Nutrient Guidelines for Commercial Vegetable Production

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Executive Summary

- The Natural Resources Conservation Service (NRCS) 590 Nutrient Management Conservation Practice Standard (CPS) is a core component of compliance with the New York Concentrated Animal Feeding Operation (CAFO) Permit and the development and operation of comprehensive nutrient management plans (CNMPs) in general. The NRCS 590 standard requires the use of Cornell University guidelines for nutrient applications. When fields in vegetable production are part of a CAFO operation and receive manure, litter, or process wastewater, the comprehensive nutrient management plan must include those fields and be created using these guidelines.

- This manual contains the most recent Cornell University guidelines for nutrient management of vegetable crops. The guidelines are also documented in the Cornell Integrated Crop and Pest Management Guidelines for Commerical Vegetable Production, a copy of which can be purchased from Cornell Cooperative Extension at: https://cropandpestguides.cce.cornell.edu/. This manual replaces Reiners et al. (2019).

- This manual contains guidance for nitrogen (N), phosphorus (P), potassium (K) and lime guidelines for vegetable crops. It should be noted that a soil test P level that exceeds the agronomic threshold does not mean that additional P in the form of fertilizer, manure or compost directly contributes to loss of P to the environment. For P loss management, the New York Phosphorus Index 2.0 governs land application of manure and fertilizer. Information on the New York Phosphorus Index 2.0 can be found in the manual and user's guide (Czymmek et al., 2021).

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Acronyms

- CAFO: Concentrated Animal Feeding Operation
- CNMP: Comprehensive Nutrient Management Plan
- CPS: Conservation Practice Standard
- NRCS: Natural Resources Conservation Service
- NYSAGM: New York State Department of Agriculture and Markets
- NYSDEC: New York State Department of Environmental Conservation
- STK/STP: soil test K/P level measured by the (modified) Morgan extraction method

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1. Introduction

Three-letter crop codes are used to identify vegetables crops for which the N, P, K, and lime guidelines are documented in this bulletin (Table 1).

Table 1: Vegetable crops and their Cornell crop codes.

Code	Description	Code	Description
ASP	Asparagus	MML	Muskmelon
BDR	Beans - Dry	MUS	Mustard
BNL	Beans - Lima	ONS	Onion-Seeded
BNS	Beans - Snap	ONP	Onion-Transplanted
BET	Beet	PSL	Parsley
BRS	Broccoli-Seeded	PSN	Parsnips
BRP	Broccoli-Transplanted	PEA	Pea
BUS	Brussels Sprouts	PEP	Peppers
CBS	Cabbage - Seeded	POP	Popcorn
CBP	Cabbage-Transplanted	POT	Potato
CAR	Carrots	PUM	Pumpkins
CFS	Cauliflower - Seeded	RAD	Radishes
CFP	Cauliflower - Transplanted	RHU	Rhubarb
CEL	Celery	RUT	Rutabagas
CRD	Chard	SPF	Spinach-Fall
CHC	Chinese Cabbage	SPS	Spinach-Spring
CKS	Cucumber - Seeded	SQS	Squash-Summer
CKP	Cucumber - Transplanted	SQW	Squash-Winter
EGG	Eggplant	SWC	Sweet Corn
END	Endive	SWP	Sweet Potatoes
GAR	Garlic	TOM	Tomato
LET	Lettuce	TUR	Turnips
MIX	Mixed Vegetables	WAT	Watermelon

2. Nitrogen Guidelines

Nitrogen guidelines for the vegetables listed in Table 1 are shown in pounds of N per acre and in pounds per 1000 square feet in Table 2. Celery, onions, potatoes, and spinach have varying N guidelines depending on the soil management group (SMG) designation of the field in which these crops are grown. See Appendix A to identify the SMG of a specific soil type. Muck type soils are classified as soil management group 6. Perennial vegetables such as asparagus and rhubarb have different N guidelines in the planting (establishment) year and subsequent (established) years. Gross requirements listed in Table 1 do not take into account N from manure or previous crops in a rotation.

Table 2. Cornell nitrogen (N) guidelines for vegetables in pounds N per acre and per 1000 square feet. Gross requirements exclude residual N from manure or rotation credits.

Crop description	Crop code	Gross nitrogen guideline	
		lbs N/acre	lbs N/1000 ft^2
Asparagus – Established	ASP	50	1.15
Asparagus – New Planting	ASP	50	1.15
Beans – Dry	BDR	30	0.69
Beans – Lima	BNL	40	0.92
Beans – Snap	BNS	40	0.92
Beet	BET	175	4.02
Broccoli-Transplanted	BRP	120	2.75
Broccoli-Seeded	BRS	120	2.75
Brussels Sprouts	BUS	120	2.75
Cabbage – Seeded	CBS	120	2.75
Cabbage-Transplanted	CBP	120	2.75
Carrots	CAR	90	2.07
Cauliflower – Transplanted	CFP	120	2.75
Cauliflower – Seeded	CFS	120	2.75
Celery, SMG = 1 to 5	CEL	180	4.13
Celery, SMG = 6	CEL	140	3.21
Chinese Cabbage	CHC	120	2.75
Chard	CRD	100	2.30
Cucumber – Transplanted	CKP	100	2.30
Cucumber – Seeded	CKS	100	2.30
Eggplant	EGG	130	2.98
Endive	END	100	2.30
Garlic	GAR	100	2.30
Lettuce	LET	100	2.30
Mixed Vegetables	MIX	120	2.75
Muskmelon	MML	100	2.30
Mustard	MUS	100	2.30
Onion-Transplant, SMG = 1 to 5	ONP	120	2.75
Onion-Transplant, SMG = 6	ONP	100	2.30
Onion-Seeded, SMG = 1 to 5	ONS	120	2.75
Onion-Seeded, SMG = 6	ONS	100	2.30
Parsley	PSL	100	2.30
Parsnips	PSN	150	3.44
Pea	PEA	50	1.15
Peppers	PEP	150	3.44
Popcorn	POP	*	*
Potato, SMG = 1 to 5	POT	150	3.44
Potato, SMG = 6	POT	100	2.30
Pumpkins	PUM	100	2.30

