency stage. The two stages leading up to the emergency are drought watch and drought warning. They are essential and appropriate stages in any drought coordination plan to set the stage for, and possibly avert, more severe actions that could be required later. These stages and appropriate response actions, along with subsequent emergency measures, help ensure reliable supplies from the limited water resources of the basin, and provide for essential water uses to protect the public health, safety, and welfare.

Section 803.27 of the Commission's regulations allows for the expedited approval of water supply projects during emergency situations to protect the public health, safety, and welfare. Drought emergency approvals are examples of the intended authority of this section. Also, the regulations in Section 803.32 allow for the reopening and modification of any project approval, again in part, to protect the public health, safety, and welfare. This docket modification process may be necessary during periods of severe drought.

Within the Commission's signatory states, drought management authority is somewhat less defined. The Pennsylvania Emergency Management Agency has authority to promulgate, adopt, and enforce the Commonwealth's drought emergency regulations by virtue of the Emergency Management Services Code, 35Pa.C.S.7101 et seq. These regulations are implemented and enforced in accordance with an emergency proclamation issued by the governor declaring a drought emergency. Response provisions may include the implementation of 4 Pa. Code Chapter 119, restrictions on nonessential water uses, or 4 Pa. Code Chapter 120, local water rationing plans. Violations of the above provisions are subject to the penalties provided for under 35Pa.C.S.7707.

In New York, the state legislature created the Disaster Preparedness Commission (DPC) through Article B of the New York State Executive Law of 1979. In 1980, Governor Carey established the Drought Management Task Force (DMTF) to coordinate state drought response and assist local agencies. The New York State Department of Environmental Conservation is the lead agency on the DMTF; however, the New York State Department of Health, which regulates public water suppliers under the authority of Article 11, Title 1 of the New York State Public Health Law, has the authority to require the submission of individual public water purveyor drought contingency plans.

New York State and local water purveyors within New York implement restrictions on nonessential water uses, as needed, to respond to drought conditions. The water purveyors implement restrictions on nonessential uses through municipal ordinances, and enforce them through the local police departments. Water rationing is implemented locally by the water purveyors based on individual drought contingency plans.

Currently, Maryland does not have specific legislative mandates covering drought management. The Maryland Department of the Environment, Water Rights Division, is responsible for conducting water supply drought management activities and can implement water restrictions via permit conditions. Coordination with the Maryland Emergency Management Agency is facilitated through the drought response coordinating committee.

DEFINITION OF DROUGHT

There are different definitions of drought, depending on the effects a drought produces. For example, an agricultural drought is when there is not enough water during the growing season. Foresters are concerned about overall dry conditions when wildfires are more likely to get out of control. The hydrologist is concerned with periods when streamflow or ground-water levels fall below statistically defined criteria. Public water supply operators must manage limited water resources during periods when supplies are inadequate to meet system requirements. Resource agencies and others seek to minimize and mitigate damage to aquatic environments and ecosystems resulting from low lake, river, and stream levels. Private interests are concerned when periods of drought disrupt industrial, commercial, and recreational activities. Finally, state and local governments are sensitive to all levels of water supply shortage and the effects on the public, economy, and the environment.

A water supply drought is defined as periods when actual or expected water supplies are insufficient to meet actual or expected demands. The term "expected" is used because, during drought management, action is usually taken in anticipation of shortages. It is for this reason that drought forecasting is important. The more accurate we are in forecasting the severity of a drought, the better and more effective preparations and response activities will be as drought conditions worsen.

Timely and effective response should minimize the potential for severe adverse impacts. The definition of water supply drought is flexible because "supply" and "demand" relate to all natural and man-made processes involving water consumption and use. Specific response actions may be designed to increase available supplies, while others are designed to achieve water conservation goals and reduce demands.

DROUGHT STAGE

To avoid or minimize public confusion, it is important that all agencies making drought declarations have the same nomenclature for each drought stage. The Commission's signatory states have agreed that three stages are appropriate for Susquehanna River Basin drought monitoring, triggering, and declaration. The three stages—from least to most severe—are drought watch, drought warning, and drought emergency. While the states have the lead role in managing droughts, it is important for uniform action to be taken in adjacent areas of the basin across state boundaries, unless the drought area ends at a state line. Therefore, the Commission will define the areal extent of basin drought stages, in conformance with the states. The Commission's primary role during drought events is to coordinate basin drought activities among the signatory parties so that effective response can be achieved. Additionally, the Commission should strive to develop uniform drought management techniques among the member states.

In general, Commission drought resolutions should **support** the drought actions taken by the member states; however, the Commission will retain the prerogative to make a declaration, including an emergency declaration. Any Commission declaration should be areally consistent with signatory state declarations, and state priorities for declarations and response actions should take precedence. Commission drought declarations should be made only after an agreement with the signatory states and concurrently with the declarations of the signatory states.

Drought Watch

This action is intended to give advanced notice of a developing drought event. At this stage, the general public can prepare, and public water purveyors and industries can update and begin to implement individual drought contingency plans. Public water purveyors should urge customers to voluntarily

reduce water usage by 5 to 10 percent, and they should monitor existing supplies so that they are stretched to cover an extended drought.

Drought Warning

This stage is a notice of impending and imminent severe drought conditions. A warning declaration includes a stepped-up public awareness program calling for increased voluntary conservation to achieve an overall 10 to 15 percent reduction in water demands, a request for public water purveyors and industries to continue to implement local drought contingency plans, and a notice for federal, state, and local water resources agencies to prepare for emergency response measures.

Drought Emergency

Drought emergency is the most severe stage. Under a drought emergency declaration, the Commission may, if warranted, implement mandatory restrictions on nonessential water uses through signatory enforcement agencies. The Appendix lists water uses that are nonessential and subject to mandatory restrictions within a Susquehanna River Basin drought emergency area. The objective of the restrictions on nonessential water uses is to achieve a 15 to 25 percent reduction in overall water demands, most of which are consumptive water uses. All available water resources and emergency equipment should be used to respond to actual emergency conditions, avoid depleting water sources, protect the public health and safety, and support essential and high priority uses. The Commission will coordinate operations of the available water storage in federal, state, and key local reservoir projects within the basin. It also may be necessary for the Commission to modify or temporarily suspend water withdrawal and consumptive water use approvals.

It is important to note the Commission and the Commission's member states are not required to issue drought declarations in consecutive order of severity. Whether a drought is emerging or ending, it may be appropriate, based on rapidly changing conditions, to skip over one drought stage. For example, it may be appropriate to go directly from normal conditions to a drought warning, or to relax a drought emergency to a drought watch level, although it is generally better not to lift conservation measures until all of the water resources have recovered to normal levels in an area. These drought actions should be carefully explained to the media, general public, and water purveyors so that there is no misunderstanding as to the intent of or response activities requested by the Commission and the member states.

DROUGHT MONITORING PARAMETERS AND TRIGGER LEVELS

The Commission uses four hydrometerological parameters for monitoring drought conditions: precipitation deficit; ground-water level; streamflow; and Palmer Drought Severity Index. Each parameter is compared against critical threshold values to indicate a normal condition, a drought watch, a drought warning, or a drought emergency. In addition, the Commission uses two other parameters to monitor drought conditions: storage levels of key water supply reservoirs in the basin and reported public water supply problems. The Commission's six drought monitoring parameters are generally consistent with those used by the Commission's signatory states; however, weighting and trigger levels of the parameters may vary between the states.

Drought parameters may be assessed regionally, based on the drought monitoring regions of the signatory states or by county, as shown in Figure 1. Regional or county monitoring assessments are useful in tracking droughts by area, since drought conditions often do not affect the entire basin at equal levels of severity.

