Chapter 4 Water Requirements

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NJ652.04 Water Requirements

(a) Crop Evapotranspiration, ETc

Plants must have a continuous supply of readily available moisture in order to maintain rapid, vigorous growth. The moisture used by plants plus the moisture evaporated directly from the field surface is called consumptive use, or evapotranspiration. The amount of moisture consumptively used in an irrigated field on any given day is related to the air temperature, the number of daylight hours, the crop, and the stage of growth of the crop. Other factors, such as wind speed, solar radiation, and relative humidity, also affect consumptive use rates. All crops have relatively low consumptive use rates when they are young. Their highest rates usually occur as they approach the stage of maximum vegetative development. For comparable stages of crop growth, consumptive use rates are greater on long, hot summer days than on short, cool spring or fall days.

Seasonal Consumptive Use
In New Jersey Seasonal Consumptive Use tables were developed using the Natural Resources Conservation Service Technical Release 21 and Software Program Irrigation Water Requirements, (modified Blaney Criddle method). This was calculated for each zone in New Jersey, (North, Central, and South), based on averaging crop water requirements developed from each station in each zone. Refer to Tables NJ 4.1, Net Irrigation Water Requirements, North, Central and South Jersey. Also the South Jersey RC&D Weather Station Network in southern and central NJ is available for use. This internet based system offers an on line irrigation scheduling program and calculates daily and monthly ET rates using the Penman-Monteith method and real time weather data.

Peak-Period Consumptive Use
The average daily water-use rate during the 6 to 10 days of the highest consumptive use of the season is called the peak-period use rate and is the design rate to be used in planning an irrigation system. The peak-use period generally occurs when the crop is starting to produce its harvest, vegetation is most abundant, and temperatures are high. In New Jersey, the following can be used for planning and design: Peak ETc crop tables developed for each New Jersey Zone using the NRCS Irrigation Water Requirement program (Refer to Tables NJ 4.2, Crop Consumptive Use and Peak ET); 0.2 inch per day for estimated average peak ET; or the South Jersey RC&D Weather Station Network for real time ET data and irrigation scheduling.

The peak-use period for various crops in a given area may occur at different times in the growing season. Early-maturing crops have their peak-use period in late spring or early summer and late-maturing crops, in late summer or early fall. Knowing when these peaks occur is important in working out a cropping plan in which the peak-use periods are staggered, thus reducing the total capacity requirement of the irrigation system. Refer to Table NJ 4.2, for peak water use month and Table NJ 4.3 Crop Coefficients for Growing Season. Crop coefficients (Kc) are highest at peak growth period and are used to calculate crop consumptive use (ETc), and net irrigation water requirements. ET x Kc = ETc

Crop Planting and Harvest Dates
Crop planting and harvest dates were determined by using information obtained by local growers, Rutgers and Penn State Cooperative Extension Production Guides. Refer to Table NJ 4.3.

Climate Data

The 1961 – 1990 NOAA Climatological Summary was used with NRCS TR 21 and NRCS Irrigation Water Requirements Software Program for calculating Effective Rainfall, Crop ET Rates and Net Irrigation Water Requirement data. Effective rainfall is the amount of precipitation that infiltrates into the root zone and is used by the plant. This was calculated using both the Normal Year (50% Chance) and Dry Year (80% Chance). The 80 percent chance rainfall, that which can be expected to be equaled or exceeded in 8 out of 10 years is normally used to determine crop irrigation requirements. Irrigation based on 80 percent chance rainfall is safer, and there is less risk of drought for the crop than if based on average years.

Climate includes several factors that affect the consumptive water requirements of crops. Therefore, three zones were established in NJ, for use in this guide, (North, South, and Central), Refer to Figure NJ 4.1, Irrigation Zones in New Jersey.

(b) Net Irrigation Water Requirements

The net irrigation water requirement is defined as the water required by irrigation to satisfy crop evapotranspiration and auxiliary water needs (leaching, temperature modification, crop quality), that are not provided by water stored in the soil profile or precipitation. The data furnished included rainfall records for each zone, (North, South, and Central) during a 30 year period, and "carryover" moisture accumulation in the soil profile during the non-growing season. Soil moisture "carryover" was estimated to be 1" for all zones. For crops grown on heavier texture soil the "carryover" can be increased to 2". However the tables are created using a 1" moisture accumulation. Refer to Table NJ 4.1 for Net Irrigation Water Requirements.

Irrigation systems must be sized to meet peak period consumptive use. Peak daily evapotranspiration rates are used for a 22 hour irrigation period for planning and designing irrigation system flow rates. The system efficiency must also be factored in for gross irrigation water requirements. For potential application efficiencies for various irrigation systems and management practices, refer to Table NJ 4.4, Suggested Before (Eb) and After (Ea) System Efficiencies.

To calculate minimum pumping capacity required, use the following formula:

$$Q = \frac{453 \text{ X } DA}{T}$$

Where: Q = flow rate, gpm
T = time, hours
D = depth, inches (gross crop ET)
A = area, acres

These values are used when planning an irrigation water source. The minimum design capacity must meet the peak-period consumptive use requirements. If the water source has insufficient capacity, a reservoir may be needed to store the peak-period consumptive use requirements. The seasonal or monthly consumptive use values allow the needed storage size to be determined when the pumping rate of the well is known, the recharge rate of a ground water recharge pit is known, the low flow rate of a stream is known, or the annual water-yield of a watershed is known.

TABLE NJ 4.1a
NET IRRIGATION WATER REQUIRMENT (INCHES)
NORTH JERSEY

Crop Name	Dry Year Net Irrigation Requirements	Normal Year Net Irrigation Requirements
Alfalfa Hay	14.06	12.30
Apple, clean cultivated	10.49	8.76
Apples, with cover	16.60	14.81
Asparagus	4.32	3.54
Azalea/shrubs	14.77	13.04
Barley	6.17	5.08
Beans, snap	7.57	6.33
Beets	3.82	3.15
Blueberries	15.50	13.66
Broccoli	5.13	4.17
Cabbage	9.28	8.02
Carrots	9.63	8.41
Cauliflower	4.77	3.82
Celery	11.96	10.36
Collards,Kale, Broccoli Rabe (fall)	3.38	2.67
Collards,Kale, Broccoli Rabe (spring)	4.39	3.75
Corn, Grain	13.20	11.67
Cranberries	15.89	13.96
Cucumbers	8.50	7.32
Dandelion	2.53	1.95
Dry beans	8.35	7.38
Egg plant	7.78	6.50
Endive,Escarole, Lettuces (fall)	0.95	0.42
Endive,Escarole, Lettuces (spring)	2.19	1.67
Fennel	1.16	0.58
Grapes, Mature no cover 25% canopy	2.47	1.30
Grapes, Mature no cover 50% canopy	8.51	7.07
Grapes,1-2year; cover;10% canopy	0.60	0.00
Grapes,1-2year;no cover;10% canopy	0.34	0.00
Grapes,Mature; cover;25% canopy	5.00	3.68
Grapes,Mature; cover;50% canopy	11.00	9.48