Crop description	Crop code	Gross nitrogen guideline	
		lbs N/acre	lbs N/1000 ft^2
Rhubarb – Established	RHU	80	1.84
Rhubarb – New Planting	RHU	100	2.30
Radishes	RAD	50	1.15
Rutabagas	RUT	60	1.38
Spinach-Spring, SMG = 1-5	SPS	125	2.87
Spinach-Spring, SMG = 6	SPS	100	2.30
Spinach-Fall, SMG = 1-5	SPF	125	2.87
Spinach-Fall, SMG = 6	SPF	100	2.30
Squash-Summer	SQS	100	2.30
Squash-Winter	SQW	100	2.30
Sweet Corn	SWC	140	3.21
Sweet Potatoes	SWP	75	1.72
Tomato	TOM	100	2.30
Turnips	TUR	60	1.38
Watermelon	WAT	100	2.30

**Popcorn N guidelines are the same as for field corn (COG, COS). See Nitrogen Guidelines for Field Crops in New York, which can be downloaded from the Nutrient Management Spear Program (NMSP) website at: http://nmsp.cals.cornell.edu/publications/extension/Ndoc2023.pdf.*

Residual N credits from sod (alfalfa/grass) fields in rotation with vegetables should be subtracted from the gross N guideline shown in Table 2. Total N required is the difference between the gross N guideline (Table 2) and residual N credits from a sod for that year (Table 3). The year since termination and the percent legume in the sod at termination are used to estimate the total N credit to be taken (Table 3). See Agronomy Factsheet #21 (http://nmsp.cals.cornell.edu/publications/factsheets/factsheet21.pdf) for more detailed information on estimating N credits from sod in rotation.

Cover crops can also supply N to the crop that follows. The amount of biomass, its N content, and its C:N ratio (maturity) can greatly influence N dynamics in the soil after termination of the cover crop. The optimum economic N rate for vegetables grown in New York after spring termination of a fall-planted, timely seeded, overwintering cover crop, such as cereal rye, winter wheat, or triticale, can be lowered by 20-30 lbs N/acre (CCN credits). Cover crop credits could be higher for interseeded legumes like red clover or hairy vetch. The optimum economic N rate for vegetables after clover that was interseeded into a small grain can be lowered by 70-120 lbs N/acre (only for the first year of the crop following clover termination). For vegetables that follow termination of a cover crop that was planted after small grain harvest in July/August of the previous season, the total N uptake may be 70-90 lbs N/acre or even higher (greater cover crop biomass production compared to late planted cover crops) which could result in cover crop credits of 40-50 lbs N/acre. All cover crop N credits apply when the C:N ratio of the cover crop biomass is less than 25, generally this is when cereal grains are at Feekes stages 9 (flag leaf) or 10 (boot stage) or less mature. The N rate for a vegetable crop grown after a more mature biomass is terminated should not be lowered.

Table 3: Expected N credits from terminated sods.

			Available N	
Legume in sod	Total N pool	Year 1*	Year 2	Year 3
%	lbs N/acre	lbs N/acre	lbs N/acre	lbs N/acre
0	150	83	18	8
1-25	200	110	24	10
26-50	250	138	30	13
50 or more	300	165	36	15

** First year following plow down or chemical termination.*

Manure has nutrients as well, including N. However, do not harvest fresh market vegetables until at least 120 days after application due to the possibility of human pathogen contamination. Processed vegetables that include a pathogen kill step may have a shorter preharvest interval.

When manure is used, the total fertilizer N required for a crop is the difference between the gross N required (Table 2) minus sod credits and minus current or residual manure N (past applications in the most recent 2 years prior to seeding of the current crop). Current manure applications can supply N in the form of ammonium N and organic N. Residual manure N is the portion of the organic N from the past two years of manure applications available to the plants in the planned crop year (yellow boxes in Figure 1).

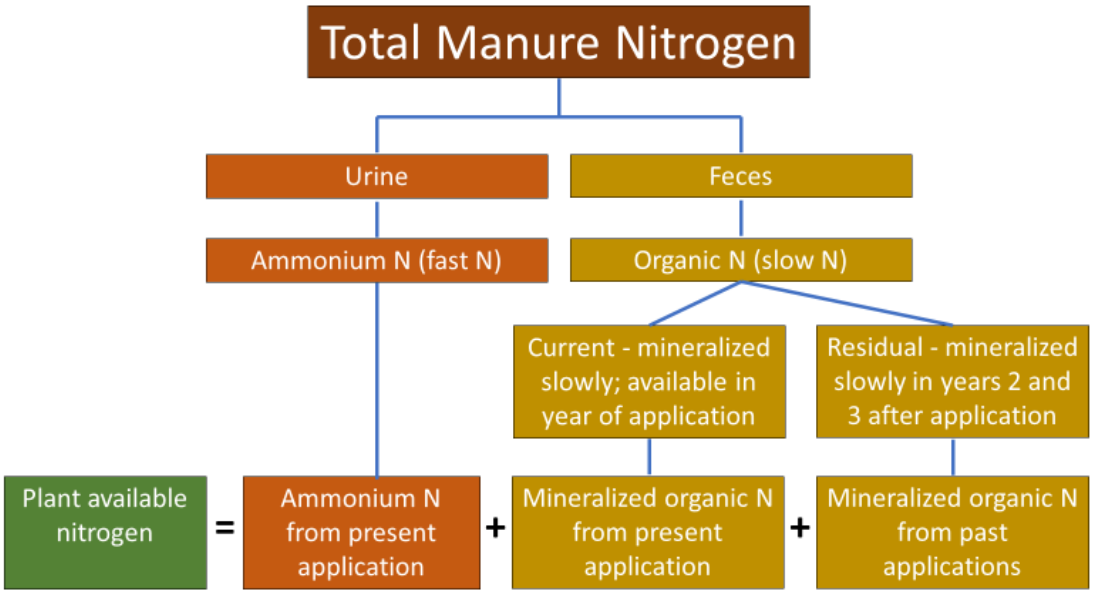

Figure 1: Manure contains ammonium and organic N (modified from Klausner, 1997).

Table 4 shows the fraction of the inorganic N remaining for plant use from various livestock manures given alternative application methods and timing of application in the year of application. To calculate N from current year manure applications, use the following calculation:

Manure N credit (lbs N/acre in current year) =

(Ammonium N applied * N utilized by crop/100) + (Organic N*Decay_current/100)

Where:

Ammonium N applied is the rate of manure applied * percent of ammonium N from the manure test

Ammonium N utilized by crop is the estimated ammonia-N availability as affected by manure application method (%, see Table 4)

Organic N is the organic N content of the applied manure on an as sampled basis

Decay_current is the organic N decay present year (%, see Table 5)

Table 4: Estimated ammonia-N availability as affected by manure application method.