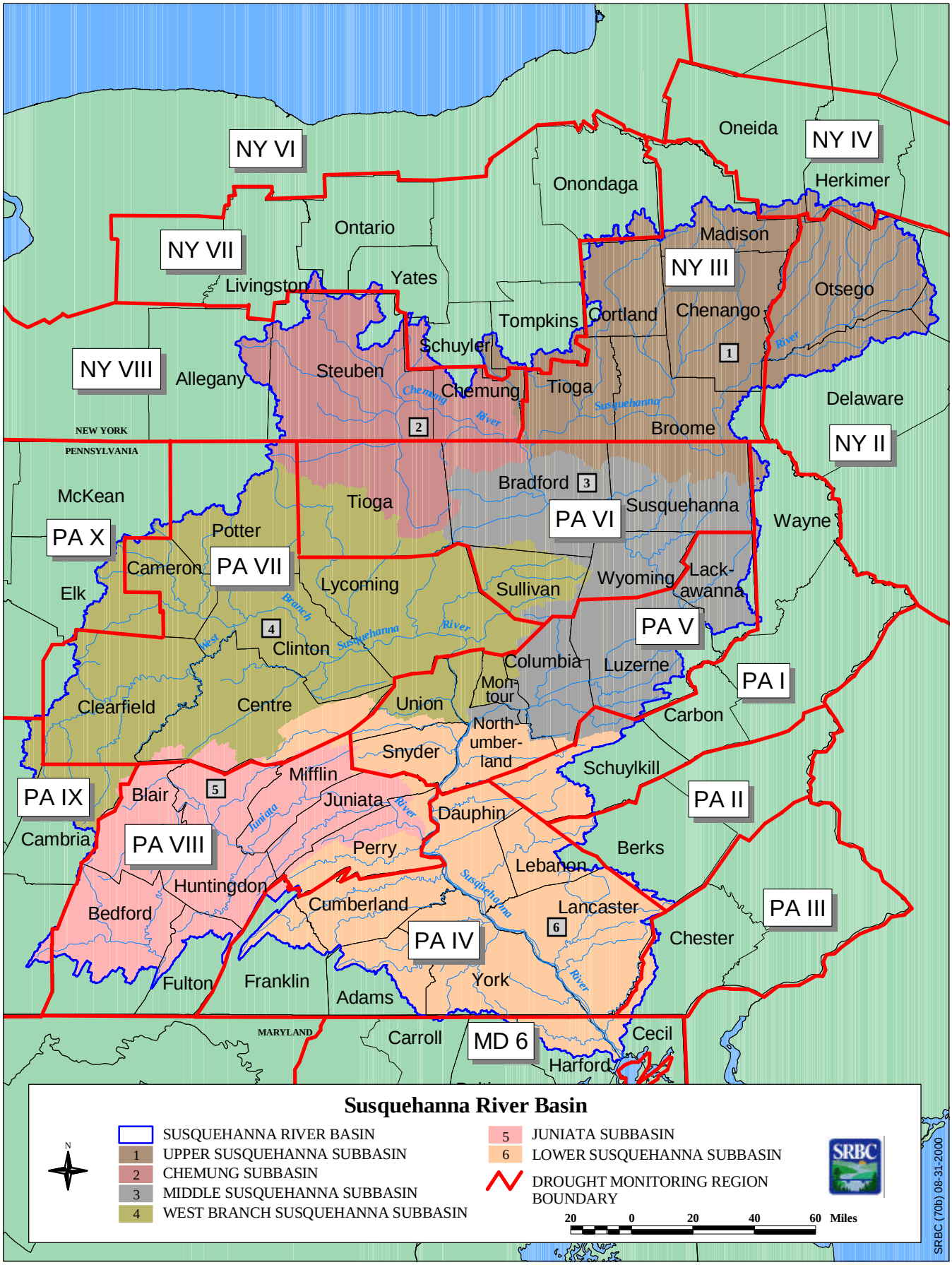

Figure 1. Drought Monitoring Regions

Precipitation Deficits

Weighted average precipitation deficits, as a percent of normal precipitation, are computed for each county on a daily basis by the Mid-Atlantic River Forecast Center. Precipitation deficits can be accumulated weekly, monthly, or on an as needed basis. Drought trigger conditions are listed in Table 1. For example, for a 3-month duration, a 45 percent precipitation deficiency indicates emergency, whereas, for a 12-month duration, a 35 percent deficiency will indicate an emergency.

Table 1. Precipitation Deficit Drought Indicators

Duration of Deficit Accumulation (months)	Drought Watch (deficit as % of normal precipitation)	Drought Warning (deficit as % of normal precipitation)	Drought Emergency (deficit as % of normal precipitation)
3	25.0	35.0	45.0
4	20.0	30.0	40.0
5	20.0	30.0	40.0
6	20.0	30.0	40.0
7	18.5	28.5	38.5
8	17.5	27.5	37.5
9	16.5	26.5	36.5
10	15.0	25.0	35.0
11	15.0	25.0	35.0
12	15.0	25.0	35.0

In applying Table 1, flexibility should be exercised in determining the number of consecutive months used to indicate a drought event. For example, even though a 3-month duration precipitation deficit may indicate a drought warning for a few counties, it may be more appropriate to use a 6-month duration, indicating a drought watch, if the areal extent of drought watch covers a subbasin. Time of year also may be a reason for looking at longer duration precipitation deficits. The other parameters will be helpful in determining the appropriate drought stage. The Drought Coordinating Committee, in consultation with Commission staff, should determine what month a specific drought event began and the appropriate duration for precipitation deficit indicator evaluation.

Ground-Water Levels

Ground-water levels for drought monitoring are measured at 34 county observation wells maintained by the U.S. Geological Survey (USGS) throughout, and adjacent to, the Susquehanna River Basin. These observation wells are listed in Table 2, and their locations are shown in Figure 2. Monthly averages of the depth to water in each well are compared to the historical monthly averages to determine the monthly percent exceedence used for drought monitoring.

A percent exceedence level is defined as the percentage of occurrences where a given indicator meets or exceeds a given value over its historical record. The exceedence levels represent the scaling of historical data between 0 and 100, where the 0 percent exceedence level represents the maximum value, and the 100 percent exceedence level represents the minimum value. The median of the historical record is equaled or exceeded 50 percent of the time.

A 75 percent or greater exceedence indicates a drought watch. A 90 percent or greater exceedence indicates a drought warning, and a 95 percent or greater exceedence indicates a drought emergency for each well. A 100 percent exceedence indicates the worst event on record for that month and well.

Table 2. Drought Monitoring Observation Well Network

Figure 2 Number	Drought Monitoring Region	County	Well Number	Year Record Began	Depth (feet)	Aquifer Description
1	NY II	Otsego	OG-23	1953	15	till
2	NY III	Broome	BM-121*	1947	53	sand
3	NY III	Chenango	CN-12 *	1975	13	gravel
4	NY III	Cortland	C-102 *	1975	45	gravel
5	NY III	Madison	M-178*	1974	16	gravel
6	NY VIII	Chemung	CM-46 *	1955	34	sand and gravel
7	NY VIII	Steuben	SB-472 *	1965	17	gravel
8	PA VI	Bradford	BR-92 *	1966	117	shale
9	PA VI	Sullivan	SU-34 **	1965	50	shale
10	PA VI	Susquehanna	SQ-61 **	1972	175	sandstone
11	PA VI	Tioga	TI-100 *	1972	23	sand and gravel
12	PA V	Luzerne	LU-294 *	1994 (correlated)	167	shale
13	PA V***	Schuylkill	SC-296**	1975	242	shale
14	PA V	Snyder	SN-130*	1968	100	shale
15	PA V	Union	UN-51 **	1967	115	shale
16	PA VII	Cameron	CM-13 **	1967	102	sandstone
17	PA VII	Clinton	CN-1 **	1950	78	sandstone
18	PA VII ***	Elk	EK-108*	1974	340	sandstone
19	PA VII	Lycoming	LY-112 **	1967	200	shale
20	PA VII	Potter	PO-72 **	1967	110	shale
21	PA VIII	Bedford	BD-150*	1965	150	shale
22	PA VIII	Blair	BA-74 *	1969	150	shale
23	PA VIII	Huntingdon	HU-301 **	1969	105	sandstone
24	PA VIII	Juniata	JU-351*	1968	110	shale
25	PA VIII	Mifflin	MF-344*	1983	200	dolomite
26	PA IV	Adams	AD-146 **	1968	100	shale and sandstone
27	PA IV	Cumberland	CU-2 *	1951	37	metarhyolite
28	PA IV	Dauphin	DA-350 **	1964	225	shale
29	PA IV	Lancaster	LN-514 *	1964	260	shale and limestone
30	PA IV	Lebanon	LB-372**	1973	80	dolomite
31	MD 6	Baltimore	BA Ce-21	1955	350	schist
32	MD 6	Carroll	CL Bf-1	1946	407	schist
33	MD 6	Harford	HA Bd-31	1954	26	gabbro
34	MD 6	Harford	HA Ca-23	1974	200	schist

* Automatic Data Recorder

** Data Collection Platform & Automatic Data Recorder

***Although this observation well is located in an adjacent region, the data is utilized for the drought monitoring region noted on Table 2.