Crop Name	Dry Year Net Irrigation Requirements	Normal Year Net Irrigation Requirements
Grass Hay	13.98	12.17
Green Beans	6.05	5.20
Lima beans	7.77	6.50
Melons	9.64	8.31
Onion/Scallions (early)	1.90	1.41
Onions (late)	7.02	6.08
Pasture (grass)	13.98	12.17
Peaches	14.15	12.29
Pears	14.15	12.29
Peas (early)	2.81	2.26
Peas (late)	2.74	2.18
Peppers	6.45	5.45
Potatoes (fall)	9.96	8.57
Potatoes, (summer)	12.10	10.67
Pumpkins	6.19	5.06
Radish (early spring)	0.23	0.02
Radishes (late spring)	1.00	0.71
Radishes (late summer)	0.98	0.61
Rasberries	14.46	12.73
Sorghum (silage)	8.00	6.58
Soybeans	7.67	6.47
Spinach (early)	1.47	1.01
Spinach (late)	1.63	1.22
Spring Oats	7.10	6.05
Squash (summer)	6.93	5.91
Strawberries	2.40	1.69
Sugar beet	14.00	12.58
Sweet Corn (2nd planting)	6.50	5.71
Sweet Corn (3rd planting)	6.96	6.07
Sweet Corn (early)	5.41	4.60
Sweet Potatoes	10.53	9.13
Tomatoes	11.04	9.67
Watermelons	9.99	8.67
Winter wheat	5.74	4.62

Reference:
NRCS, Irrigation Water Requirements Software Program; NEH Chapter 2, Irrigation Water Requirements.
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TABLE NJ 4.1b
NET IRRIGATION WATER REQUIRMENT (INCHES)
CENTRAL JERSEY

Crop Name	Dry Year Net Irrigation Requirements	Normal Year Net Irrigation Requirements
Alfalfa Hay	16.74	14.96
Apple, clean cultivated	12.87	11.12
Apples, with cover	19.61	17.82
Asparagus	5.60	4.84
Azalea/shrubs	17.63	15.89
Barley	6.94	6.03
Beans, snap	9.20	7.91
Beets	5.08	4.45
Blueberries	18.55	16.71
Broccoli	6.29	5.29
Cabbage	10.89	9.58
Carrots	11.26	10.00
Cauliflower	5.90	4.91
Celery	14.43	12.80
Collards,Kale, Broccoli Rabe (fall)	4.28	3.54
Collards,Kale, Broccoli Rabe (spring)	5.27	4.62
Corn, Grain	15.33	13.73
Cranberries	18.79	16.81
Cucumbers	10.04	8.83
Dandelion	3.60	3.07
Dry beans	9.66	8.67
Egg plant	9.43	8.13
Endive,Escarole, Lettuces (fall)	1.27	0.73
Endive,Escarole, Lettuces (spring)	3.14	2.64
Fennel	1.52	0.89
Grapes, Mature no cover 25% canopy	3.58	2.31
Grapes, Mature no cover 50% canopy	10.33	8.86
Grapes,1-2year; cover;10% canopy	0.80	0.00
Grapes,1-2year; no cover;10% canopy	0.46	0.00
Grapes,Mature; cover;25% canopy	6.45	5.09
Grapes,Mature; cover;50% canopy	13.27	11.74

Crop Name	Dry Year Net Irrigation Requirements	Normal Year Net Irrigation Requirements
Grass Hay	17.09	15.28
Green Beans	7.55	6.73
Lima beans	9.42	8.13
Melons	11.38	10.03
Onion/Scallions (early)	2.52	2.05
Onions (late)	8.24	7.27
Pasture (grass)	17.09	15.28
Peaches	16.90	14.98
Pears	16.90	14.98
Peas (early)	3.88	3.35
Peas (late)	3.54	2.97
Peppers	7.63	6.59
Potatoes (fall)	11.94	10.53
Potatoes, (summer)	14.25	12.81
Pumpkins	7.72	6.56
Radish (early spring)	0.53	0.27
Radishes (late spring)	1.51	1.24
Radishes (late summer)	1.17	0.80
Rasberries	17.35	15.61
Sorghum (silage)	9.89	8.42
Soybeans	9.01	7.77
Spinach (early)	2.12	1.67
Spinach (late)	2.37	1.92
Spring Oats	8.79	7.76
Squash (summer)	8.17	7.11
Strawberries	3.53	2.83
Sugar beet	16.13	14.67
Sweet Corn (2nd planting)	7.60	6.78
Sweet Corn (3rd planting)	8.11	7.20
Sweet Corn (early)	6.82	6.02
Sweet Potatoes	12.21	10.79
Tomatoes	12.98	11.59
Watermelons	11.83	10.48
Winter wheat	8.20	7.17

Reference:
NRCS, Irrigation Water Requirements Software Program; NEH Chapter 2, Irrigation Water Requirements.

TABLE NJ 4.1c
NET IRRIGATION WATER REQUIRMENT (INCHES)
SOUTH JERSEY

Crop Name	Dry Year Net Irrigation Requirements	Normal Year Net Irrigation Requirements
Alfalfa Hay	18.96	17.25
Apple, clean cultivated	14.87	13.16
Apples, with cover	22.00	20.27
Asparagus	5.80	5.01
Azalea/shrubs	19.90	18.24
Barley	7.29	6.38
Beans, snap	10.76	9.56
Beets	5.59	4.96
Blueberries	20.45	18.67
Broccoli	7.44	6.49
Cabbage	12.45	11.21
Carrots	12.89	11.68
Cauliflower	7.30	6.38
Celery	16.55	14.97
Collards,Kale, Broccoli Rabe (fall)	5.28	4.59
Collards,Kale, Broccoli Rabe (spring)	5.87	5.22
Corn, Grain	17.42	15.87
Cranberries	21.07	19.12
Cucumbers	11.58	10.44
Dandelion	4.08	3.56
Dry beans	11.13	10.21
Egg plant	11.13	9.90
Endive,Escarole, Lettuces (fall)	1.96	1.47
Endive,Escarole, Lettuces (spring)	3.54	3.04
Fennel	3.36	2.68
Grapes, Mature no cover 25% canopy	4.87	3.66
Grapes, Mature no cover 50% canopy	12.19	10.81
Grapes,1-2year; cover;10% canopy	1.02	0.32
Grapes,1-2year; no cover;10%canopy	0.61	0.00
Grapes,Mature; cover;25% canopy	7.92	6.62
Grapes,Mature; cover;50% canopy	15.31	13.87

Crop Name	Dry Year Net Irrigation Requirements	Normal Year Net Irrigation Requirements
Grass Hay	19.39	17.67
Green Beans	8.31	7.49
Lima beans	11.12	9.89
Melons	13.12	11.87
Onion/Scallions (early)	2.88	2.40
Onions (late)	9.68	8.78
Pasture (grass)	19.63	17.79
Peaches	19.18	17.31
Pears	19.18	17.31
Peas (early)	4.31	3.78
Peas (late)	4.40	3.87
Peppers	9.74	8.69
Potatoes (fall)	13.84	12.50
Potatoes, (summer)	15.97	14.57
Pumpkins	9.27	8.16
Radish (early spring)	0.66	0.39
Radishes (late spring)	1.73	1.46
Radishes (late summer)	1.69	1.34
Rasberries	19.59	17.93
Sorghum (silage)	11.75	10.34
Soybeans	10.44	9.28
Spinach (early)	2.39	1.92
Spinach (late)	3.12	2.61
Spring Oats	9.86	8.85
Squash (summer)	9.47	8.47
Strawberries	4.01	3.30
Sugar beet	18.23	16.84
Sweet Corn (2nd planting)	8.51	7.72
Sweet Corn (3rd planting)	9.25	8.39
Sweet Corn (early)	7.63	6.85
Sweet Potatoes	13.97	12.64
Tomatoes	14.88	13.55
Watermelons	13.67	12.40
Winter wheat	9.18	8.16

Reference:
NRCS, Irrigation Water Requirements Software Program; NEH Chapter 2, Irrigation Water Requirements.