Manure application method	Ammonium N utilized by the crop (%)
Injected during growing season	100
Incorporated within 1 day	65
Incorporated within 2 days	53
Incorporated within 3 days	41
Incorporated within 4 days	29
Incorporated within 5 days	17
No conservation/Injected in fall	0

A decay or mineralization series is commonly used to estimate the rate of N availability from stable organic N in the year of application and following years (Table 5). For example, a decay series of 35, 12, and 5% is used to estimate the rate of decomposition of organic N in liquid (<18% dry matter, DM) dairy manure in New York (other livestock manure is also listed in Table 5). This sequence of numbers means that 35% of the organic N is mineralized and potentially taken up by the growing crop during the year the manure was applied, 12% of the initial organic N application is mineralized and taken up during the second year after application, and 5% is mineralized and taken up in the third year. There is evidence that both manure containing large amounts of straw or sawdust bedding and composted manure mineralize at a slower rate than fresh manure. For these materials, the estimated N availability during the year that the bedded pack or compost is applied is reduced to 25% (Table 5). See Agronomy Factsheet #4 (http://nmsp.cals.cornell.edu/publications/factsheets/factsheet4.pdf) for more information on estimating N credits from manure.

The following calculations are used to determine the residual manure N contribution (ResidualN_manure) from previous years' manure applications:

ResidualN_manure = ResidN1 + ResidN2

ResidN1 = Decay_lastyr/100 * (Organic N/100) * ManureRate_lastyr

ResidN2 = Decay_2yrs/100 * (Organic N/100) * ManureRate_2yrs

Where:

ResidualN_manure is the total residual N from manure (lbs N/acre)

ResidN1 is the residual N from manure applied last year (lbs N/acre)

ResidN2 is the residual N from manure applied two years ago (lbs N/acre)
Decay_lastyr is the organic N decay last year (%, see Table 4)
Decay_2yrs is the organic N decay 2 years ago (%, see Table 4)
ManureRate_lastyr is the amount of manure applied last year (lbs/acre)
ManureRate_2yrs is the amount of manure applied 2 years ago (lbs/acre)
Organic N is the organic N content of the applied manure on an as sampled basis

Table 5: Decay series for stable organic N in manure or compost by animal type. A "last year release rate" of 12% indicates that an estimated 12% of the organic N applied in the manure/compost is expected to be utilized by the crop a year after application.

		Release rate for organic N in manure (%)		
Source	Dry matter content (%)	Present Year "Decay_current"	Last Year "Decay_lastyr"	Two Years Ago "Decay_2yrs"
Cows	<18	35	12	5
Cows	≥18	25	12	5
Poultry	<18	55	12	5
Poultry	≥18	55	12	5
Swine	<18	35	12	5
Swine	≥18	25	12	5
Horses	<18	30	12	5
Horses	≥18	25	12	5
Sheep	<18	35	12	5
Sheep	≥18	25	12	5

The remaining N needs of a crop after accounting for sod and past manure or compost credits, can be met with fertilizer N, manure/compost, or a combination of both. However, for vegetables a starter fertilizer N application of up to 25 lbs N per acre (0.57 lbs per 1000 ft^2) is recommended for all direct seeded, non-legume, vegetable crops. Popcorn N guidelines are the same as field corn (COG, COS). See Nitrogen Guidelines for Field Crops in New York, downloadable from the NMSP website: http://nmsp.cals.cornell.edu/publications/extension/Ndoc2023.pdf.

3. PHOSPHORUS GUIDELINES

The P guidelines for vegetables depend on the soil test phosphorus (STP) level as measured by the (modified) Morgan extraction method. Carrots, celery, endive, lettuce, onions, potatoes, and spinach have different P guidelines when grown on mineral soil (SMG 1 to 5) and muck soils (SMG 6). Vegetable P guidelines in pounds of P_2O_5 per acre for mineral soils and muck soils are shown in Tables 6 and 7, respectively. To convert to pounds per 1000 square feet, multiply by 0.023. Popcorn P guidelines are the same as for field corn (COG, COS). See Phosphorus Guidelines for Field Crops in New York: http://nmsp.cals.cornell.edu/publications/extension/Pdoc2022.pdf.

Table 6. Phosphorus (P) guidelines for selected vegetable crops grown on mineral soils (soil management groups 1-5) in lbs of P_2O_5 per acre. To convert to lbs per 1000 square feet, multiply by 0.023.

		Cornell P guideline ---------- lbs P_2O_5/acre ----------				
Crop description	Code	---------Morgan Soil Test P (lbs P/acre)----------				
		<3	3-5	6-12	13-39	40+
Asparagus (new)	ASP	160	110	60	30	20
Asparagus (established)	ASP	100	75	60	25	0
Beans - Dry	BDR	100	80	60	40	20
Beans - Lima	BNL	100	80	60	40	20
Beans - Snap	BNS	100	80	60	40	20
Beet	BET	200	150	100	50	20
Broccoli-Transplanted	BRP	160	120	80	40	20
Broccoli-Seeded	BRS	160	120	80	40	20
Brussels Sprouts	BUS	160	120	80	40	20
Cabbage - Seeded	CBS	160	120	80	40	20
Cabbage-Transplanted	CBP	160	120	80	40	0
Carrots	CAR	160	120	80	40	20
Cauliflower - Transplanted	CFP	160	120	80	40	20
Cauliflower - Seeded	CFS	160	120	80	40	20
Celery	CEL	200	150	100	50	20
Chinese Cabbage	CHC	160	120	80	40	20
Chard	CRD	160	120	80	40	20
Cucumber - Transplanted	CKP	160	120	80	40	20
Cucumber - Seeded	CKS	160	120	80	40	20
Eggplant	EGG	200	150	100	50	20
Endive	END	160	120	80	40	20
Garlic	GAR	200	150	100	50	20
Lettuce	LET	160	120	80	40	20
Mixed Vegetables	MIX	160	120	80	40	20
Muskmelon	MML	160	120	80	40	20
Mustard	MUS	160	120	80	40	20
Onion-Transplant	ONP	200	150	100	50	20
Onion- Seeded	ONS	200	150	100	50	20
Parsley	PSL	160	120	80	40	20
Parsnips	PSN	160	120	80	40	20
Pea	PEA	120	100	75	50	20
Peppers	PEP	200	150	100	50	20
Popcorn	POP	*	*	*	*	*
Pumpkins	PUM	160	120	80	40	20
Rhubarb - New Planting	RHU	160	110	60	30	20
Rhubarb - Established	RHU	100	75	50	25	0
Radishes	RAD	125	100	75	50	20
Rutabagas	RUT	125	100	75	50	20