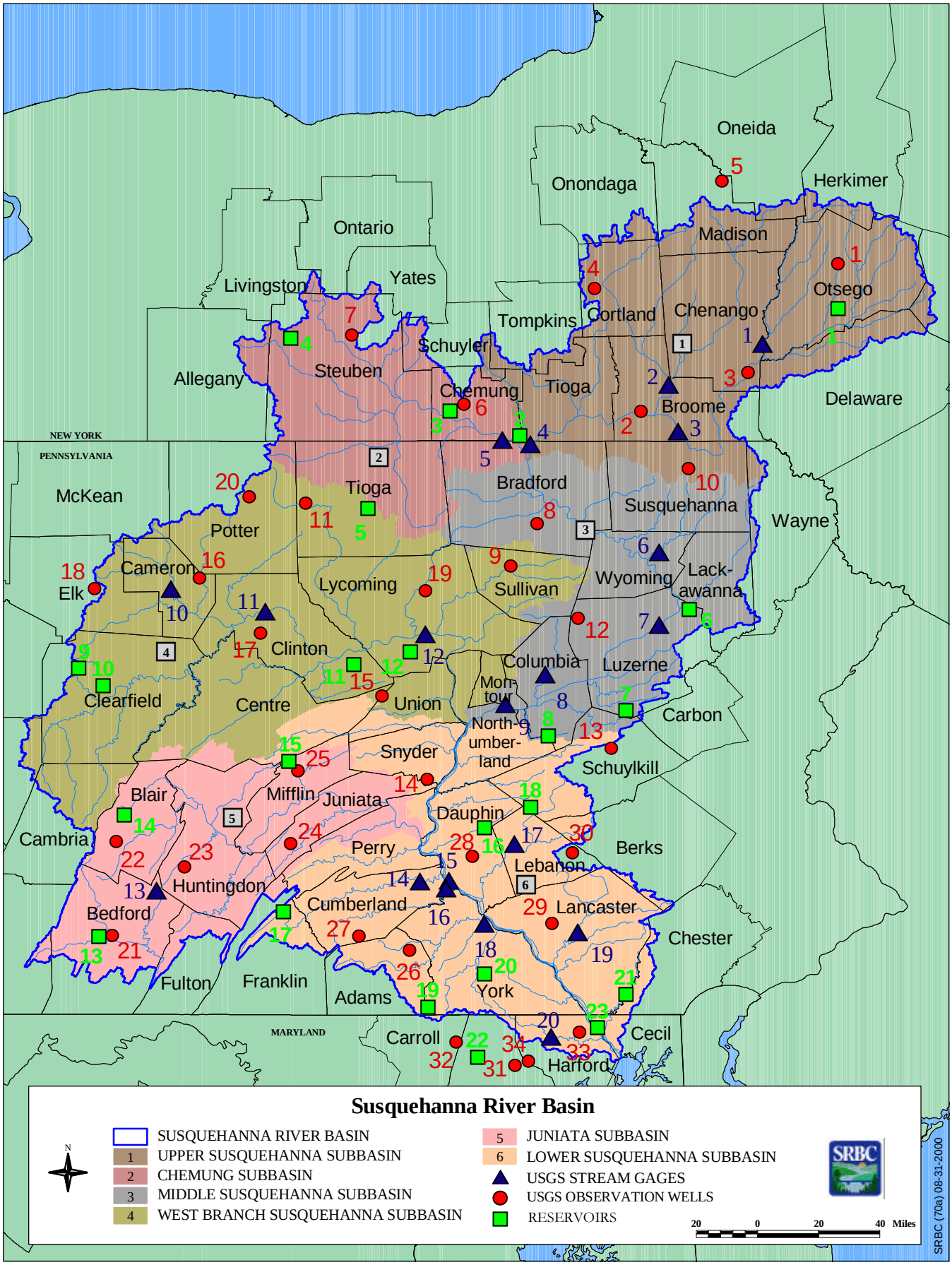

Figure 2. Drought Monitoring Stream Gages, Observation Wells, and Reservoirs

The Maryland wells shown in Table 2 and Figure 2 are read only one day per month, and have no daily recorders. Still, monthly percent exceedence curves were developed using the daily values. Although these readings are not monthly averages, because of the time interval of the reading, the exceedence curves are sufficiently compatible to use for drought operations. Current readings of depth-to-water are provided by the Maryland Department of the Environment for drought monitoring.

Three of the Maryland wells are located in the Gunpowder River Basin in close proximity to the Susquehanna basin. They have been included in the Susquehanna River Basin's drought monitoring network, because of their location, historically reliable drought monitoring performance, and their geologic characteristics typical of this portion of the basin.

In addition, three Pennsylvania observation wells, two located in the Delaware River Basin and one located in the Allegheny River Basin, are in close proximity to the Susquehanna basin and are included in the network. These observation wells also have historically reliable drought monitoring performance, and have geologic characteristics typical of adjacent areas of the Susquehanna basin. The Schuylkill County well (SC-296) is used with drought monitoring region PA V, the Lebanon County well (LB-372) is used with region PA IV and the Elk County well (EK-108) is used with region PA VII. Based on the same criteria, the Madison County observation well (M-178), located in New York's Oneida River Basin, is included in the network.

In Table 2, wells are organized by drought monitoring region, and regional ground-water conditions are determined by averaging the well exceedences within the region. Since most public water purveyors within the basin derive their supplies from ground-water sources, it is essential that ground-water levels in the majority of observation wells within the drought area return to normal ranges before drought declarations and associated water use restrictions are lifted.

As shown in Table 2, 12 of the 23 Pennsylvania Observation wells have data collection platforms installed on the wells. For these twelve wells, daily and instantaneous ground-water levels are available for drought stage analysis. While the use of average monthly ground-water level percent exceedences are recommended for drought stage triggering, daily percent exceedence determination is helpful in analyzing rapid increases in ground-water levels and aquifer recharge resulting from substantial rainfall events. Currently, daily or instantaneous ground-water levels are compared to the average ground-water percent exceedence levels for that *month* and well. As the technology improves, it is expected that daily ground-water percent exceedence levels will be available from the U.S. Geological Survey. This will facilitate more accurate daily drought stage analyses.

Streamflows

Streamflow measurements from 20 representative USGS stream gages within the basin are recommended for drought monitoring. These gages have long-term, unregulated historic records, and are listed in Table 3. Their locations are shown in Figure 2. Monthly average streamflow in cubic feet per second (cfs) is computed for each stream gage and compared to the historic monthly average streamflows to determine the monthly percent exceedence of the current event.

A 75 percent or greater exceedence indicates a drought watch. A 90 percent or greater exceedence indicates a drought warning, and a 95 percent or greater exceedence indicates a drought emergency. The worst event on record for a given month and stream gage has a 100 percent exceedence. In Table 3, stream gages are organized by drought monitoring regions, and regional monthly streamflow conditions are determined by averaging the streamflow exceedences within a region.

Table 3. Drought Monitoring Stream Gage Network

Figure 2 Number	Drought Monitoring Region	River or Stream Location	Drainage Area (sq. mi.)	Year Record Began
1	NY III	Unadilla River at Rockdale, N.Y.*	520	1929
2	NY III	Chenango River at Chenango Forks, N.Y.	1,483	1912
3	NY III	Susquehanna River at Conklin, N.Y.	2,232	1912
4	NY III	Susquehanna River at Waverly, N.Y.*	4,773	1937
5	NY VIII	Chemung River at Chemung, N.Y.	2,506	1903
6	PA VI	Tunkhannock Creek near Tunkhannock, Pa.	383	1914
7	PA V	Susquehanna River at Wilkes-Barre, Pa.	9,960	1899
8	PA V	Fishing Creek near Bloomsburg, Pa.	274	1938
9	PA V	Susquehanna River at Danville, Pa.	11,220	1899
10	PA VII	Driftwood Branch Sinnemahoning Creek at Sterling Run, Pa.	272	1913
11	PA VII	West Branch Susquehanna River at Renovo, Pa.	2,975	1907
12	PA VII	West Branch Susquehanna River at Williamsport, Pa.	5,682	1895
13	PA VIII	Raystown Branch Juniata River at Saxton, Pa.	756	1911
14	PA IV	Conodoguinet Creek near Hogestown, Pa.	470	1911
15	PA IV	Susquehanna River at Harrisburg, Pa.	24,100	1890
16	PA IV	Yellow Breeches Creek near Camp Hill, Pa.	216	1909-1919, 1954
17	PA IV	Swatara Creek at Harpers Tavern, Pa.	337	1919
18	PA IV	West Conewago Creek near Manchester, Pa.	510	1928
19	PA IV	Conestoga River at Lancaster, Pa.	324	1928
20	MD 6	Deer Creek at Rocks, Md.**	94.4	1926

* Updated rating curve required to restore stream gage to full service.
****** Need data collection platform.