TABLE NJ 4.2a
CROP CONSUMPTIVE USE AND PEAK ET
NORTH JERSEY

Crop Name	Seasonal Consumptive use (inches)	Month	Peak ET
Alfalfa Hay	26.18	July	0.30
Apple, clean cultivated	22.44	July	0.24
Apples, with cover	28.90	July	0.31
Asparagus	9.73	June	0.17
Azalea/shrubs	26.75	July	0.28
Barley	14.27	June	0.18
Beans, snap	16.44	August	0.23
Beets	9.01	May	0.12
Blueberries	28.14	July	0.29
Broccoli	12.23	August	0.21
Cabbage	18.26	July	0.26
Carrots	18.40	July	0.27
Cauliflower	11.83	August	0.20
Celery	23.10	July	0.27
Collards,Kale, Broccoli Rabe (fall)	8.88	August	0.16
Collards,Kale, Broccoli Rabe (spring)	9.45	June	0.21
Corn, Grain	23.42	August	0.30
Cranberries	29.06	July	0.31
Cucumbers	16.97	July	0.25
Dandelion	6.65	June	0.15
Dry beans	15.45	July	0.26
Egg plant	16.80	August	0.23
Endive,Escarole, Lettuces (fall)	5.02	September	0.10
Endive,Escarole, Lettuces (spring)	6.51	May	0.14
Fennel	5.78	August	0.11
Grapes, Mature no cover 25% canopy	11.24	July	0.12
Grapes, Mature no cover 50% canopy	18.61	July	0.21
Grapes,1-2year; cover;10% canopy	7.13	July	0.07
Grapes,1-2year;no cover;10% canopy	5.56	July	0.06
Grapes,Mature; cover;25% canopy	14.39	July	0.16
Grapes,Mature; cover;50% canopy	21.65	July	0.25

Crop Name	Seasonal Consumptive use (inches)	Month	Peak ET
Grass Hay	26.51	July	0.26
Green Beans	12.36	June	0.25
Lima beans	16.79	August	0.23
Melons	19.00	July	0.29
Onion/Scallions (early)	5.79	May	0.10
Onions (late)	13.97	August	0.23
Pasture (grass)	26.51	July	0.26
Peaches	27.00	July	0.28
Pears	27.00	July	0.28
Peas (early)	7.36	May	0.13
Peas (late)	7.29	September	0.14
Peppers	13.82	July	0.22
Potatoes (fall)	19.76	August	0.26
Potatoes, (summer)	22.14	July	0.29
Pumpkins	14.40	August	0.21
Radish (early spring)	2.27	May	0.10
Radishes (late spring)	3.34	June	0.15
Radishes (late summer)	4.06	September	0.11
Rasberries	26.49	July	0.29
Sorghum (silage)	17.98	August	0.24
Soybeans	15.74	August	0.25
Spinach (early)	4.84	May	0.13
Spinach (late)	5.99	September	0.14
Spring Oats	14.73	June	0.24
Squash (summer)	14.42	July	0.24
Strawberries	7.88	June	0.16
Sugar beet	23.98	July	0.31
Sweet Corn (2nd planting)	12.57	June	0.19
Sweet Corn (3rd planting)	13.58	July	0.28
Sweet Corn (early)	11.63	June	0.23
Sweet Potatoes	19.94	July	0.26
Tomatoes	20.68	July	0.28
Watermelons	19.34	August	0.27
Winter wheat	14.12	June	0.21

Reference:
NRCS, Irrigation Water Requirements Software Program; NEH Chapter 2, Irrigation Water Requirements.

TABLE NJ 4.2b
CROP CONSUMPTIVE USE AND PEAK ET
CENTRAL NEW JERSEY

Crop Name	Seasonal Consumptive use (inches)	Month	Peak ET
Alfalfa Hay	28.55	July	0.31
Apple, clean cultivated	24.55	July	0.25
Apples, with cover	31.55	July	0.33
Asparagus	10.75	June	0.19
Azalea/shrubs	29.15	July	0.30
Barley	13.46	May	0.16
Beans, snap	18.07	August	0.25
Beets	9.90	May	0.13
Blueberries	30.74	July	0.31
Broccoli	13.35	August	0.22
Cabbage	19.77	July	0.28
Carrots	19.93	July	0.29
Cauliflower	12.91	August	0.21
Celery	25.32	July	0.29
Collards,Kale, Broccoli Rabe (fall)	9.78	August	0.17
Collards,Kale, Broccoli Rabe (spring)	10.24	June	0.22
Corn, Grain	25.56	August	0.32
Cranberries	31.81	July	0.33
Cucumbers	18.38	July	0.26
Dandelion	7.31	June	0.16
Dry beans	16.68	July	0.27
Egg plant	18.27	August	0.25
Endive,Escarole, Lettuces (fall)	5.51	September	0.09
Endive,Escarole, Lettuces (spring)	7.18	May	0.15
Fennel	6.31	August	0.11
Grapes, Mature no cover 25% canopy	12.23	July	0.13
Grapes, Mature no cover 50% canopy	20.26	July	0.22
Grapes,1-2year; cover;10% canopy	7.76	July	0.08
Grapes,1-2year; no cover;10% canopy	6.05	July	0.06
Grapes, Mature; cover;25% canopy	15.67	July	0.17
Grapes, Mature; cover;50% canopy	23.57	July	0.26

Crop Name	Seasonal Consumptive use (inches)	Month	Peak ET
Grass Hay	29.02	July	0.27
Green Beans	13.52	June	0.27
Lima beans	18.27	August	0.25
Melons	20.57	July	0.31
Onion/Scallions (early)	6.37	May	0.11
Onions (late)	15.12	August	0.25
Pasture (grass)	29.02	July	0.27
Peaches	29.58	July	0.30
Pears	29.58	July	0.30
Peas (early)	8.10	May	0.15
Peas (late)	8.03	September	0.15
Peppers	14.92	July	0.23
Potatoes (fall)	21.54	August	0.28
Potatoes, (summer)	24.02	July	0.31
Pumpkins	15.77	August	0.23
Radish (early spring)	2.57	May	0.11
Radishes (late spring)	3.65	June	0.16
Radishes (late summer)	4.46	September	0.12
Rasberries	28.91	July	0.31
Sorghum (silage)	19.78	August	0.26
Soybeans	17.13	August	0.27
Spinach (early)	5.39	May	0.14
Spinach (late)	6.67	September	0.15
Spring Oats	16.06	June	0.26
Squash (summer)	15.56	July	0.26
Strawberries	8.71	June	0.17
Sugar beet	26.02	August	0.33
Sweet Corn (2nd planting)	13.55	June	0.21
Sweet Corn (3rd planting)	14.61	July	0.30
Sweet Corn (early)	12.62	June	0.25
Sweet Potatoes	21.50	August	0.28
Tomatoes	22.48	July	0.29
Watermelons	21.00	August	0.30
Winter wheat	15.50	June	0.23

Reference:
NRCS, Irrigation Water Requirements Software Program; NEH Chapter 2, Irrigation Water Requirements.