		Cornell P guideline ---------- lbs P_2O_5/acre ----------				
Crop description	Code	---------Morgan Soil Test P (lbs P/acre)----------				
		<3	3-5	6-12	13-39	40+
Spinach-Spring	SPS	170	140	110	80	50
Spinach-Fall	SPF	170	140	110	80	50
Squash-Summer	SQS	160	120	80	40	20
Squash-Winter	SQW	160	120	80	40	20
Sweet Corn	SWC	160	120	80	40	20
Sweet Potatoes	SWP	300	200	100	50	0
Tomato	TOM	200	150	100	50	20
Turnips	TUR	125	100	75	50	20
Watermelon	WAT	160	120	80	40	20

**See Phosphorus Guidelines for Field Crops in New York, which can be downloaded for free from the NMSP website at: http://nmsp.cals.cornell.edu/publications/extension/Pdoc2023.pdf.*

Table 7. Phosphorus (P) guidelines for selected vegetable crops grown on muck soils (soil management group 6) in lbs of P_2O_5 per acre. To convert to lbs per 1000 square feet, multiply by 0.023.

		Cornell P guideline ---------- lbs P_2O_5/acre ----------				
Crop description	Code	---------Morgan Soil Test P (lbs P/acre)----------				
		<= 40	41-100	101-160	161-220	221+
Carrots	CAR	160	120	80	40	0
Celery	CEL	200	150	100	50	0
Endive	END	160	120	80	40	0
Garlic	GAR	200	150	100	50	0
Lettuce	LET	160	120	80	40	0
Onion-Transplant	ONP	200	150	100	50	0
Onion- Seeded	ONS	200	150	100	50	0
Spinach-Spring	SPS	170	140	110	80	0
Spinach-Fall	SPF	170	140	110	80	0

Potato P guidelines depend on county, (modified) Morgan STP, soil test iron (Fe), soil test aluminum (Al) and pH:

For potatoes (POT) grown in Suffolk County, New York:

If STP < 40, P guideline = 240 lbs P_2O_5/acre
If STP ≥ 40, and (Al + Fe) ≤ 200, P guideline = 150 lbs P_2O_5/acre
If STP ≥ 40, and (Al + Fe) > 200, P guideline = 240 lbs P_2O_5/acre

For potatoes (POT) grown in Upstate New York:

If STP < 20, P guideline = 240 lbs P_2O_5/acre
If STP ≥ 20, and (Al + Fe) < 100, P guideline = 120 lbs P_2O_5/acre
If STP ≥ 20, and (Al + Fe) ≥ 100 and ≤ 200, P guideline = 150 lbs P_2O_5/acre

If STP ≥ 20, and (Al + Fe) > 200, P guideline = 240 lbs P_2O_5/acre

For potatoes (POT) grown in Upstate New York if soil test Al and Fe are <u>not</u> available:

If STP < 20, P guideline = 240 lbs P_2O_5/acre
If STP ≥ 20, and pH ≤ 5.2, P guideline = 240 lbs P_2O_5/acre
If STP ≥ 20, and pH > 5.2 and ≤ 5.6, P guideline = 150 lbs P_2O_5/acre
If STP ≥ 20, and pH > 5.6, P guideline = 120 lbs P_2O_5/acre

4. POTASSIUM GUIDELINES

The potassium (K) guidelines for vegetables depend on the soil test K (STK) level as measured by the (modified) Morgan extraction method. Carrots, celery, endive, lettuce, onions, potatoes, and spinach have different K guidelines when grown on mineral soils (soi management group [SMG] 1 to 5) and muck soils (SMG 6). Potassium guidelines are listed in pounds of K_2O per acre in Tables 8 and 9 for mineral and muck soils, respectively. To convert to pounds per 1000 square feet, multiply by 0.023. Popcorn K guidelines are the same as for field corn (COG, COS). See Potassium Guidelines for Field Crops in New York, downloadable from the Cornell NMSP website at: http://nmsp.cals.cornell.edu/publications/extension/Kdoc2003.pdf. Guidelines for K for potatoes depend on the STK and the SMG. The Appendix shows the SMG of each of the soil types in New York.

Table 8. Potassium (K) guidelines for selected vegetable crops grown on mineral soils (soil management groups 1-5) in lbs of K_2O/acre. To convert to lbs per 1000 square feet, multiply by 0.023.

		Cornell K guideline ---------- lbs K_2O/acre ----------				
Crop description	Code	---------Morgan Soil Test K (lbs K/acre)----------				
		< 50	50-99	100-199	200-299	300+
Asparagus (new)	ASP	200	150	100	50	0
Asparagus (established)	ASP	100	80	60	40	0
Beans - Dry	BDR	80	60	40	20	0
Beans - Lima	BNL	80	60	40	20	0
Beans - Snap	BNS	80	60	40	20	0
Beet	BET	400	300	200	100	50
Broccoli-Transplanted	BRP	200	160	120	60	0
Broccoli-Seeded	BRS	200	160	120	60	0
Brussels Sprouts	BUS	200	160	120	60	0
Cabbage - Seeded	CBS	200	160	120	60	0
Cabbage-Transplanted	CBP	200	160	120	60	0
Carrots	CAR	200	160	120	60	0
Cauliflower - Transplanted	CFP	200	160	120	60	0
Cauliflower - Seeded	CFS	200	160	120	60	0

		Cornell K guideline ---------- lbs K_2O/acre ----------				
Crop description	Code	---------Morgan Soil Test K (lbs K/acre)----------				
		< 50	50-99	100-199	200-299	300+
Celery	CEL	300	240	180	120	60
Chinese Cabbage	CHC	200	160	120	60	0
Chard	CRD	200	150	100	50	0
Cucumber - Transplanted	CKP	160	120	80	40	0
Cucumber - Seeded	CKS	160	120	80	40	0
Eggplant	EGG	200	150	100	50	0
Endive	END	200	150	100	50	0
Garlic	GAR	200	150	100	50	0
Lettuce	LET	200	150	100	50	0
Mixed Vegetables	MIX	160	120	80	40	0
Muskmelon	MML	160	120	80	40	0
Mustard	MUS	200	150	100	50	0
Onion-Transplant	ONP	200	150	100	50	0
Onion- Seeded	ONS	200	150	100	50	0
Parsley	PSL	200	150	100	50	0
Parsnips	PSN	200	160	120	60	0
Pea	PEA	160	120	80	40	0
Peppers	PEP	200	150	100	50	0
Popcorn	POP	*	*	*	*	*
Pumpkins	PUM	160	120	80	40	0
Rhubarb - New Planting	RHU	200	150	100	50	0
Rhubarb - Established	RHU	100	80	60	40	0
Radishes	RAD	200	150	100	50	0
Rutabagas	RUT	200	150	100	50	0
Spinach-Spring	SPS	200	150	100	50	0
Spinach-Fall	SPF	200	150	100	50	0
Squash-Summer	SQS	160	120	80	40	0
Squash-Winter	SQW	160	120	80	40	0
Sweet Corn	SWC	160	120	80	40	0
Sweet Potatoes	SWP	350	300	200	100	0
Tomato	TOM	240	180	120	60	0
Turnips	TUR	200	150	100	50	0
Watermelon	WAT	160	120	80	40	0