During periods when streams and rivers are experiencing extended base flow conditions, daily streamflows may be used for streamflow drought stage analysis to supplement monthly streamflow percent exceedences. In this case, daily streamflows are compared to the daily percent exceedence values available from the USGS. Daily streamflow percent exceedence has the advantage of being available for drought monitoring on any given day without waiting until monthly averages are available. Thus, when drought conditions are rapidly emerging during prolonged base flow periods, the magnitude of drought impacts may be monitored on a daily or weekly basis. In addition, streamflow levels during base flow periods are a surrogate monitoring parameter for ground-water levels that can be used to interpret ground-water conditions where county observation well data are not available.

Palmer Drought Severity Index

Developed in 1965, the Palmer Drought Severity Index (PDSI) is the most widely used and well known of the mathematical drought indexes. Others include the Palmer Hydrologic Drought Index and Keetch-Byram Drought Index. The PDSI is based on both meteorological and hydrologic data to measure the departure of soil moisture supply and overall water availability. It is particularly effective for monitoring agricultural droughts, but also has been useful for monitoring water supply droughts, because the magnitude, duration, and area of the drought can be assessed.

The PDSI is compiled weekly by the Climate Prediction Center of the U.S. National Weather Service (NWS) for the agency's climatological regions. Where the NWS climatological regions do not exactly coincide with the drought monitoring regions of the Commission's signatory states, they can be adapted to the drought monitoring regions by averaging Palmer values. Table 4 presents the PDSI trigger levels.

Table 4. Palmer Drought Severity Index

Drought Level	Index Trigger Levels
Drought Watch	-2.00 to –2.99
Drought Warning	-3.00 to –3.99
Drought Emergency	-4.00 and greater

Reservoirs

The Commission's signatory states monitor reservoir storage levels in key public water supply reservoirs across, and contiguous to, the Susquehanna River Basin, as listed in Table 5 and shown in Figure 2. This information also is useful in determining drought condition status, but must be used with care. There has to be sufficient demand on the reservoir, so that it draws down and is a good indicator of drought conditions.

The New York State Department of Environmental Conservation monitors four public water supply reservoirs in the Susquehanna River Basin on a monthly basis. While storage rule curves have not been developed for these systems, current storage conditions are available.

The Pennsylvania Department of Environmental Protection monitors 17 public water suppliers that have reservoir storage within the basin. While the Maryland Department of the Environment does not have public water supply reservoirs within the Susquehanna River Basin, the monitoring of Baltimore's water supply reservoirs in Baltimore County (Loch Raven and Prettyboy) and Carroll County (Liberty) and reservoir levels in the Conowingo pool and Muddy Run Reservoir are important to the Commission's drought monitoring program.

For the larger public water supply reservoirs, rule curves, based on water storage remaining and time of year, should be available. The rule curves are used to trigger both supply-side and demand-side drought response actions within the water purveyor's system. Therefore, storage levels in key water purveyor reservoirs are critical in assessing both the magnitude and duration of a drought event. In coming out of a drought, it is essential that storage levels within the key public water supply reservoirs return to normal ranges before drought declarations and associated water use restrictions are lifted.

Public Water Supply Problems

With the assistance of the Commission's signatory states, public water supply problems are monitored during drought events. Each member state, in consultation with Commission staff, should maintain lists of those public water purveyors implementing their individual system drought contingency plans and placing drought-related voluntary or mandatory restrictions on their customers. The lists should be updated, as needed, throughout a drought event. Commission staff, in cooperation with the states, also should assist any public water systems within the basin requiring the implementation of local water rationing or needing to develop an emergency supply.

Determination of Regional and Basinwide Drought Stages

An important factor in determining regional and basinwide drought stages is knowing how to incorporate different types of information into one indicator. For example, ground-water data are available for some counties and not others, and streamflow information and Palmer indexes are not county specific. As such, it is necessary to use techniques to tie the differently based information

Table 5. Key Public Water Supply Drought Monitoring Reservoirs

Figure 2 Number	Drought Monitoring Region	Public Water Purveyor	Reservoir Names	Storage Rule Curve Available
1	NY II	Oneonta City	Wilbur Lake	
2	NY III	Waverly Village	Dry Brook	
3	NY VIII	Elmira Water Board	Hoffman Brook	
4	NY VIII	Hornell City	Upland Reservoirs # 1, 2 and 3	
5	PA VI	Wellsboro Water Department	Hamilton Lake	
6	PA V	PA American–Scranton and Springbrook Divisions	Nesbitt, Maple Lake, Huntsville, Gardners Creek, Mill Creek, Watres, Crystal Lake, Ceasetown, Johnson Pond, Hollister, Curtis, Elmhurst, Lake Scranton, Williams Bridge, Griffin, Summit, Brownell, Carbondale #4, Fall Brook, Crystal Lake (C), Stillwater (USACE)	Yes
7	PA V	Hazleton City Authority	Dreck Creek, Mt. Pleasant, Humboldt	Yes
8	PA V	Consumers Water Co.– Roaring Creek Division	Bear Gap 1, 2, 6, Trout Run 4, Klines	
9	PA VII	DuBois Water Department	Anderson Creek	
10	PA VII	Clearfield Municipal Water Authority	Montgomery	
11	PA VII	Lock Haven City Authority	Ohl, Keller, Castanea	
12	PA VII	Williamsport Municipal Water Authority	Hagermans Run, Mosquito Creek	Yes
13	PA VIII	Bedford Borough Water Authority	Smith, Todd, Milburn	
14	PA VIII	Altoona City Water Department	Mill Run, Homer Gap, Plane Nine, Tipton Run, Bells Run, Kettle	
15	PA VIII	Lewistown Municipal Authority	Laurel Run	
16	PA IV	Harrisburg City Authority	Dehart	
17	PA IV	Shippensburg Borough Authority	Gunter Valley	Yes
18	PA IV	Lebanon Municipal Water Authority	Highbridge	Yes
19	PA IV	Hanover Municipal Waterworks	Long Arm, Sheppard Meyers	Yes
20	PA IV	York Water Company	Lake Williams, Lake Redman	Yes
21	PA IV	Chester Water Authority	Octoraro Lake	Yes
22	MD 6	City of Baltimore	Prettyboy, Loch Raven, Liberty	
23	MD 6	City of Baltimore and Chester Water Authority	Conowingo, Muddy Run	

together. To determine the regional implications of a drought parameter, individual parameter data may be combined according to the drought monitoring regions of Figure 1 (page 6).

For the purposes of defining a regional parameter, a drought watch stage is given a value of 1, a drought warning stage is given a value of 2, and a drought emergency stage is given a value of 3. Then, county parameter data may be combined regionally by averaging the numerical drought stages scaled from 1 to 3.

County precipitation deficits can be combined regionally, as described above. However, precipitation information is often a strong indicator in defining the counties experiencing different degrees of drought severity, and therefore, county stage may be used in lieu of the regional stage.

Ground-water and streamflow stages on a scale of 1 to 3 for each monitoring site in a region may be similarly averaged to get corresponding regional drought stages. Reservoir storage levels for key water supply reservoirs in a region should be converted to individual water purveyor drought stages, based on reservoir rule curves in the purveyor's drought contingency plan. These drought stages for key reservoirs may then be averaged regionally.

Palmer indexes are regional values that may be scaled as previously noted. The number of public water supply problems within a region is more subjective, but an indication of regional drought stage may be derived from the number of individual water purveyors on the regional list and the severity of water use restrictions imposed on their customers.

Once regional drought stages have been determined for individual drought monitoring parameters, the parameter stages may be combined to obtain one regional drought stage for triggering a drought response. Assuming all parameters have an equal weight, this can be accomplished by again averaging the stages for each parameter based on a scale of 1 to 3. Also, when one or more of the parameters indicate a specific drought condition, that condition may be considered.

When going into a drought, the best indicators for early warning of an impending drought are precipitation deficits, Palmer indexes, and the water purveyor status lists. Therefore, they should be given added consideration at the beginning of drought events.

Conversely, when coming out of a drought event with water supply conditions improving, ground-water and reservoir levels are the key indicators used to determine when a drought has truly ended. These two parameters are important because each has water storage associated with them. Water storage levels, both in ground-water aquifers and in reservoirs, are the last parameters to recover, due to the added time required to fill the storage available in the aquifers and reservoirs. Thus, drought declarations should not be lifted regionally, or basinwide, until the majority of ground-water observation wells and key reservoir levels are back within normal ranges for a time, perhaps several weeks. Time of year also is an important consideration in lifting declarations.

In monitoring drought parameters, consideration also must be given to the time of year. From December through March, Palmer index values will be inaccurate because frozen ground conditions distort soil moisture readings. During this same period, erroneous stage readings due to ice effects may cause streamflow levels to be reported in error. However, both the USGS and the Mid-Atlantic River Forecast Center have procedures to analyze the data and can provide reasonable estimates of actual streamflow, particularly during drought base flow conditions. Therefore, streamflows, as adjusted, may continue to be used as a primary drought monitoring parameter in winter.