TABLE NJ 4.2c
CROP CONSUMPTIVE USE AND PEAK ET
SOUTH JERSEY

Crop Name	Seasonal Consumptive use (inches)	Month	Peak ET
Alfalfa Hay	29.88	July	0.33
Apple, clean cultivated	25.71	July	0.26
Apples, with cover	33.00	July	0.35
Asparagus	11.14	June	0.20
Azalea/shrubs	30.45	July	0.32
Barley	13.51	May	0.18
Beans, snap	18.70	August	0.27
Beets	10.23	May	0.13
Blueberries	31.91	July	0.33
Broccoli	14.06	August	0.24
Cabbage	20.61	July	0.29
Carrots	20.84	July	0.31
Cauliflower	13.60	August	0.22
Celery	26.62	July	0.30
Collards,Kale, Broccoli Rabe (fall)	10.34	August	0.18
Collards,Kale, Broccoli Rabe (spring)	10.62	June	0.23
Corn, Grain	26.85	August	0.34
Cranberries	33.28	July	0.35
Cucumbers	19.22	July	0.27
Dandelion	7.59	June	0.17
Dry beans	17.46	July	0.29
Egg plant	19.18	August	0.26
Endive,Escarole, Lettuces (fall)	5.84	September	0.10
Endive,Escarole, Lettuces (spring)	7.42	May	0.16
Fennel	8.32	August	0.12
Grapes, Mature no cover 25% canopy	12.81	July	0.13
Grapes, Mature no cover 50% canopy	21.23	July	0.23
Grapes,1-2year; cover;10% canopy	8.12	July	0.08
Grapes,1-2year; no cover;10% canopy	6.34	July	0.06
Grapes,Mature; cover;25% canopy	16.41	July	0.18
Grapes,Mature; cover;50% canopy	24.68	July	0.28

Crop Name	Seasonal Consumptive use (inches)	Month	Peak ET
Grass Hay	30.35	July	0.29
Green Beans	14.00	June	0.28
Lima beans	19.17	August	0.26
Melons	21.34	July	0.32
Onion/Scallions (early)	6.59	May	0.12
Onions (late)	15.86	August	0.26
Pasture (grass)	31.22	July	0.29
Peaches	30.98	July	0.32
Pears	30.98	July	0.32
Peas (early)	8.37	May	0.15
Peas (late)	8.50	September	0.16
Peppers	16.77	July	0.25
Potatoes (fall)	22.61	August	0.30
Potatoes, (summer)	25.02	July	0.33
Pumpkins	16.71	August	0.24
Radish (early spring)	2.70	May	0.12
Radishes (late spring)	3.77	June	0.17
Radishes (late summer)	4.72	September	0.13
Rasberries	30.20	July	0.33
Sorghum (silage)	20.86	August	0.27
Soybeans	17.83	August	0.28
Spinach (early)	5.61	May	0.14
Spinach (late)	7.08	September	0.16
Spring Oats	16.67	June	0.27
Squash (summer)	16.23	July	0.27
Strawberries	9.04	June	0.18
Sugar beet	27.23	August	0.35
Sweet Corn (2nd planting)	14.08	June	0.22
Sweet Corn (3rd planting)	15.22	July	0.31
Sweet Corn (early)	13.09	June	0.26
Sweet Potatoes	22.44	August	0.30
Tomatoes	23.58	July	0.31
Watermelons	22.03	August	0.31
Winter wheat	16.14	June	0.24

Reference:
NRCS, Irrigation Water Requirements Software Program; NEH Chapter 2, Irrigation Water Requirements.

NEW JERSEY TABLE NJ 4.3
CROP GROWING SEASON AND CROP COEFFICIENT VALUES (Kc)