*Popcorn K guidelines are the same as field corn (COG, COS). See Potassium Guidelines for Field Crops in New York: http://nmsp.cals.cornell.edu/publications/extension/Kdoc2003.pdf. Guidelines for K for potatoes depend on the soil test K (STK, [modified] Morgan, and the soil management group [SMG]).

The K guidelines for potatoes (POT) depend on STK and constants associated with the soil type. The minimum recommended K_2O application is 50 lbs per acre. The maximum rate is 300 lbs/acre for potatoes grown in SMGs 1, 2, 3 and 4. The maximum

rate is 350 lbs/acre for production in SMGs 5 and 6. Between the minimum and maximum rates, the following equation is used to calculate the K rate:

K guideline (lbs K_2O /acre) = [(400-STK) * A] – 50

where A is 0.75 (SMG 1 and 2), 0.85 (SMG 3), 1.00 (SMG 4), or 1.15 (SMG 5 and 6).

Example:
Using this equation, if the STK is 200 lbs K/acre for a soil that belongs to SMG 3, the amount of K to apply to potatoes grown in this soil is: [(400-200)*0.85]-50 = 120 lbs K_2O/acre.

Table 9. Potassium (K) guidelines for selected vegetable crops grown on muck soils (soil management group 6) in lbs of K_2O/acre. To convert to lbs per 1000 square feet, multiply by 0.023.

		Cornell K guideline ---------- lbs K_2O/acre ----------				
Crop description	Code	----------Morgan Soil Test K (lbs P/acre)----------				
		≤ 220	220-370	371-520	521-670	> 670
Carrots	CAR	200	160	120	60	0
Celery	CEL	300	240	180	120	0
Endive	END	200	150	100	50	0
Garlic	GAR	200	150	100	50	0
Lettuce	LET	200	150	100	50	0
Onion-Transplant	ONP	200	150	100	50	0
Onion- Seeded	ONS	200	150	100	50	0
Spinach-Spring	SPS	200	150	100	50	0
Spinach-Fall	SPF	200	150	100	50	0

The K guidelines for potatoes (POT) depend on STK and constants associated with the soil type. The minimum recommended K_2O application is 50 lbs per acre. The maximum rate is 300 lbs/acre for potatoes grown in SMGs 1, 2, 3 and 4. The maximum rate is 350 lbs/acre for production in SMGs 5 and 6. Between the minimum and maximum rates, the following equation is used to calculate the K rate:

K guideline (lbs K_2O /acre) = [(400-STK) * A] – 50

where A is 0.75 (SMG 1 and 2), 0.85 (SMG 3), 1.00 (SMG 4), or 1.15 (SMG 5 and 6).

Example:
Using this equation, if the STK is 200 lbs K/acre for a soil that belongs to SMG 3, the amount of K to apply to potatoes grown in this soil is: [(400-200)*0.85]-50 = 120 lbs K_2O/acre.

5. LIME GUIDELINES

Lime is recommended if the soil pH is below the optimum range for the crops in a rotation (Table 10), where the minimum pH of the rotation is determined by the crop with highest desired pH. Lime application should be considered if the pH of the field is below the minimum pH listed in Table 10.

A pH measurement can only tell us whether or not liming of the soil should be considered. We need a measure of the soil's "buffer capacity" or ability to counteract a pH change upon lime addition to determine how much lime is needed. Guidelines for pH management are based on the modified Mehlich buffer (which contains $CaCl_2$ instead of $BaCl_2$). No lime is recommended if the soil pH is above the desired pH. No lime is recommended if the soil pH is below the desired pH but above the minimum pH as applications would not be economical (but to test the soil again in 2-3 years). If the soil pH is lower than the minimum rotation pH, lime addition is recommended.

Table 10. Desired and minimum crop pH levels for vegetables.

Crop	Crop code	Desired pH	Minimum pH
Asparagus	ASP	7.0	6.8
Beans – Dry	BDR	6.4	6.0
Beans – Lima	BNL	6.4	6.0
Beans – Snap	BNS	6.4	6.2
Beet	BET	6.5	6.2
Broccoli-Seeded	BRS	6.5	6.2
Broccoli-Transplanted	BRP	6.5	6.2
Brussels Sprouts	BUS	6.5	6.2
Cabbage – Transplanted	CBP	6.5	6.2
Cabbage – Seeded	CBS	6.5	6.2
Carrots	CAR	6.4	6.0
Carrots (SMG=6)	CAR	5.5	5.5
Cauliflower – Transplanted	CFP	6.5	6.2
Cauliflower – Seeded	CFS	6.5	6.2
Celery	CEL	6.4	6.0
Celery (SMG = 6)	CEL	5.5	5.5
Chard	CRD	6.5	6.2
Chinese Cabbage	CHC	6.5	6.2
Cucumber – Seeded	CKS	6.4	6.0
Cucumber – Transplanted	CKP	6.4	6.0
Eggplant	EGG	6.4	6.0
Endive	END	6.5	6.2
Endive (SMG=6)	END	5.6	5.6
Garlic	GAR	6.4	6.0
Lettuce	LET	6.5	6.2
Lettuce (SMG=6)	LET	5.6	5.6
Mixed Vegetables	MIX	6.4	6.0