Performance of Drought Triggers

In a 2-year study[1], The Pennsylvania State University tested the effectiveness of the drought triggers recommended in this plan to accurately indicate drought stages. After some minor modifications, the triggers were found to be compatible, and to complement each other in trigger timing and duration. The triggers were thoroughly tested over years of records for accurately indicating the onset and ending of historic droughts, including the droughts in the early 1960s, 1980-81 and 1984-85. In the study, the entire period of record from 1931 through 1985 was modeled for all hydrometerological triggers.

[1] Kibler, D.F., E.L. White, and G.L. Shaffer. 1987. Investigation of the Sensitivity, Reliability, and Consistency of Regional Drought Indicators in Pennsylvania. Environmental Resources Research Institute, The Pennsylvania State University (Report No. ER8705-1)

Recent experience by Commission staff in monitoring the droughts of 1988-89, 1990-91, 1995, 1997, and 1998-99 have confirmed the continued effectiveness of the triggers, as proposed in this plan. The triggers have stood the test of time and have performed well.

DROUGHT DECLARATIONS

As conditions worsen during a drought event, the Commission's Drought Coordinating Committee will continue to evaluate the current drought monitoring data and information. When a specific drought stage is indicated, Commission staff will advise the commissioners of such conditions. Close coordination must be maintained with key personnel in the Commission's signatory states and federal agencies, through the Drought Coordinating Committee, so that a consensus of unified action can be determined and carried out.

The Drought Coordinating Committee will recommend to the commissioners any needed drought stage declarations, including a recommendation of the proposed area to be declared. In addition, the committee's proposal will include advice on the appropriateness of discretionary response actions such as areawide restrictions on nonessential water uses, marshalling reservoirs, and modification of approvals. Ordinarily, restrictions on nonessential water uses are most effective in the months of May through October. Any restrictions on nonessential water uses will be implemented and administered by the Commission's signatory state agencies.

After a recommendation by the Drought Coordinating Committee, Commission staff will prepare a drought resolution for consideration and action by the commissioners. In general, Commission drought resolutions should **support** the drought declarations and actions taken by the member states. However, the Commission will retain the prerogative to make its own declarations, including an emergency declaration.

The commissioners will evaluate, determine, and act on the drought resolution and may include any appropriate response actions based on conditions. A drought emergency declaration by the Commission requires unanimous approval by the commissioners after a public hearing, which is held subsequent to at least a 20-day public notice. Public hearings should be held in areas where the drought is being declared unless the drought is a basinwide event. Any Commission drought declaration should be made concurrently with the declarations of the signatory states. The Commission will issue a press release advising the public of drought actions and requesting that the appropriate response measures be taken.

It is important to note that any drought emergency declaration and associated reductions in water usage required of water users within the basin as a whole, or particularly within the lower basin, must apply to and include any water users diverting water from the basin. Currently, lower basin diversions include the City of Baltimore, the Town of Perryville, the County of Cecil, and the Aberdeen Proving Grounds in Maryland, the Chester Water Authority and Letterkenny Depot in Pennsylvania, and the Artesian Water Company in Delaware. Similarly, the Borough of Berlin in Somerset County and the City of DuBois and Union Township Municipal Authority in Clearfield County, Pennsylvania, divert water from the Juniata River Basin and West Branch Susquehanna River Basin, respectively. In New York State, there currently are no significant diversions of water being made from the basin.

To ensure that both in-basin and out-of-basin water users via diversion share equitably in the hardship of necessary water use reductions during drought emergency, the following policy shall apply:

Whenever water is withdrawn or diverted from the Susquehanna River Basin and transported for use outside the basin, the required drought emergency response, concurrent with in-basin restrictions on nonessential water uses, shall be that the withdrawal or diversion shall be limited to 75 to 85 percent, as may be determined by the Commission, of the total amount of water being withdrawn or diverted prior to the emergency declaration.

In those instances where water was not being withdrawn prior to the emergency declaration or where other reasons cause the reductions to be inappropriate, the water user may make the withdrawal or diversion provided that all users of that water are subject to the same restrictions and limitations imposed on the in-basin water users, including restrictions on nonessential uses of water.

RESPONSE ACTIONS

During drought declarations, the Commission will conduct the following response actions and activities, as appropriate, based on drought stage. Actions taken may depend on time of year and other considerations. The commissioners will make the final determination of discretionary actions to be taken after considering the recommendations of the Drought Coordinating Committee.

Drought Watch

Commission actions and activities are:

1. May declare a drought watch or support a drought watch declared by the member states for a specific area and include any appropriate response actions needed to deal with the conditions at hand. (A Commission declaration is issued by the commissioners via resolution.)

2. Issue public notice of a drought watch declaration calling for voluntary water conservation from individual water users within the Susquehanna River Basin's designated area and users of the basin's water resources via diversions. The public notice should include tips for water conservation appropriate for the time of year and type of user. The goal for voluntary water conservation measures during this stage is a 5 to 10 percent reduction in overall water demand.

   The Commission has various methods for issuing a drought watch public notice, including the Commission web site, press releases for media weather and news staff, briefings, and public service announcements.

3. Initiate a public media program to disseminate drought information and encourage implementation of water conservation measures.

4. Urge public water purveyors and self-supplied industrial water users to develop, review, or update, as necessary, and begin to implement individual drought contingency plans.

5. Monitor and appraise drought parameter data and drought status, as needed, and provide this information to all member state agencies with drought management responsibility via the Commission's e-mail drought distribution list.

6. Hold Drought Coordinating Committee meetings/conference calls, as needed, to assess drought monitoring information and coordinate drought management activities.

Drought Warning

Commission actions and activities are:

1. May declare a drought warning or support a drought warning declared by the member states for a specific area and include any appropriate response actions needed to deal with the conditions at hand. (A Commission declaration is issued by the commissioners via resolution.)

2. Issue public notice of a drought warning declaration calling for increased voluntary water conservation from individual water users within the designated basin drought area and users of the basin's water resources via diversions. The public notice should include tips for water conservation appropriate for the time of year and type of user. The goal for increased voluntary water conservation measures during this drought stage is to achieve an overall 10 to 15 percent reduction in water demands, particularly during peak hours of the day.

3. Continue a public media program to disseminate drought information and encourage implementation of water conservation measures.

4. Urge public water purveyors and self-supplied industries to continue to implement individual drought contingency plans.

5. Continue to monitor and appraise drought parameter data and drought status, as needed, and provide this information to all member state agencies with drought management responsibility via the Commission's e-mail drought distribution list.

6. Conduct Drought Coordinating Committee meetings/conference calls, as needed, to assess drought monitoring information and coordinate drought management activities.

7. Advise the commissioners and key state and federal personnel regarding the changing water resource conditions and imminent severe drought.

Drought Emergency

Commission actions and activities are:

1. May declare a drought emergency or support a drought emergency declared by the member states for a specific area and include any appropriate response actions needed to deal with the conditions at hand. For a Commission drought emergency declaration, the Compact requires a unanimous vote by the commissioners after a duly noticed public hearing. (A Commission declaration is issued by the commissioners via resolution.)

2. Issue public notice of a drought emergency declaration calling for a maximum effort to conserve water by individual water users within the Susquehanna River Basin's designated drought area and users of the basin's water resources via diversions. The public notice should include directions to water users for achieving water conservation requirements appropriate for the time of year and type of user. The goal for water conservation measures during this stage is to achieve a 15 to 25 percent reduction in overall water demand.

3. Conduct an accelerated public media program to disseminate drought information and encourage implementation of all reasonable water conservation measures.

4. Frequently and thoroughly monitor and appraise drought parameter data and drought status, as required, and provide this information to all member state agencies having drought management responsibility via the Commission's e-mail drought distribution list.

5. Require public water purveyors and self-supplied industries to continue to implement individual drought contingency plans. Assist public water purveyors in implementing local water rationing, as necessary.

6. Continue Drought Coordinating Committee meetings/conference calls, as needed, to assess drought monitoring information and coordinate drought management activities.

7. Advise the commissioners and key state and federal personnel regarding the severe drought conditions through frequent status reports.

8. Coordinate operations of the available water storage in federal, state and key local reservoir projects within the basin.

9. May adopt (by Commission resolution) restrictions on nonessential water uses applying to all individual water users in the affected area of the basin. In addition, all users of the basin's water resources via diversion from the affected area shall implement equitable reductions in their diversion, or limitations on water usage as may be approved by the Commission, while the resolution is in effect. (See the policy on page 16.) Resolutions implementing restrictions on nonessential water uses and reductions in diversions will be for a specific period of time and may be renewed, as necessary.