CROP NAME	GROWING SEASON		% GROWING SEASON Kc FACTORS									
	Begin Growth	End Growth	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
VEGETABLES												
Asparagus	1-Apr	10-Jun	0.25	0.43	0.69	0.95	1.00	1.00	1.00	1.00	0.93	0.25
Azalea	15-May	1-Oct	0.25	0.43	0.69	0.95	1.00	1.00	1.00	1.00	0.93	0.25
Beets	1-Apr	30-Jun	0.25	0.25	0.36	0.57	0.79	1.00	1.00	1.00	0.98	0.90
Broccoli	20-Jun	30-Sep	0.25	0.28	0.44	0.59	0.75	0.90	0.95	0.95	0.94	0.80
Bunch Onion	1-Apr	20-Jun	0.25	0.25	0.28	0.43	0.58	0.74	0.89	0.95	0.95	0.95
Cabbage	1-Apr	30-Aug	0.25	0.28	0.44	0.59	0.75	0.90	0.95	0.95	0.94	0.80
Carrots	1-May	15-Sep	0.25	0.25	0.50	0.75	1.00	1.00	1.00	1.00	0.88	0.70
Cauliflower	20-Jun	30-Sep	0.25	0.28	0.44	0.59	0.75	0.90	0.95	0.95	0.94	0.80
Celery	1-May	30-Oct	0.25	0.40	0.70	1.00	1.00	1.00	1.00	1.00	0.99	0.90
Collards	1-May	30-Aug	0.25	0.25	0.48	0.72	0.95	0.95	0.95	0.95	0.95	0.90
Cucumbers	30-Apr	5-Sep	0.25	0.27	0.51	0.74	0.90	0.90	0.90	0.90	0.83	0.70
Dandelion	1-Mar	15-Jun	0.25	0.25	0.33	0.51	0.70	0.89	0.95	0.95	0.95	0.90
Dry Onion	25-Mar	15-Sep	0.25	0.69	0.95	0.95	0.95	0.95	0.95	0.91	0.83	0.75
Egg Plant	15-May	30-Sep	0.25	0.25	0.43	0.64	0.86	0.95	0.95	0.95	0.89	0.80
Endive	15-May	15-Sep	0.25	0.25	0.33	0.51	0.70	0.89	0.95	0.95	0.95	0.90
Escarole	15-May	15-Sep	0.25	0.25	0.33	0.51	0.70	0.89	0.95	0.95	0.95	0.90
Fennel	15-May	15-Sep	0.25	0.25	0.33	0.51	0.70	0.89	0.95	0.95	0.95	0.90
Lettuce	1-May	5-Sep	0.25	0.25	0.33	0.51	0.70	0.89	0.95	0.95	0.95	0.90
Lima Beans	10-Apr	10-Jul	0.25	0.25	0.41	0.62	0.83	0.95	0.95	0.95	0.94	0.85
Muskmelons	1-May	30-Sep	0.25	0.25	0.53	0.82	1.10	1.10	1.10	1.10	0.95	0.65
Peas	10-Apr	10-Sep	0.25	0.25	0.55	0.84	1.05	1.05	1.05	1.05	1.02	0.95
Peppers	1-May	30-Aug	0.25	0.25	0.48	0.72	0.95	0.95	0.95	0.95	0.90	0.80
Potatoes	30-Mar	1-Oct	0.25	0.25	0.57	0.89	1.05	1.05	1.05	1.05	0.88	0.70
Pumpkins	20-Jun	20-Oct	0.25	0.25	0.47	0.68	0.90	0.90	0.90	0.90	0.80	0.70
Radish	1-Apr	15-May	0.25	0.25	0.43	0.62	0.80	0.80	0.80	0.80	0.79	0.75
Snap Beans	10-May	30-Sep	0.25	0.25	0.41	0.62	0.83	0.95	0.95	0.95	0.94	0.85
Spinach	30-Mar	30-May	0.25	0.25	0.48	0.72	0.95	0.95	0.95	0.95	0.95	0.90
Squash	15-May	1-Sep	0.25	0.25	0.47	0.68	0.90	0.90	0.90	0.90	0.80	0.70
Sweet Corn	1-May	30-Sep	0.25	0.25	0.43	0.66	0.89	1.03	1.03	1.03	1.02	0.95
Sweet Potatoes	15-May	1-Nov	0.25	0.25	0.57	0.89	1.05	1.05	1.05	1.05	0.88	0.70
Tomatoes	1-May	30-Sep	0.25	0.25	0.52	0.78	1.05	1.05	1.05	1.05	0.95	0.85
Watermelons	15-May	30-Sep	0.25	0.25	0.53	0.82	1.10	1.10	1.10	1.10	0.93	0.60
SMALL FRUIT/ORCHARDS												
Apples	10-Apr	30-Oct	0.50	0.75	1.00	1.00	1.00	1.10	1.10	1.10	0.85	0.85
Blueberries	15-Apr	15-Oct	0.46	1.10	1.10	1.10	1.04	0.97	0.87	0.82	0.75	0.67
Cranberries	1-Apr	1-Nov	0.40	0.40	1.05	1.10	1.10	1.10	0.85	0.50	0.40	0.40
Grapes	1-May	30-Oct	0.50	0.50	0.60	0.65	0.75	0.80	0.80	0.75	0.65	0.65
Peaches	1-Apr	30-Oct	0.50	0.70	0.70	0.90	1.00	1.00	1.00	0.95	0.75	0.75
Pears	1-Apr	30-Oct	0.50	0.70	0.70	0.90	1.00	1.00	1.00	0.95	0.75	0.75
Raspberries	15-Apr	15-Oct	0.40	1.05	1.05	1.05	1.05	1.05	.85	0.75	0.50	0.50
Strawberries	30-Aug	20-Feb	0.25	0.40	0.55	0.70	0.70	0.70	0.70	0.70	0.70	0.70
FIELD CROPS/ HAY LAND												
Alfalfa	30-Mar	15-Oct	0.25	0.44	0.72	0.99	1.05	1.05	1.05	1.05	0.98	0.25
Barley	1-Mar	1-Jul	0.25	0.53	0.93	1.05	1.05	1.05	1.05	0.89	0.57	0.25
Corn	10-May	15-Oct	0.25	0.35	0.69	1.03	1.20	1.20	1.20	1.15	0.87	0.60
Oats	1-Apr	31-Jul	0.25	0.53	0.93	1.05	1.05	1.05	1.05	0.89	0.57	0.25
Sorghum	30-May	10-Nov	0.25	0.37	0.65	0.94	1.00	1.00	1.00	0.90	0.70	0.50
Soybeans	30-May	10-Nov	0.25	0.42	0.76	1.00	1.00	1.00	1.00	1.00	0.74	0.45
Wheat	1-Mar	15-Jul	0.25	0.53	0.93	1.05	1.05	1.05	1.05	0.89	0.57	0.25

TABLE NJ 4.4
SUGGESTED BEFORE (Eb) AND AFTER (Ea) SYSTEM EFFICIENCIES

PROPOSED IRRIGATION METHOD	EFFICIENCY BEFORE	EFFICIENCY AFTER	IWM APPLIED
SPRINKLER IRRIGATION (TRAVELING GUN) Replace leaky alum. pipe with buried mainline.	45%	55%	65%
SPRINKLER IRRIGATION (HAND MOVE PORTABLE) Replace leaky alum. pipe with buried mainline	50%	60%	70%
SPRINKLER IRRIGATION (SOLID SET) Replace hand move to solid set ABOVE canopy.	50%	65%	75%
SPRINKLER IRRIGATION (SOLID SET) Replace hand move to solid set BELOW Canopy.	50%	70%	80%
SPRINKLER IRRIGATION (CENTER PIVOT/LINEAR MOVE) Replace leaky alum. Pipeline with buried main, impact nozzles on lateral.	60%	70%	80%
SPRINKLER IRRIGATION (CENTER PIVOT/LINEAR MOVE) Renozzle to LEN and LDN nozzles on drops in canopy, replace leaky alum. Pipe with buried mainline	60%	85%	88%
SPRINKLER IRRIGATION (CENTER PIVOT/LINEAR MOVE) Replace traveling gun to center pivot, and renozzle to LEN and LDN nozzles on drops in canopy.	55%	85%	88%
DRIP/MICRO IRRIGATION Replace traveling gun with drip and replace leaky alum. Pipe with buried main.	45%	85%	90%
DRIP/MICRO IRRIGATION Replace traveling gun with drip, existing buried main.	55%	85%	90%
DRIP/MICRO IRRIGATION Replace hand move to drip and replace leaky alum. Pipe to buried mainline.	50%	85%	90%
DRIP/MICRO IRRIGATION Replace hand move with drip, existing buried mainline.	60%	85%	90%
DRIP/MICRO IRRIGATION Replace solid set to drip/micro.	70%	85%	90%
SUBSURFACE DRIP (SDI) Replace surface drip with buried drip laterals >6" depths.	85%	90%	95%

Reference: Soil Conservation Service, Farm Irrigation Rating Index (FIRI)

(c) Management Allowed Soil-Water Depletion

Management Allowed Depletion (MAD) is generally defined for each local crop. It is a grower's management decision based on yield and product quality objectives whether or not to fine tune generalized MAD values. MAD is the greatest amount of water to be removed by plants before irrigation so that undesirable crop water stress does not occur. The determination of when and how much to apply requires a knowledge of the available water holding capacity (AWC) of the soil, the plant stress level for the specified crop, the peak consumptive use, crop rooting depth, and the critical periods in the growing season when a crop should not be stressed, or may need to be stressed for higher quality fruit (wine grapes). Historically, an allowable depletion of between 30 and 60 percent of the soil Available Water Capacity (AWC) has been used for management purposes. See Chapter 3, Crops, for summary of recommended MAD levels for various crops. Most crops should be irrigated before more than half of the available moisture in the crop root zone has been used. Some crops, however, are thought to do better at higher moisture levels (less moisture deficiency at time of irrigation), while some require higher depletion levels at different growth stages (deficit irrigation in wine grapes). Refer to Chapter 3, Crops, National Irrigation Guide and NJIG, for a summary of recommended MAD levels for various crops. Irrigation must begin so that the entire area to be covered can be irrigated before the available moisture level in the last portion of the field reaches a point to cause unfavorable moisture stress to the crop. This aspect of management is crucial for systems that may need several days to irrigate the entire field area, such as traveling guns and hand move laterals.