Crop	Crop code	Desired pH	Minimum pH
Muskmelon	MML	6.4	6.0
Mustard	MUS	6.5	6.2
Onion-Seeded	ONS	6.4	6.0
Onion-Seeded (SMG=6)	ONS	5.2	5.2
Onion-Transplant	ONP	6.4	6.0
Onion-Transplant (SMG=6)	ONP	5.2	5.2
Parsley	PSL	6.5	6.0
Parsnips	PSN	6.4	6.0
Pea	PEA	6.5	6.2
Peppers	PEP	6.4	6.0
Popcorn	POP	6.2	6.0
Potato (consult CCE)	POT	-	-
Pumpkins	PUM	6.4	6.0
Radishes	RAD	6.4	6.0
Rhubarb	RHU	6.5	6.2
Rutabagas	RUT	6.4	6.0
Spinach-Fall	SPF	6.7	6.5
Spinach-Fall (SMG=6)	SPF	5.6	5.6
Spinach-Spring	SPS	6.7	6.5
Spinach-Spring (SMG=6)	SPS	5.6	5.6
Squash-Summer	SQS	6.4	6.0
Squash-Winter	SQW	6.4	6.0
Sweet Corn	SWC	6.5	6.2
Tomato	TOM	6.4	6.0
Turnips	TUR	6.4	6.0
Watermelon	WAT	6.4	6.0

The recommended lime rate can be read from Table 11 using the soil's buffer pH and the desired crop pH (from Table 10). For example, if the buffer pH is 5.5 and desired rotation pH is 6.5, 4.5 ton/acre lime is recommended. The recommendations listed in Table 11 assume a 6- to 7-inch tillage depth. For an 8-inch tillage depth, multiply the rates by 1.33. For a 10+ inch tillage depth, multiply the rate listed in Table 11 by 1.67.

Lime rates in Table 11 also assume liming material with 100% Effective Neutralizing Value (ENV). To adjust for specific materials, divide the recommended lime rate by the percent ENV reported for the lime source. For example, if the recommended lime rate is 4.5 tons/acre and the lime source available is 75% ENV, 4.5 / 0.75 = 6 tons of this liming material should be applied per acre.

Table 12 provides guidelines for lime recommendations given the incidence of potato scab for the location and the resistance associated with the variety. There are limitations on rate and sequence of lime applications. This includes:

Continuous potatoes:

1. Maximum of 0.5 ton/acre per year (even in rye year). Rye-potato rotation is considered to be the same as continuous potatoes.
2. If the total lime requirement cannot be met with 0.5 ton/acre per year, apply recommended amount and re-sample at end of the listed rotation.

Rotation:

1. Maximum of 0.5 ton/acre per year in the potato year.
2. Maximum of 4.0 tons/acre per year can be applied on the non-potato year, except for cole crops where the maximum is 1.0 ton/acre per year. If the total lime requirement can be met for a 3-year rotation by application on the non-potato year, all lime may be applied on the non-potato year.
3. If the lime recommendation is greater than 2.0 ton/acre per split lime rate; plow in half, work rest in seed zone before planting.
4. If lime recommendation is not satisfied for rotation options 1 and 2, the overall lime requirement for the potato rotation was not satisfied and it is recommended to resample at the end of listed rotation.

Table 11: Lime guidelines for soil with a pH less than the minimum pH for the rotation, based on the Mehlich Buffer pH.

Buffer pH	Desired rotation pH (minimum pH)			
	7.0 (6.7)	6.8 (6.6)	6.5 (6.4)	6.2 (6.0)
	---- tons/acre (100% Effective Neutralizing Value [ENV]) -----			
5.0	11.0	10.0	8.5	6.5
5.1	10.0	9.0	7.5	6.0
5.2	9.0	8.0	7.0	5.5
5.3	8.0	7.5	6.0	5.0
5.4	7.5	6.5	5.5	4.0
5.5	6.5	6.0	4.5	3.5
5.6	5.5	5.0	4.0	3.0
5.7	4.5	4.0	3.0	2.5
5.8	4.0	3.5	2.5	1.5
5.9	3.0	2.5	2.0	1.0
6.0	2.0	1.5	1.0	0.5
6.1	1.0	1.0	0.5	0.5
6.2	1.0	0.5	0.5	0.5
6.3	1.0	0.5	0.5	0.5
6.4	1.0	0.5	0.5	0.5
6.5	1.0	0.5	0.5	0.5
6.6	1.0	0.5	0.5	0.5

For more details on deriving lime guidelines, see Lime Guidelines for Field Crops in New York: http://nmsp.cals.cornell.edu/publications/extension/LimeDoc2003.pdf.

Anytime lime is recommended, use a limestone containing magnesium (Mg) unless soil magnesium level is very high, in which case a low magnesium limestone is recommended. If soil test for Mg is less than 100 lbs/acre or pH less than 5.0: apply 30 lbs

of magnesium (50 lbs of magnesium oxide) per acre to address the magnesium deficiency. This is independent of soil pH.

Table 12: Lime recommendations for potatoes.

Scab incidence		Scab resistant variety grown			Minimum pH	Desired pH	Comments
No	Minor to severe	Yes		No			
Continuous potatoes							
X		X	or	X	5.3	5.5	1. If rye for grain is the only crop in rotation with potatoes, lime as if continuous potatoes.
	X	X	or	X	5.0	5.2	2. Use of a scab resistant variety recommended.
Potatoes in rotation							
X		X	or	X	5.3	5.6	3. Rotation with clover, grasses, wheat barley, oats, buckwheat, corn, millet, sorghum and sudangrass (for Suffolk Co. only, include cabbage, Brussels sprouts, broccoli and cauliflower). Use of a scab resistant variety recommended.
X		X			5.8	6.0	4. Rotation with all other crops not listed in comment #3.
X				X	5.8	6.0	5. Rotation with all other crops not listed in comment #3. For this rotational sequence, a scab resistant variety is recommended.
	X	X			5.3	5.6	6. Same as comment #3.
	X			X	5.3	5.6	7. Same as comment #3. Use of a scab resistant variety is recommended.
	X	X			5.8	6.0	8. Rotation with crops other than those listed in comment #3: CAUTION - because of scab problem, rotation needs to be reviewed. Consult Cooperative Extension.
	X			X	5.8	6.0	9. Rotation with crops other than those listed in comment #3. Use of a scab resistant variety is recommended". CAUTION – because of scab problem, rotation needs to be reviewed.

References

- Cornell Integrated Crop and Pest Management Guidelines for Vegetable Crops. Order at: https://cropandpestguides.cce.cornell.edu/.
- Lime Guidelines for Field Crops in New York. http://nmsp.cals.cornell.edu/publications/extension/LimeDoc2023.pdf.
- Nitrogen Guidelines for Field Crops in New York. Downloadable from: http://nmsp.cals.cornell.edu/publications/extension/Ndoc2023.pdf.
- Phosphorus Guidelines for Field Crops in New York. Downloadable from: http://nmsp.cals.cornell.edu/publications/extension/Pdoc2022.pdf.
- Potassium Guidelines for Field Crops in New York. Downloadable from: http://nmsp.cals.cornell.edu/publications/extension/Kdoc2003.pdf.