   Restrictions on nonessential water uses will be administered by the Commission's signatory state agencies in cooperation with local police departments and public water purveyors. The Commission, as necessary, will administer reductions in diversions.

10. May modify or temporarily suspend, where necessary, water withdrawal or consumptive water use permits to achieve water conservation goals or to reallocate available supplies. This action may be particularly applicable to diversions and lower priority uses.

11. May resolve conflicts among competing users of the basin's waters, as the need arises.

DROUGHT MANAGEMENT ACTIVITIES OF SIGNATORY STATES

State of New York

The New York State Department of Environmental Conservation (NYSDEC) is the lead agency in New York for the management of a water supply drought. Agricultural droughts are monitored and managed by the Department of Agriculture. New York State is divided into nine drought management regions. The portion of the Susquehanna River Basin in New York is covered primarily by three of the state's drought regions, including regions II, III, and VIII, as shown on Figure 1 (page 6). Small portions of regions IV and VII also are within the Susquehanna River Basin.

The New York State Disaster Preparedness Commission (DPC) was created by the state legislature to manage all types of emergencies within the state. In 1980, Governor Carey established the State Drought Management Task Force (DMTF) to coordinate state drought response and assist local agencies in their drought management activities. The DMTF includes the Departments of Environmental Conservation (lead agency), Health, Transportation, Economic Development, Agriculture and Markets, the Office of Parks, Recreation and Historical Preservation, the Public Service Commission, the Division of Military and Naval Affairs, and the Division of Budget. The DMTF coordinates drought planning and mitigation activities with interstate agencies such as Susquehanna River Basin Commission and Delaware River Basin Commission, U.S. Geological Survey, U.S. Weather Service, New York City Department of Environmental Protection and other agencies to alleviate potential drought impacts. The DMTF is on standby during normal conditions and meets on an as needed basis during drought conditions.

In cooperation with the DMTF, NYSDEC prepared the New York State Drought Plan (1988) in 1982 and updated the plan in 1988. This drought plan includes five stages for drought management: normal, alert, warning, emergency, and disaster. Subsequently, the DMTF has split the state drought region II and has defined the first drought stage as 'watch' instead of 'alert' to ensure consistency in terminology between the state plan and other agency drought plans. The state drought plan is being revised to make it more of an action plan. The DPC manages emergency and disaster stages. The drought disaster stage goes beyond the emergency stage to include provisions for requesting federal disaster assistance.

NYSDEC monitors five parameters to forecast drought. They are the PDSI, average monthly streamflow and ground-water levels, precipitation deficits, and reservoir storage levels. Triggering levels are generally compatible with those used by the other states and those proposed in this plan. The latter four parameters have been weighted by region to derive the state drought index, as presented in the New York State Drought Plan. Currently, the NYSDEC considers the PDSI along with the state drought index, when appropriate, in making regional drought stage determinations. In areas where ground-water information is not available, streamflow data are used and compared with base flow exceedence levels.

In New York, only the governor has the authority to make drought emergency declarations. Declarations are made regionally or for individual counties. Restrictions on nonessential water uses and water rationing are implemented only by individual public water purveyors. For water purveyors over a specified size, water supply emergency plans, which include plans for dealing with drought emergencies, are required by law to be submitted to the N.Y. State Department of Health (NYSDOH). The NYSDOH regulates public water purveyors and is responsible for reviewing all water supply emergency plans. Local water conservation plans are required by NYSDEC as a condition of a water supply permit.

Drought Watch

Under a drought watch, the DMTF monitors and appraises drought status, and meets, as needed. The DMTF coordinates with all agencies involved to alleviate potential drought impacts. Voluntary water conservation is promoted at the local levels. The DMTF recommends to the DPC any funding requirements and state legislation that may be required and establishes priorities for the use of state equipment and technical assistance.

Drought Warning

Drought warning activities include continued monitoring and appraisal of drought status by the DMTF, which meets monthly during this stage. The DPC is alerted to the status of developing drought conditions. A state drought preparedness coordinator is designated by the DMTF. Local agencies are urged to review and update drought contingency plans. Where applicable, public water purveyors are

urged to make provisions for the utilization of emergency sources of supply. The DMTF directs state agency response actions and requests public water purveyors, by letter, to adopt measures to conserve water. At the local level, voluntary water conservation and leakage control efforts are intensified.

Drought Emergency

After a drought emergency is declared, the DMTF and the DPC closely monitor and evaluate drought status and implement activities to alleviate potential drought impacts. State agencies are responsible for providing emergency equipment and technical assistance to local agencies. In addition, state agencies must implement water conservation in state office buildings, and inventory industrial users for emergency supplies that could be made available to public water purveyors.

Drought Disaster

As previously noted, a drought disaster can be implemented in addition to a drought emergency. During this stage, the DPC requests federal disaster assistance. Worst-case options from the state drought plan are implemented under DPC guidance. Locally, further water use restrictions are initiated.

Commission Action Areas

There are 19 New York counties entirely or partially located within the Susquehanna River Basin. Seven of these counties have the majority of their area located within the basin. These seven principal counties include Steuben, Chemung, Tioga, Broome, Cortland, Chenango, and Otsego Counties. Commission drought status resolutions, declarations, or announcements will generally include these seven principal counties.

Commonwealth of Pennsylvania

In Pennsylvania, the Pennsylvania Department of Environmental Protection (Pa. DEP) is the lead agency for monitoring and managing a water supply drought. The Department of Agriculture manages agricultural drought activities. Pennsylvania is divided into ten drought-monitoring regions. The portion of the Susquehanna River Basin in Pennsylvania covers five of the state's regions.

Since Pa. DEP has the flexibility to monitor individual counties, drought triggers need not be restricted to whole regions. Generally, whole counties are assigned to river basins, based on the larger percent area in a given basin. Efforts are made to insure that subregional declarations are made for contiguous groups of counties.

Pa. DEP follows a drought contingency planning concept that establishes a phased response at the onset of drought. Effective response requires the Pa. DEP to have an early detection mechanism that will monitor emerging drought conditions sufficiently early so that appropriate response actions may be implemented.

Pa. DEP uses four drought parameters (precipitation deficit, ground-water levels, streamflow, and PDSI) on a statewide basis for monitoring drought conditions. Each indicator is compared against threshold values to indicate a drought watch, drought warning, or drought emergency. In addition, key water supply reservoirs are a fifth parameter, with triggers based on storage remaining and the time of year. When three out of five parameters indicate a specific drought stage, that stage is considered for declaration. Presently, there is no index for combining drought parameter data. Coming out of a drought, Pa. DEP likes to see all parameter data return to normal ranges before lifting a declaration.

A sixth parameter that is considered in drought triggering is the number of public water purveyors in a county or region that have imposed voluntary or mandatory restrictions on their customers before state action is taken. Regional and district offices of Pa. DEP monitor local water purveyor conditions and forward that information to central office as conditions change.

In Pennsylvania, the Drought and Energy Task Force, chaired by the lieutenant governor and made up of all state agencies involved in drought response, is responsible for implementing drought management activities. This task force is a component element of the Pennsylvania Emergency Management Council. In Pennsylvania, only the governor can declare a drought emergency. Drought watch or drought warning announcements can be made by either the governor, lieutenant governor, or secretary of Pa. DEP.

Under a drought emergency declaration, the restrictions on nonessential water uses, found in 4 Pa. Code Chapter 119, may be implemented, if appropriate, depending on the time of year and local water purveyor status. The nonessential water use restrictions of Chapter 119 generally apply to outdoor uses, including lawn, tree and shrub watering, car washing by individuals, golf course watering, and ornamental fountains. Also, under a drought emergency declaration, individual public water purveyors may implement local water rationing plans with the approval of the Emergency Management Council.

The Commonwealth Drought Coordinator (CDC) is designated by Pa. DEP to coordinate drought management activities. Pa. DEP is responsible for the long term monitoring of hydrologic parameters and reporting this information, including declarations, to local water purveyors.

During a drought event, the CDC convenes drought-monitoring meetings to gather and disseminate drought information. Along with the Pa. DEP press office, the CDC is a primary point of contact for drought-related media, legislative, and general public inquiries.

Under the direction of the CDC, Pa. DEP staff reviews and approves drought contingency plans, reviews local water rationing plans, and processes requests for variances from nonessential water use restrictions. The CDC recommends to the task force, lieutenant governor, and governor the counties to be designated as drought watch, warning, or emergency, and provides an assessment of drought conditions to the Pennsylvania Emergency Management Agency (PEMA) for inclusion in that agency's drought situation report.

