CURRENT CALCULATIONS IN THE WISCONSIN P INDEX

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The intent of this document is to inform Wisconsin Phosphorus Index (WPI) users about the equations and assumptions for the current WPI that is part of the Snap-Plus nutrient management planning software package, Version 1.132. The WPI provides a relative indicator of the potential for runoff P from a given field to contaminate surface water. It is calculated as an estimate of average annual runoff P delivery from a field to the nearest surface water in pounds per acre per year. The crop year is defined as the day after fall harvest of one crop to the completion of the next fall's harvest, roughly from November 1 to October 30. In order for the WPI to be calculated "seamlessly" during the Snap-Plus nutrient management planning process, it must use the types of data that can be maintained in Snap-Plus databases or obtained and entered by the user. The goal throughout WPI development has been to create the best scientifically based indexing model possible with information inputs that are easily accessible to farmers and agricultural consultants. For the most part, it uses data already required for nutrient management planning and conservation planning. The units for many of the WPI factors described in this document are ones commonly used in Wisconsin for planning fertilizer and manure applications (e.g. lb per acre), rather than standard international units.

Wisconsin's PI is currently limited to estimating surface runoff P transport and does not consider delivery through subsurface flow or tile drainage. Although a great deal of recent Wisconsin research has gone into the refinement of the WPI, some components do not yet have an extensive research base. Where we know accuracy is limited by a lack of research or by the imprecision of information available for the model, we try to err on the side of over-estimating rather than under-estimating P delivery.

The only adjustments to this version compared to previous versions are in the equations for dissolved P losses from soil and from manure applications. These changes are noted in the text and are expected to result in insignificant changes in the WPI values under most Wisconsin cropping situations. The adjustments were made to improve the WPI fit for runoff dissolved P loads from a dataset of 86 field years of runoff monitoring on sites throughout Wisconsin. This monitoring is described in Stuntebeck et al. 2008, Bonilla et al. 2006, Jokela and Casler 2010.

The Principal Equation and Its Components

Total Risk Index for Phosphorus (PI, lb per acre per year) = [Particulate P losses from the edge of the field (PP, lb per acre per year) + Dissolved P losses from the edge of the field, lb per acre per year (SP)] x Total P Delivery Ratio (TPDR)

<u>Equation components</u>:

Particulate P from the edge of the field = annual P losses in eroded sediment …….. See page 2
Soluble P from the edge of the field = annual dissolved P losses in runoff …………See page 4
Total P delivery ratio = proportion of total edge-of-field P losses delivered to surface water ………………………………………………………………………………………..See page 15

Additional information used for more than one component:

Adjusting reported plow layer soil test P values to represent surface soil test P…….See page 17

The Particulate Phosphorus Component

Sediment-bound P losses in pounds per acre per year are calculated by estimating the mass of three size-classes of eroded particles with the NRCS soil loss estimation software, RUSLE2, which is imbedded within the WPI in the Snap-Plus software. The mass of each class is multiplied by a P concentration, and the resulting calculated P masses are summed.

Particulate P = [(**Clay x Clay P)** + (**Silt x Silt P)** + (**Large Particles x Large Particle P)] x correction factor for units**

The correction factor to convert the units to pounds per acre per year is 0.002.

Calculating Annual Sediment Mass by Particle Size

The unit area mass of eroded particles is calculated with RUSLE2 (USDA-Agricultural Research Service, 2006). RUSLE2 routes particles with five diameters: clay (0.0020 mm), silt (0.010 mm), small aggregates (0.03 - 0.1 mm), sand (0.20 mm), and large aggregates (0.3 - 1 mm). The diameters of the small and large aggregates increase with increasing soil clay content.

Factor	Source or equation
Clay *(tons acre^{-1} yr^{-1})*	Mass per area for clay from RUSLE2
Silt *(tons acre^{-1} yr^{-1})*	Mass per area for silt from RUSLE2
Large particles *(tons acre^{-1} yr^{-1})*	Mass per area for (sand + small aggregates + large aggregates) from RUSLE2

Calculating Sediment P Concentration by Particle Size

Each of these particle sizes is assigned a P concentration based on the enrichment of that particle size compared to surface soil total P. These P enrichment ratios (PER) are based on measurements of runoff sediment P by particle size class and bulk soil total P for Plano silt loam soil at the Arlington Agricultural Research Station (Panuska and Karthikeyan 2010, Panuska 2006). Research on silt loam soils at the UW-Platteville Pioneer Farm has confirmed these enrichment ratios for similar soils. Note that the PER for clay may be an underestimate for fields with little erosion. In the WI runoff studies noted on page 1, P enrichment of sediment was observed to be greater than 3 times soil total P in cases where total sediment yields were very low (less than 0.2 T a^{-1} yr^{-1}) and thus likely to be dominated by very fine particles. The underestimation of ER at low erosion rates has little impact on total calculated particulate P losses, however, because of the low sediment mass loss.

Factor	Source or equation
Clay P *(mg P kg^{-1}) P concentration in the clay fractions of sediment*	**Surface soil total P** x 3
Silt P *(mg P kg^{-1}) P concentration in the silt fractions of sediment*	**Surface soil total P** x 1
Combined Large Particle P *(mg P kg^{-1}) P concentration in sand, small and large aggregate fractions of sediment*	**Surface soil total P** x 0.7

The one exception to the use of the above method for calculating P enrichment of runoff sediments for the WPI in Snap-Plus is on fields in strip crops. Currently we are unable to retrieve the correct sediment delivery values by particle size from RUSLE2 for fields in contour strips. If strip crops are selected, then the total RUSLE2 sediment delivery mass is used with an enrichment ratio of 1.