Appendix: Soil Management Groups for New York Agricultural Soils

General descriptions of soil management groups (SMGs).

SMG	General description
1	Fine-textured soils developed from clayey lake sediments and medium- to fine-textured soils developed from lake sediments.
2	Medium- to fine-textured soils developed from calcareous glacial till and medium-textured to moderately fine-textured soils developed from slightly calcareous glacial till mixed with shale and medium-textured soils developed in recent alluvium.
3	Moderately course textured soil developed from glacial outwash and recent alluvium and medium-textured acid soil developed on glacial till.
4	Course-to medium-textured soils formed from glacial till or glacial outwash.
5	Course- to very course-textured soils formed from gravelly or sandy glacial outwash or glacial lake beach ridges or deltas.
6	Organic or muck soils with more than 80% organic matter.

Modified from: Cornell Field Crops & Soils Handbook, Cornell Cooperative Extension, 1987).

Name	SMG
Acton	4
Adams	5
Adirondack	4
Adjidaumo	1
Adrian	6
Agawam	4
Albia	3
Albrights	2
Alden	3
Allagash	5
Allard	3
Allendale	3
Allis	3
Alluvial land	3
Almond	3
Alps	3
Altmar	5
Alton	5
Amboy	4
Amenia	4
Angola	2
Appleton	2

Name	SMG
Arkport	4
Armagh	2
Arnot	3
Ashville	3
Atherton	3
Atkins	3
Atsion	5
Au gres	5
Aurelie	3
Aurora	2
Barbour	3
Barcelona	3
Barre	1
Bash	3
Basher	3
Bath	3
Becket	4
Becraft	3
Belgrade	3
Benson	4
Bergen	6
Berkshire	5

Name	SMG
Bernardston	4
Berrien	5
Berryland	5
Beseman	6
Bice	5
Biddeford	2
Birdsall	3
Blasdell	3
Bombay	4
Bonaparte	4
Bono	1
Boots	6
Borosaprists	6
Boynton	3
Braceville	4
Brayton	4
Bridgehampton	3
Bridport	2
Briggs	4
Brinkerton	2
Broadalbin	4
Brockport	1

Name	SMG
Brookfield	3
Buchanan	3
Buckland	3
Bucksport	6
Budd	4
Burdett	2
Burnham	3
Burnt Vly	6
Busti	3
Buxton	2
Cambria	2
Cambridge	3
Camillus	3
Camroden	3
Canaan	4
Canaan rock outcrop	4
Canadice	2
Canandaigua	3
Canaseraga	3
Canastota	2
Caneadea	2
Canfield	3
Canton	4
Carbondale	6
Cardigan	4
Carlisle	6
Carrollton	3
Carver	5
Carver-Plymouth	5
Castile	4
Cathro	6
Cathro-Greenwood	6
Cattaraugus	3
Cavode	2
Cayuga	2
Cazenovia	2
Ceres	3
Ceresco	3
Chadakoin	3
Chagrin	3

Name	SMG
Champlain	5
Charles	3
Charlton	4
Chatfield (E)	4
Chatfield (WE)	4
Chaumont	1
Chautauqua	3
Cheektowaga	5
Chenango	3
Cheshire	4
Chippeny	6
Chippewa	3
Churchville	2
Cicero	2
Clarkson	2
Claverack	4
Clymer	4
Cohoctah	4
Collamer	3
Colonie	5
Colosse	4
Colrain	4
Colton	5
Colwood	3
Conesus	2
Conotton	3
Constable	5
Cook	5
Copake	4
Cornish	3
Cosad	4
Cossayuna	4
Covert	4
Covertfalls	4
Coveytown	4
Covington	1
Crary	4
Croghan	5
Culvers	3
Dalbo	3
Dalton	3
Danley	2

Name	SMG
Dannemora	4
Darien	2
Dawson	6
Deerfield	5
Deford	4
Deinache	5
Dekalb	4
Depeyster	3
Deposit	3
Derb	3
Dixmont	5
Dorval	6
Dover	4
Duane	4
Dunkirk	3
Dutchess	4
Duxbury	4
Eldred	3
Edwards	6
Eel	2
Eelweir	4
Elka	4
Elko	3
Ellery	3
Elmridge	5
Elmwood	4
Elnora	5
Empeyville	4
Enfield	3
Ensley	3
Erie	3
Ernest	3
Essex	5
Factoryville	5
Fahey	5
Farmington	3
Farnham	4
Fernlake	4
Flackville	4
Fonda	2
Franklinville	4
Fredon	4

Name	SMG
Freetown	6
Fremont	2
Frenchtown	3
Frewsburg	3
Fryeburg	3
Fulton	1
Gage	3
Galen	4
Galestown	5
Galoo	4
Galoo rock outcrop	4
Galway	4
Genesee	2
Geneseo	2
Georgia	4
Getzville	3
Gilpen	3
Gilpin	3
Glebe	4
Glebe-Saddleback	4
Glendora	4
Glenfield	3
Gloucester	4
Glover	4
Gougeville	5
Granby	5
Grattan	5
Greene	3
Greenwood	6
Grenville	4
Gretor	3
Groton	4
Groveton	4
Guff	1
Guffin	1
Gulf	4
Guyanoga	3
Hadley	3
Haights	3
Haights-Gulf	3

Name	SMG
Hailesboro	3
Halcott	2
Halsey	4
Hamlin	2
Hamplain	2
Hannawa	4
Hartland	4
Haven	4
Hawksnest	3
Hemlock	2
Hempstead	4
Henniker	4
Henrietta	6
Herkimer	3
Hermon	4
Hero	4
Heuvelton	2
Highmarket	4
Hilton	2
Hinckley	5
Hinesburg	4
Hogansburg	4
Hogback	5
Hogback-ricker	5
Holderton	3
Hollis	4
Holly	2
Holyoke	3
Holyoke rock outcrop	3
Homer	2
Honeoye	2
Hoosic	4
Hornell	2
Hornellsville	3
Houghtonville	5
Houghtonville-Rawson	5
Houseville	2
Howard	3
Hudson	2
Hulberton	2