PEMA, which is a member of the task force, has the authority to require public water purveyors to update drought contingency plans during a declared drought emergency. In cooperation with the Pennsylvania National Guard, PEMA coordinates the issuing of tank trucks, quick couple pipe, and pumps to municipalities and local water purveyors requiring this type of assistance. Municipalities and purveyors must provide their own transportation for pipe and pumps.

Drought Watch

Under a drought watch, voluntary cutbacks in water consumption by the general public of 5 to 10 percent are requested. A watch announcement is intended to give advanced notice of a developing drought event, so that water suppliers can update drought contingency plans, do necessary hydrant flushing, step up leakage reduction efforts, and conserve existing supplies.

Drought Warning

A drought warning is an alert of impending severe drought, again with a request for voluntary conservation aimed at a 10 to 15 percent cutback in water consumption by the general public. Increased

media involvement and public information updates are associated with a warning announcement. Public water purveyors are urged to follow their individual drought contingency plans.

If additional measures are needed locally, Pa. DEP staff will assist local governments or water purveyors in developing emergency supplies or implementing restrictions on nonessential water uses. Meter testing and system usage monitoring by water purveyors also are encouraged at this stage.

Drought Emergency

Under a governor's drought emergency declaration, a 20 to 25 percent reduction in water usage is sought from the general public within the declaration area. Depending upon the time of year and other factors, the governor's proclamation may include the implementation of areawide restrictions on nonessential water uses, as recommended by the task force. At this stage, PEMA requires the update of local drought contingency plans, and the Emergency Management Council approves local water rationing, as needed.

Commission Action Areas

Along the Susquehanna River Basin's southern, western, and eastern boundaries within Pennsylvania, it is recognized that the disparity between basin and county boundaries may cause some confusion when drought stages are declared within the basin. To reduce this confusion, the Commission will use the following guidelines for determining drought status resolutions, declarations, or announcements in these Pennsylvania border counties:

- On the western boundary, the counties of McKean, Elk, Jefferson, Indiana, Cambria, and Somerset are located predominately outside the Susquehanna River Basin. The Commission will generally exclude these counties from any drought status resolutions, declarations, or announcements.

- On the western boundary, Potter and Clearfield Counties are located predominately within the Susquehanna River Basin. The Commission will generally include these counties in any drought status resolutions, declarations, or announcements.

- On the southern boundary, the counties of Bedford, Fulton, Franklin, and Adams are regionally most closely associated with the Susquehanna River Basin. The Commission will generally include these counties in any drought status resolutions, declarations, or announcements.

- On the eastern boundary, guidelines for shared Pennsylvania counties between the Commission and the DRBC are addressed on page 27 under **Drought Coordination with the Delaware River Basin Commission**.

- In service areas associated with diversions between major basins, the drought status declaration or announcement for the basin of origin of the diversion should apply.

- Commission coordination with Pennsylvania declarations or announcements for the above border counties is essential, and state priorities should take precedence.

State of Maryland

In Maryland, the Maryland Department of the Environment (MDE) is the lead agency for monitoring and managing water supply droughts. Maryland, however, has no official drought coordinator.

It is recommended that Maryland form a technical level drought response coordinating committee with representatives from the MDE, the Maryland Department of Agriculture, and the Maryland Emergency Management Agency. The committee could be informal, and might only meet by telephone. However, the implementation of such a committee, and particularly the assignment of agency drought coordinators, would greatly improve the coordination of drought response activities and provide for an improved exchange of information between agencies.

During the 1999 drought, coordination between agencies did occur at the policy level. However, technical coordinators in each agency need to be identified for ongoing drought preparedness activities.

Maryland has eight drought monitoring regions based on the NWS climatological regions. Region 6 covers the portion of the Susquehanna River Basin drainage in Maryland. Three stages of drought are used; drought watch, warning, and emergency.

MDE monitors five drought parameters: precipitation deficits; streamflow; ground-water levels; Palmer Hydrologic Drought Index (PHDI); and reservoir levels. For streamflow and ground-water levels, trigger criteria follow the same methodology as Pennsylvania; 75, 90, and 95 percent exceedences for watch, warning, and emergency, respectively.

Due to the limited number of suitable streamflow gages, ground water is the more important parameter of the two. Water purveyor reservoirs are monitored by contacting individual purveyors on an as needed basis.

Maryland uses the PHDI, not the PDSI. Monthly trigger levels have been developed for drought watch, warning, and emergency for each of Maryland's regions, based on an examination of the period of record of the index. For Region 6, in January a PHDI of –1.68 triggers a drought watch, while a PHDI of –3.5 triggers a drought emergency.

Rainfall deficit triggers also were developed for each month and region by an examination of the period of record. As with streamflow and ground-water levels, the 75, 90, and 95 percent exceedences were used for watch, warning, and emergency, respectively. Precipitation deficit triggers for durations of three, six, nine, and twelve months were developed. For the longer durations, the precipitation deficit trigger is considered under the last month of the group of months comprising the duration.

Currently, MDE has no procedure for weighting drought parameter data. Best judgement is used for assessing the drought information gathered. Coming out of a drought event, specific criteria have not been established for relaxing a declaration.

The State of Maryland is reexamining its drought management activities. On January 7, 2000, Governor Parris Glendening established two advisory committees by Executive Order to assist the state in developing and implementing long-term water conservation policies and programs. The committees are the Statewide Water Conservation Advisory Committee and the Technical Advisory Committee on Water Supply Infrastructure.

The Statewide Water Conservation Advisory Committee is charged with the following duties:

1. Establish uniform statewide indicators for evaluating drought conditions;

2. Examine current water conservation efforts and the need for regional enhancements;

3. Assess well failures and programs for groundwater conservation;

4. Develop comprehensive public education and outreach programs;

5. Recommend short- and long-term planning solutions for responding to future drought conditions; and

6. Suggest mechanisms to address its findings, if necessary.

The Technical Advisory Committee on Water Supply Infrastructure is charged with the following duties:

1. Study the impact of infrastructure deficiencies on water conservation;

2. Recommend and prioritize infrastructure improvements to minimize water loss;

3. Identify all possible funding sources for infrastructure improvements; and

4. Suggest statutory or regulatory amendments to address its findings, if necessary.

The Advisory Committees will report on a quarterly basis to the Secretary of the MDE.

In response to the governor's charge, the Statewide Water Conservation Advisory Committee has prepared a draft report outlining the committee's recommendations for ongoing, statewide water conservation measures on a year-round basis, regardless of drought status. The report also includes a recommended Drought Monitoring and Response Plan for the State of Maryland.

Currently, declarations for a water supply drought can be made by MDE, but in practice, declarations are made by the governor's office. Declarations can be for a region or for individual counties. Depending on conditions, drought stage declarations may vary by county within a region, but declarations are never made for areas smaller than a county.

There are no state level regulations for implementing restrictions on nonessential water uses; however, individual permits may contain such restrictions. Golf courses must have drought management plans as a condition of their water appropriation permit. Generally, these plans contain phased reductions in irrigating rough, fairways, greens, and tees.

Drought Watch

Under a drought watch declaration, the only action taken is a public notice of caution on the use of water and a request for water conservation.

Drought Warning

In drought warnings, letters are sent to permittees encouraging water conservation and drought preparedness. Presently, public water purveyors are not required to develop individual drought contingency or water conservation plans.

Drought Emergency

In the event of a declared drought emergency, MDE can:

1. Require golf courses and other permittees that were required to develop drought management plans to implement their plans;

2. Suspend or modify individual permits, as needed, to protect other water users. The following uses have priority for appropriation or use of water in the order listed:

   a. Domestic and municipal uses for sanitation, drinking water, and public health and safety;

   b. Agricultural uses, including the processing of agricultural products; and

   c. All other uses.

3. Request that the governor order emergency restrictions on nonessential water uses.

   During the summer of 1999, the governor of Maryland declared a statewide drought emergency and implemented restrictions on nonessential water uses.

Commission Action Areas

Although parts of four Maryland counties are located within the Susquehanna River Basin, the Commission has historically issued drought status resolutions, declarations, or announcements applicable only to Harford and Cecil Counties. The remaining two counties, Baltimore and Carroll, only have small watershed areas draining to the Susquehanna River Basin, and Commission actions for these counties are therefore not appropriate.

DROUGHT MANAGEMENT ACTIVITIES OF THE U.S. ARMY CORPS OF ENGINEERS, BALTIMORE DISTRICT

The USACE has developed drought management plans for its reservoir projects in the Susquehanna River Basin. The plans are intended to be used as guides, so actual management practices by the USACE may differ as changing water supply needs and drought conditions dictate. The plans provide for two phases of drought management activities.