Estimated irrigation frequency, in days, is based on the MAD level for the AWC in the total crop root zone and the estimated crop ET.

Irrigation frequency in days can be determined by:

$$\frac{\text{MAD x AWC for crop root zone in inches}}{\text{Daily ETc rate in inches/day}}$$

(d) Auxiliary Water Requirements

In addition to crop evapotranspiration water requirements, irrigation systems can also meet special needs of crops and soils. In New Jersey, sprinkler irrigation is extensively used for frost protection on cranberries, blueberries, orchard and strawberries. Sprinkler systems are also used for crop cooling. Chemicals (fertilizers, pesticides, etc.) are also applied through sprinkler or microirrigation systems. Applications need to be timed and incorporated into the irrigation scheduling program to prevent over-irrigating, leaching, and runoff.

Frost Control

For frost control, the irrigation system must have enough capacity to cover the entire area with a fine mist of water, (application rates 0.1"/hr or less). Irrigation for frost control utilizes the latent heat of fusion released when water changes from the liquid form to ice. The water is applied as a fine spray and the latent heat of fusion is released when the water freezes on the plant surface. The heat thus released maintains ice temperature around 32 degrees F. The ice acts as a buffer against cooling of plant surfaces by radiation or contact with cold air. The principle is valid and the process is effective only so long as the water application and subsequent ice formation continues. Not all of the heat is retained by the ice. Some is lost to cold air in contact with the ice, and some is lost to evaporation and sublimation at the water-ice surface. Each gallon of water at 32 degrees F., changing into ice at 32 degrees F gives off 1,200 BTU's of heat. Properly designed and operated systems can provide protection for certain crops to temperatures as low as 15 degrees F. Reports indicate that celery has been protected to 15F, cranberries to 16F, strawberries to 16F, tomatoes to 26F, blueberries to 24F, peppers to 21F, gladioli to 27F, hydrangea to 20F, and cherries to 23F. The rate of water application for frost protection depends somewhat on the air temperature. As the air temperature lowers, more water must be applied to provide protection. The degree of crop frost protection available and the optimum sprinkling procedures to be used are a function of the crop's resistance to freezing, stage of growth, general weather conditions, and the design and operation of the system. Table NJ 4.5 gives recommended application rates for strawberries. An application rate of 0.10 inch per hour is recommended for frost protection of cranberries in the critical spring and fall periods.

TABLE NJ 4.5 RECOMMENDED APPLICATION RATES FOR STRAWBERRIES

Air Temperature °F.	28	26	24	22
Application Rate (inches/hour)	0.08	0.10	0.125	0.20

TABLE NJ 4.6 GALLONS PER MINUTE NEEDED FOR VARIOU5 APPLICATION RATES FOR EACH ACRE TO BE FROST PROTECTED

Application Rate (inches/hour)	0.08	0.09	0.10	0.11	0.125	0.15	0.20
Gallons per Minute per Acre	39	43	48	53	60	73	97

System Operation - The frost control system should be turned on when air temperature at the plant level reaches 34 degrees F. An alarm system consisting of a thermo-switch set in the field at the plant level and wired to an alarm bell in the house will alarm the operator when to turn the system on.

Sprinkling should continue until the ice has melted loose from the plants. If the water supply is cut off prior to this time, the supply of heat is also cut off, and sublimation will reduce the temperature of the ice surface to the wet bulb temperature if there is sufficient wind. In dry air, the wet bulb temperature may be several degrees below the dry bulb or air temperature, and if the sublimation process continues over a period of time, the temperature of the entire mass of ice and plant will approach the wet bulb temperature. It is, therefore, necessary to continue constant application of water until the wet bulb temperature is above the critical temperature of the plant.

Frost protection with irrigation works best on low-growing crops, such as strawberries, and plants which are not broken by the weight of ice. The weight of the accumulated ice may often damage tall-growing vegetable plants and fruit trees.

Sprinklers - Single-nozzle low-gallonage sprinklers, designed especially for frost protection, are slightly different from regular sprinklers in that they have special bearings and low tension arm springs or speed washers for faster rotation. Sprinklers should rotate 1 to 2 times a minute for adequate frost protection. Operating pressures in the high side of the specified pressure range for the particular sprinkler should be used to obtain both good coverage and finer water droplets desirable for frost protection. Sprinklers spaced in a triangular pattern, rather than a square or rectangular one, provide more uniform coverage. Sprinkler performance charts should be used as a guide for selecting sprinklers. Clean water is also a must, since foreign material in the water can easily clog the small sprinkler orifices.

Crop Cooling

Practical experience and research have proven that increased yields can be expected if crops are cooled by moisture supplied with sprinkler systems when temperatures above 90^0F prevail for extended periods of time. Cooling a crop is accomplished by drifting moist air over the field, which will cause a drop in the temperature and reduce the transpiration rate of the plants. A sufficient number of sprinklers must be operated simultaneously, and water pressure in the system must be sufficient to provide good breakup at the nozzle, if an effective moisture pattern is to be achieved. Plants cannot draw sufficient moisture through their structures to meet transpiration requirements if temperatures are much higher than 90^0F. for a few hours per day for several successive days. This is true even if there is sufficient moisture in the root zone to support normal plant development and growth. If extremely high temperatures continue, a plant will begin to draw moisture from its own produce --blossoms, stems, or fruit -- causing cell breakdown and subsequent fruit dropping.

Sprinkler cooling should be started when the temperature reaches 90^0F and water application continued until it drops back to that level. Several research and testing projects have indicated that the extra water used for crop cooling is offset by a savings in water normally drawn from the soil reservoir during the same period. Even if extra water is used, the results are reflected in higher quality yields. For crop cooling, the entire field must either be covered continuously or by a frequent cycling operation. This practice will reduce field temperatures around the plant as much as 15 degrees during periods of high temperatures.

Fertilizer and Chemical Application

Using irrigation water as the carrier for fertilizers, herbicides, and other chemicals used in crop production is a practice that is increasing in popularity and acceptance. Savings in labor and time, and in many instances a more efficient fertilization program can be achieved through fertigation. Fertilizers can be applied with irrigation water, regardless of the methods used for water distribution. Equipment designed to inject fertilizer solutions into the water system is considered an integral part of practically all microirrigation designs offered on today's market. Likewise, injector pumps and metering devices are frequently considered as a standard component of any newly installed microirrigation and sprinkler system. Field tests and research projects have established that nitrogen mechanically applied before planting is often lost to the plant through leaching by rains or early irrigations that carry the nutrient to depths below the root feeder zone. This possibility shores up the arguments for the concept of "spoon feeding" a growing crop by applying smaller amounts of fertilizer at regular irrigation intervals throughout the season than with one or two applications. These same tests have further established that applying nitrogen with irrigation water is more effective on sandy soils and just as beneficial on fine-textured soils as when using mechanical applicators.