Name	SMG
Ilion	2
Insula	4
Ipswich	6
Ira	4
Ischua	3
Ivory	2
Jebavy	5
Joliet	4
Junius	5
Kalurah	4
Kanona	2
Kars	4
Kearsarge	3
Kendaia	2
Kibbie	3
Kingsbury	1
Kinzua	3
Knickerbocker	5
Lackawanna	3
Lagross	3
Lagross-Haights	3
Lairdsville	2
Lakemont	1
Lakewood	5
Lamson	4
Lanesboro	3
Langford	3
Lansing	2
Leck kill	3
Leicester	4
Leon	5
Lewbath	3
Lewbeach	3
Leyden	2
Lima	2
Limerick	3
Linden	4
Linlithgo	3
Livingston	1
Lobdell	3
Lockport	2
Lorain	1

Name	SMG
Lordstown	3
Lovewell	2
Lowville	4
Loxley	6
Lucas	2
Ludlow	4
Lupton	6
Lyman	4
Lyman-Becket-Berkshire	4
Lyme	5
Lyonmounten	3
Lyons	2
Machias	4
Macomber	4
Macomber-Taconic	4
Madalin	1
Madawaska	5
Madrid	4
Malone	4
Manahawkin	6
Mandy	3
Manheim	2
Manhoning	2
Manlius	3
Mansfield	3
Maplecrest	2
Marcy	3
Mardin	3
Marilla	3
Markey	6
Marlow	4
Martisco	6
Massena	4
Matoon	1
Matunuck	6
Medihemists	6
Medina	3
Medomak	3
Melrose	4
Menlo	4

Name	SMG
Mentor	4
Merrimac	4
Metacomet	3
Middlebrook	3
Middlebrook-Mongaup	3
Middlebury	3
Millis	4
Millsite	4
Mineola	4
Miner	1
Mino	4
Minoa	4
Mohawk	2
Moira	4
Monadnock	4
Monarda	4
Mongaup	3
Montauk	4
Mooers	5
Morocco	4
Morris	3
Mosherville	4
Muck	6
Muck-peat	6
Mundal	4
Mundalite	3
Mundalite-Rawsonville	3
Munson	2
Munuscong	4
Muskego	6
Muskellunge	3
Naples Creek	3
Napoleon	6
Napoli	3
Nassau	4
Naumburg	5
Nehasne	4
Nellis	4
Neversink	4
Newfane	4

Name	SMG
Newstead	4
Newton	5
Niagara	3
Nicholville	4
Ninigret	4
Norchip	3
Northway	5
Norwell	5
Norwich	3
Nunda	2
Oakville	5
Oatka	2
Occum	4
Occur	4
Odessa	2
Ogdensburg	4
Olean	2
Ondawa	4
Oneida	4
Onoville	3
Ontario	2
Onteora	3
Ontusia	3
Oquaga	3
Oramel	2
Organic	6
Orpark	2
Orwell	2
Ossipee	6
Otego	2
Otisville	4
Ottawa	5
Ovid	2
Palatine	2
Palms	6
Palmyra	3
Panton	1
Papakating	2
Parishville	4
Parsippany	1
Patchin	3
Pavilion	4

Name	SMG
Pawcatuck	6
Pawling	4
Paxton	4
Peacham	3
Peasleeville	4
Peat	6
Peat-muck	6
Peru	4
Petoskey	4
Phelps	3
Philo	3
Pillsbury	4
Pinckney	3
Pipestone	5
Pittsfield	4
Pittstown	4
Plainbo	5
Plainfield	5
Plessis	3
Plymouth	4
Podunk	4
Poland	2
Pompton	4
Pootatuck	4
Pope	4
Portville	3
Potsdam	4
Poygan	1
Punsit	3
Pyrities	4
Quetico	4
Quetico-rock outcrop	4
Raquette	4
Rawsonville	5
Rawsonville-Beseman	5
Rayne	3
Raynham	3
Raypol	3
Red hook	4
Redwater	3

Name	SMG
Remsen	2
Retsof	2
Rexford	4
Rhinebeck	2
Ricker	4
Ricker-Lyman	4
Ridgebury	4
Rifle	6
Riga	2
Rippowam	4
Riverhead	4
Rockaway	2
Romulus	2
Ross	2
Roundabout	3
Rumney	2
Runeberg	4
Ruse	4
Rushford	3
Saco	3
Salamanca	3
Salmon	4
Saprists	6
Saugatuck	5
Scantic	2
Scarboro	4
Schoharie	1
Schroon	5
Schuyler	3
Scio	3
Sciota	5
Scituate	4
Scriba	4
Searsport	4
Shaker	2
Sheddenbrook	5
Shongo	3
Shoreham	2
Sisk	4
Skerry	5
Sloan	3
Sodus	4

Name	SMG
Somerset	5
St johns	4
Staatsburg	3
Stafford	4
Steamburg	3
Stetson	5
Stissing	4
Stockbridge	3
Stockholm	5
Stowe	4
Sudbury	4
Suffield	2
Summerville	4
Sun	4
Sunapee	4
Suncook	5
Suny	4
Surplus	4
Surplus-Sisk	4
Sutton	4
Swanton	4
Swartswood	4
Swormville	1
Taconic	3
Taconic-Macomber	3
Tawas	6
Teel	2
Tioga	3
Toledo	2
Tonawanda	2
Tor	4
Torull	3
Towerville	3
Trestle	3
Trout river	5
Troy	3
Trumbull	1
Tughill	4
Tuller	3
Tunbridge	4

Name	SMG
Tunbridge-Adirondack	4
Tunkhannock	3
Turin	2
Tuscarora	4
Unadilla	3
Valois	3
Varick	2
Varysburg	2
Venango	3
Vergennes	1
Vly	3
Volusia	3
Waddington	4
Wainola	5
Wakeland	3
Wakeville	3
Wallace	5
Wallington	3
Wallkill	3
Walpole	4
Walton	3
Wampsville	3

Name	SMG
Wappinger	3
Wareham	5
Warners	3
Wassaic	4
Watchaug	4
Waumbeck	4
Wayland	2
Weaver	3
Wegatchie	3
Wellsboro	3
Wenonah	4
Westbury	4
Westland	2
Wethersfield	4
Wharton	2
Whately	4
Whippany	2
Whitelaw	4
Whitman	4
Wilbraham	4
Willdin	3
Willette	6
Williamson	4

Name	SMG
Willowemoc	3
Wilmington	4
Wilpoint	1
Windsor	5
Winooski	4
Wiscoy	3
Wolcottsburg	1
Wonsqueak	6
Woodbridge	4
Woodlawn	4
Woodstock	4
Woodstock-rock outcrop	4
Wooster	3
Woostern	3
Woostern-Bath-Valois	3
Worden	4
Worth	4
Wurtsboro	4
Wyalusing	3
Yalesville	4
Yorkshire	3