Phase I drought assistance activities may be pursued when precipitation deficits over a given time period are sufficient to warrant "drought watch" conditions, as indicated in the plans. Under this phase, additional water can be stored above normal pool elevations at seven USACE reservoirs if hydrologic conditions allow. Increases are limited to elevations that will have no significant impacts on other project purposes, primarily flood control and recreation. The additional storage that is gained will be utilized later to sustain downstream conservation releases over a longer period of time.

Table 6 provides the maximum increases in reservoir elevations and the associated storage for the seven reservoirs that are currently able to provide Phase I assistance. Target conservation releases also are provided. Curwensville, Tioga-Hammond, and Almond Lakes are unable to provide Phase I assistance due to significant impacts to in-lake recreation. However, recent modifications to the recreational facilities at Curwensville Lake may allow for some storage of water above the normal pool elevation in the future. Aylesworth Lake's outlet facilities will not permit any additional water to be stored.

Table 6. Storage Available at U.S. Army Corps of Engineers Reservoirs

Reservoir Name	Phase I Assistance			Phase II Assistance
	Maximum Elevation Increase Above Normal Pool (feet)	Additional Storage Provided (acre-feet)	Target Flow to Be Sustained (cubic feet per second)	Conservation Storage at Normal Pool Elevation (acre-feet)
East Sidney	1.0	200	15	3,350 (summer) 1,700 (winter)
Whitney Point	0.5	630	15	12,500 (summer) 5,000 (winter)
Aylesworth	—	—	—	64
Stillwater	8.0	1,000	10	None Available
Cowanesque	1.0	1,000	25	7,000
Tioga-Hammond	—	—	—	18,350
Almond	—	—	—	1,105
Curwensville	—	—	—	4,180
Bush	1.0	155	25	1,745
Sayers	2.0	3,580	150	28,800 (summer) 6,300 (winter)
Raystown	0.5	4,000	200 (summer) 480 (winter)	514,000

Phase II drought assistance provides for the use of "surplus" conservation storage at a reservoir to be used as an emergency source of municipal and industrial water supply, as authorized under Section 6 of the Flood Control Act of 1944. In this case, "surplus" storage is defined as water that would be more beneficially used as municipal and industrial water supply than the authorized purpose and that, when withdrawn, would not significantly affect authorized purposes over some specific time period. Withdrawals for this purpose will require a reasonable fee for the water provided, even in the case of a declared national disaster area.

Phase II assistance should not be counted on as an alternative for developing additional water supply resources. In addition, storage from USACE reservoirs should not be utilized until all other reasonable, publicly-owned resources have been exhausted. Requests for this type of assistance are expected to be rare, since most water supply requirements are less than available streamflows, even during a severe drought. The last column of Table 6 provides an estimate of the total conservation storage that is available at each USACE reservoir in the Susquehanna River Basin. The preferred procedure to request Phase II assistance is as follows:

1. The utility or consumer contacts the Commission, the state, or local agency to request a purchase of storage for an in-lake withdrawal or downstream release from the USACE reservoir.

2. The Commission, the state, or local agency will agree to act as a broker on behalf of the utility or consumer and contact the Baltimore District Engineer to request the withdrawal or release.

3. The District Engineer will then convene a meeting with representatives from the Commission and the affected signatory states to discuss the request and the required compensation.

4. If the withdrawal or release is recommended, a contract between the broker and the USACE will be drawn up and signed before the withdrawal or release can begin.

5. If a downstream release is requested, a target flow should be determined for a nearby stream gage equipped with real-time satellite telemetry. If in-lake withdrawals are requested, a method for verifying withdrawals must be established.

In Cowanesque and Curwensville Lakes, there are 24,335 acre-feet and 5,360 acre-feet of water supply storage, respectively, that is owned by the Commission. The Commission water supply storage is supplemental to the USACE conservation storage at these projects, shown in Table 6. Additionally, the Commission is considering the purchase of 8,500 acre-feet of existing conservation storage at Whitney Point Lake for environmental restoration.

Some flexibility or deviations in the way a USACE reservoir is operated may be permitted to provide some additional assistance. During previous droughts, scheduled water drawdowns at several reservoirs have been staggered and prolonged to help improve hydrologic conditions over a longer time period. Depending upon the time of year and reservoir conditions, other options also may be possible and will be evaluated on a case-by-case basis. Deviations from the normal water control plan for a reservoir project require approval by higher authority and coordination with applicable resource agencies and other project users.

DROUGHT COORDINATION WITH THE DELAWARE RIVER BASIN COMMISSION

The Delaware River Basin Commission (DRBC) adopted a Schedule of Phased Reductions in Diversions, Releases and Flow Objectives During Drought in 1983, and has implemented it many times. This drought operations plan is in response to a recognition that, during a repeat of the drought of record (1961-1966), there is insufficient basin reservoir storage and flow to meet all the demands established in the U.S. Supreme Court Amended Decree of 1954. The plan provides for staged predetermined cutbacks in diversions, reservoir releases, and flow targets during drought periods.

In addition, the DRBC adopted a plan for the Coordinated Operation of Reservoirs During a Lower Basin Drought Warning and Drought. This plan allows the upper basin storage (New York City reservoirs) to assist in meeting flow targets at Trenton when drought conditions have significantly impacted lower basin storage, but the upper basin storage remains in a normal range. The lower basin plan also provides for staged cutbacks of flows, releases and diversions based on the status of the lower basin reservoirs.

Similar to this Commission's Drought Coordination Plan, both of DRBC's plans provide for voluntary conservation of water during drought warnings and mandatory restrictions during drought emergencies. DRBC's lower basin plan includes a list of nonessential water uses, which are the same items as those listed in Appendix A of this plan.

DRBC's drought operating plans, outlined above, only use reservoir storage levels to determine drought status. However, the plans provide for flexibility and have been temporarily modified to accommodate other hydrologic factors. The DRBC generally relies on state and local plans to monitor local drought conditions and take appropriate actions based on all hydrologic conditions, including Palmer Index/soil moisture, ground-water levels, streamflow, precipitation, storage, and reported problems specific to the area.

In April 1999, the DRBC, as part of an experimental program, modified its operations plan to divide the Drought Warning stage and create a Drought Watch stage. Now the DRBC plan has the same drought stages as the Susquehanna River Basin plan and those generally used in most drought plans, i.e. watch/warning/emergency.

During any drought event, the DRBC and the Commission should continue to cooperate, exchange information, and discuss proposed actions. This is best accomplished through DRBC's Flow Management Committee and the Commission's Drought Coordinating Committee. To facilitate coordination between the commissions during periods of impending or actual drought, the Commission should be represented and participate on the DRBC Flow Management Committee and DRBC should be represented and participate on the Commission's Drought Coordinating Committee. Neither agency will be a voting member on the other agency's committee.

In addition, the Commission, DRBC, and the signatory states recognize that the disparity between basin and county boundaries may cause some public confusion when drought stages are declared in one basin and not the other. In order to reduce this confusion, the commissions will coordinate their drought activities for shared counties to the maximum extent practicable. This Commission will use the following guidelines for determining drought status resolutions, declarations, or announcements in the shared counties:

- Chester, Berks, Carbon, and Wayne Counties in Pennsylvania and Delaware County in New York are located predominately outside the Susquehanna River Basin. The Commission will generally exclude these counties from any drought status resolutions, declarations, or announcements.

- Significant areas of Lancaster, Lebanon, Luzerne, Lackawanna and Schuylkill Counties in Pennsylvania and Broome County in New York are located within the Susquehanna River Basin. The Commission will generally include these counties in drought status resolutions, declarations, or announcements.

- In service areas associated with diversions between major basins, the drought status resolutions, declarations, or announcement for the basin of origin of the diversion should apply.

- Commission coordination with signatory state declarations or announcements for the above shared counties is essential, and state priorities should take precedence.

APPENDIX

NONESSENTIAL WATER USES IN A SUSQUEHANNA RIVER BASIN DROUGHT EMERGENCY AREA

The following water uses are deemed nonessential and are subject to restrictions within a Susquehanna River Basin drought emergency area, if unanimously resolved by the commissioners.

1. Serving water to patrons at any restaurant, club, or other eating establishment, unless specifically requested by the patrons.

2. Using water for ornamental purposes, including fountains, artificial waterfalls, and reflecting pools. Ponds used to sustain fish and aquatic life are exempt.

3. Washing paved surfaces such as streets, sidewalks, outdoor plazas, driveways, garage floors, parking areas, and patios, except as necessary for public health and safety.

4. Noncommercial washing or cleaning of vehicles, except as necessary for public health and safety.

5. Watering established grass. Newly seeded or sodded lawns are exempt.

6. Irrigation of golf courses.

7. Watering noncommercial outdoor gardens, landscaped areas, trees, shrubs and other outdoor plants.