The danger of polluting underground aquifers or surface streams with leached or runoff water laden with nitrates is alleviated if the fertilizer is applied in amounts that can be readily absorbed by the growing crop while the fertilizer is still in the upper part of the root zone. This danger is more likely in coarse textured, sandy soils than in soils having fine textures, but can be of significant concern on any farm.

Nitrogen fertilizers can be applied with irrigation water, although some are not recommended for use in certain types of distribution systems. Solutions of ammonium nitrate, ammonium sulfate, and urea will not cause corrosion or encrustation of aluminum pipe and fittings in any irrigation system and are recommended for sprinkler, gated pipe, and other type systems using aluminum pipe, as well as for open ditch distribution.

Anhydrous ammonia can cause encrustation problems with some irrigation waters, if they are distributed through gated pipe. The irrigator should know the mineral content of the water supply and should be further aware of the fact that water sources can vary in mineral content from season to season and even change during an irrigation season.

If anhydrous ammonia is used with sprinkler systems, a high loss of ammonia can be expected when it is sprayed into the air and salts can plug the sprinkler nozzles if the water is not compatible with this type of fertilizer. To sum up the limitations, anhydrous and aqua ammonia can be used through siphon tubes in most waters and with gated pipe systems in some waters, but neither should be used with sprinklers.

The task of putting the proper amount of fertilizer into the irrigation water has been minimized within recent years by the development of a large number of metering and injecting pumps. These units can be driven by a belt from a pump motor or drive shaft, by directly connected electric motors or by air-cooled engines. They are capable of measuring and injecting fertilizer solutions accurately and uniformly into any irrigation water supply.

Fungicides - Several tests on a wide variety of crops have been made in the last few years involving the application of fungicides with sprinkler systems. Many chemical manufacturers recommended that the foliage of the crop be thoroughly wet in order for the fungicide to be effective. Sprinkler systems of any type certainly become the ideal distribution and application apparatus. A more uniform distribution pattern over the field has often been attained with sprinkler systems than with aerial applications.

Herbicides - Applying herbicides in combination with sprinkler irrigation systems is now almost an accepted practice in many areas, and operators have reported a more even weed kill pattern than with other application methods, while at the same time cutting labor costs and reducing trips over the field with equipment during the growing season.

It should be remembered that the success of any combination program involving fertilizers, herbicides, or other agricultural chemicals is directly hinged to applying the proper amount of a particular substance at the right time. The mixture must be correct and this can only be done by knowing exactly how much water is being applied to the crop's root zone.

Although many successful metering devices have been designed that can be made from sprayer parts and other "around the farm" materials, the refined accuracy of the commercial fertilizer pumps makes them the most desirable devices to use.

Most fertilizer dealers can furnish data charts to help the irrigator determine how many gallons per hour of solution should be added to the water supply, and their advice can be confidently followed in most cases.

Recent trials and tests indicate that a uniform mix can be expected if the solution is added at any point near the initial water source. Some authorities advise the installation of the line on the suction side of a centrifugal pump, but satisfactory mixtures have been obtained by injecting the fertilizer on the pressure side of such pumps. Most metering pumps are high pressure, positive displacement types, and deliver the fertilizer into the pipeline at pressures higher than the water therein. Fertilizer should be injected into sprinkler systems at some point near the pump.

Injector Pumps - Any irrigator using an electric-powered metering-injecting pump for fertilizer application should be certain that it is wired so that the injector pump will cease operation if the water pump stops. If the unit is belt driven from the pump or its power unit, this safety measure has been taken care of at installation. In addition, there should be backflow prevention on the main line between the injection point and the water source to prevent accidental back flow of polluted water into the water source. Practically all manufacturers of these devices are producing a range of capacity sizes. Selecting a pump to do the required job becomes a catalogue exercise at the dealer's place of business. Some injector pump models are constructed with dual pumps, permitting the injection of fertilizer and pesticides into the water supply with the same unit. These models can be used to handle large amounts of fertilizer if the desired application exceeds the capacity of the single pump.

Phosphates - Numerous trials and tests have been conducted by irrigators desiring to add phosphorus to the soil by applying ammonium polyphosphate, through irrigation water. Both surface methods and sprinkler systems have been used in these experiments. Present indications are that the phosphate can be moved to the proper root zone depth in sandy soils, but penetration of soils with clay content has proved very shallow.

(e) <u>Water Requirements for Soil-Water Budget/Balance Analysis</u>

The components of a soil-water budget/balance analysis must include all water going *in* and water going *out* of an area for the period of consideration. The basic purpose of such an analysis is to determine the location of all water applied.

An example of a simplified soil-water budget in New Jersey is as follows:

Crop = tomatoes
Mature rooting depth = 24”
Total AWC = 3.1”
MAD = 25%
Field Capacity at start of season
Drip Irrigation with gross application = 0.8”
Application efficiency = 90%
Net application/irrigation = 0.7”
DU = 100% no surface runoff
No contribution from a shallow water table
Effective Precipitation (Reference Irrigation Water Requirements, Technical Release 21).

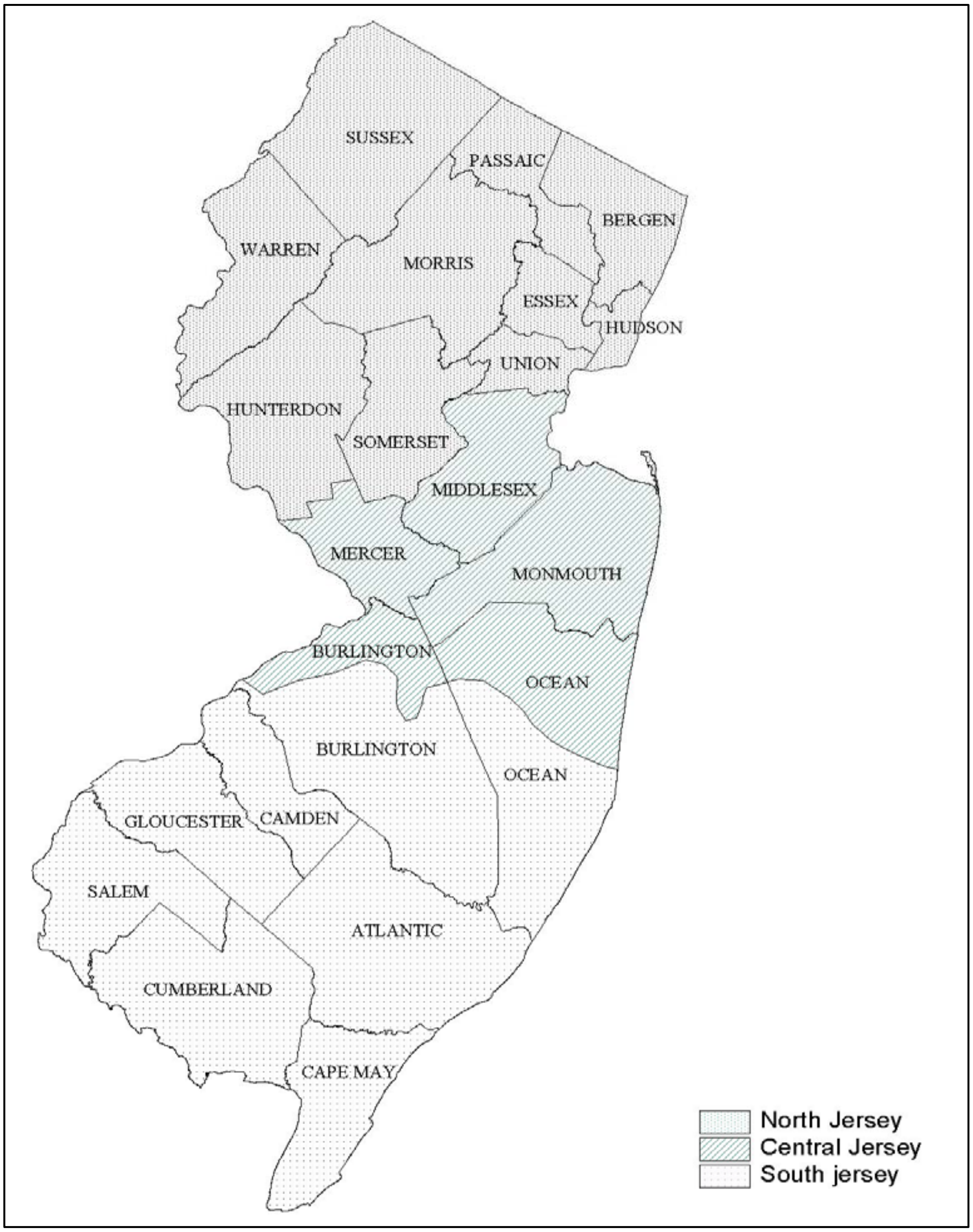
All crop ET, irrigation, and precipitation units are in inches. Additional and more detailed examples of a soil-water budget/balance are in Chapter 8, Project and Farm Irrigation Water Requirements, National Irrigation Guide.

<u>Table NJ 4.7</u> Example Soil-Water Budget

Month	Crop ET	Soil Water Used	Precipitation		Irrigations		Water	
			Total	Effect 1/	No.	Net Water Applied	Deficit	Surplus
May	.87	.87	3.51	.87	0	0	0	0
June	3.36	3.36	3.58	1.49	3	2.1	0	.23
July	7.57	7.57	4.31	2.22	7	4.9	.45	0
Aug	7.25	7.7	4.06	2.07	8	5.2	.43	0
Sept	4.35	4.78	3.55	1.53	4	2.8	.45	0
Total	23.4	24.3		8.18	22	15		.23 2/

1/ Assuming all effective precipitation infiltrated into the soil.
2/ Typically lost to deep percolation. The total is in inches.

Figure NJ 4.1
IRRIGATION ZONES OF NEW JERSEY



(f) Water Sources

The sources of irrigation water most common in New Jersey are wells, irrigation pits with ground water recharge, flowing streams, surface reservoirs, and public water supplies.

Wells
The daily yield or supply of water from a well depends upon the kind of aquifer or water-bearing geologic material in which the intake part of the well is placed. The size and diameter of the well casing also affects the rate and efficiency of water withdrawal.

It is difficult to predict the probable amount or quantity of water that can be obtained from a well that is drilled at any given location. Information, however, is available in New Jersey through records maintained by the Department of Environmental Protection, Bureau of Water Allocation. These records can assist by providing information regarding depth and yield of other wells drilled in the vicinity. A permit is required to drill a well and all wells must be drilled by a New Jersey licensed well driller.

Irrigation Pits with Ground Water Recharge
Ground water pumped from shallow pits is a common source of supply in New Jersey. The ground water level determines the maximum water level in the pit and should be close enough to the surface to be available when needed. Highly permeable gravel or sand provides better recharge than soils with silts or clays. Munch and Spence in the Freehold District 1956 Annual Report gave rule-of-thumb recharge estimates based on field testing of 20 pits as shown in Table NJ 4.8. These rates are per 1000 cubic yards of excavation below the water table with an average depth below the water table of 9 feet and average pond width of 60 feet. A few deep auger holes at the dry time of year can be used to determine the material, depth to ground water, and direction of ground water flow. Most irrigation pits are not large enough to store all of the water needed for an irrigation season so recharge is necessary. The depth, shape, and orientation of the pit affect the recharge rate. The rate of ground water flow into the pit is approximately proportional to the reduction of the water level in the pit. For example, when the pit and ground water levels are equal, no recharge occurs. When the pit water level is 6 feet below the ground water level, the recharge rate will be approximately 3 times as high as when the pit water level is 2 feet below the ground water level. As a guide, the minimum storage volume of a pit with good recharge should be large enough to supply water for one complete irrigation of the entire irrigated area, or about 1 to 1 ½ acre-inches for each irrigated acre. The storage volume must be larger if the anticipated recharge rate will not replenish the storage during the irrigation interval.

Table NJ 4.8 Estimated Recharge Rates

Soil Material	Intake Rate per 1000 cy Gallons per minute
Sharpe, coarse sand and medium gravel i.e. Pensauken	12
Medium to coarse sand i.e. Red Bank	6
Fine to medium fine sand with clay and silt	3
Tight clay	No measurable intake

The maximum suction lift for irrigation pumps is about 22 feet. This is the distance from the water surface to the center of the pump. Pits should be as deep as possible for good recharge but should not exceed 22 feet.

The long side of a pit should be at a right angle to the direction of ground water flow to obtain maximum recharge. The direction of flow can be determined with three observation wells (auger holes) drilled about 300 feet apart on the vertices of a triangle. Take the elevations of the ground water surface at each well and plot the ground water contour lines. The direction of flow is at a right angle to the contour lines.

Streams

A stream must have sufficient, continuous flow during drought periods when irrigation is most needed. The stream flow should be measured during a drought period to determine if the flow is adequate. Stream data available from the U.S. Geologic Survey may be checked to determine flow records on gaged streams. Permits will be required for most withdrawals from stream sources.

Reservoirs

A reservoir, either excavated or embankment, with no certainty of inflow during the irrigation season must have a storage capacity large enough to meet crop needs for the season plus evaporation and seepage losses. The amount of water required will vary according to the needs of the different crops. A reservoir can be used in combination with a stream to provide an adequate volume of irrigation water where the stream has adequate base flow to refill the reservoir between irrigations.

Public Water Supplies

Public supplies are more likely to be used when the volume of water required is small and the pressure requirements are compatible with the local system. Therefore, a small mircoirrigation system may be economically supplied by a public water system. If a public water system is considered as a supply, the requirements of the system owner must be met before using the system as an irrigation source. A common concern and requirement of the system owner will be backflow prevention.