The initial surface soil total P is calculated using routine soil test P and organic matter (OM %). This relationship was identified for mineral (OM % < 10) soils collected throughout WI using a dataset of 189 plow layer samples ($R^2 = 0.83$) and for organic soils using a dataset of 19 plow layer samples with OM % ranging from 11% to 57% ($R^2 = 0.63$) (unpublished data). The estimated surface soil total P is then further adjusted for manure and fertilizer P added during the crop year.

Factor	Source or equation
Initial Surface Total P *(mg kg^{-1})* *This is the initial (beginning of the crop year) surface soil total P concentration before new additions of manure or fertilizer.*	If routine soil OM is less than 10%: **In. Surface TP** = (13+ (2.7 x OM %) + (0.03 x **In. Surface Bray P1***))^2 If routine soil OM is greater than 10%: **In. Surface TP** = 631 + (16 OM %) + (6.6 x **In. Surface Bray P1*)** ***** Before being entered into the equation, the soil test P value is adjusted for stratification (See page 17)
Total P Added to Surface (*lb elemental P acre^{-1}***)** *This is the sum of all of the manure and fertilizer P applied to the surface in the crop year*	**TP Added to Surf.** = P broadcast (lb/acre) + (P incorp.(lb/acre) x 0.4) The 0.4 factor represents the proportion of manure left on the surface following incorporation by tillage. Research by Wolkowski (2003) on incorporation of solid dairy manure with bedding at four locations in Wisconsin shows that this proportion varies by type of tillage and by manure application rate. The 0.4 value was within the range for residue left on the surface found in that research and also within the range of values used for P fraction left on the surface in the Minnesota P Index (Moncrief et al, 2006). This probably overestimates P on the surface following incorporation by moldboard plow and underestimates that following disking or cultivation. Injected manure or subsurface P applications are not included in this calculation.
Surface soil total P *This is the total P concentration in surface soil adjusted for the total P added (mg kg^{-1}).*	**Surface soil total P** = **In. Surface TP** + (**TP Added to Surface** * 8) Note: This equation uses the assumption that 1 lb P is equivalent to 0.5 mg kg^{-1} in a 6-inch plow layer and further assumes that, on average for the crop year, the total P applied with the manure is completely mixed with the surface 1 cm of soil.

The Soluble Phosphorus Component

Surface runoff dissolved P losses in pounds per acre per year are calculated by adding the annual dissolved P in runoff from the soil and from manure or fertilizer applied to the soil surface.

Soluble Phosphorus = Soil Runoff dissolved P + Direct dissolved P losses from manure or fertilizer applied to the surface

Runoff dissolved P from the soil in pounds per acre per year is estimated

Soil Runoff dissolved P (lb per acre per year) = [(Winter runoff x Frozen soil period dissolved P concentration) + (Non-frozen soil period runoff x Non-frozen soil runoff dissolved P concentration)] x Correction factor for units

The **Correction factor** to convert the units to lb per acre per year is 0.2265.

Calculating Runoff Volumes

Both frozen and non-frozen soil runoff are important contributors of P to surface water in Wisconsin. For non-frozen soil runoff, we have adapted the NRCS standard runoff curve number (CN) method to estimate annual volumes. In contrast, we were unable to find a suitable standard method that could be adapted for estimating runoff volumes from frozen soil. Therefore we used long-term stream flow records to obtain an empirical estimate of runoff from agricultural land during the period when the soil is frozen or thawing as described below.

Calculating Frozen and Thawing Soil (Winter) Runoff Volumes

Winter runoff = Base winter runoff x Fall Soil Conditions Factor

For WPI runoff volume calculations, the period of time when the soil surface is likely to be frozen or snow covered is designated November 15 to April 1 for southern and central Wisconsin and November 15 to April 15 for northern Wisconsin. Average frozen-soil period runoff was determined through an analysis of long-term (10-year) USGS daily stream flow gage records for 17 small (avg. 92 mi^2), primarily agricultural, watersheds throughout Wisconsin. A base flow separation program (Arnold et al., 1995) was run for each site to estimate the volume of stream flow attributable to overland flow. We found that the average runoff across all watersheds during the frozen/snow-covered period was 1 inch, while the average total annual runoff (frozen + non-frozen soil period) was 3 inches. There was, however, a wide range (0.3 to 2.4 in) in the average winter runoff volumes. Examination of the geographic distribution of these 10-year average winter runoff volumes for individual watersheds suggested that variations in soil/landscape and regional precipitation contributed to the variation in runoff volume. In the absence of detailed information on the soils, landscape, and climate in these watersheds during the 10-year monitoring period, it is not possible to precisely define these relationships. We chose the Wisconsin soil groups used for nutrient application guidelines as categories for assigning base winter runoff volumes to soil series. A group name is assigned to each soil series mapped in Wisconsin in UW-Extension publication A2809 (Laboski et al, 2006). The base winter runoff volumes shown below represent the mean value for all of the watersheds within a soil group region. Average winter runoff volumes for watersheds with predominately A or mixed A and B soils ranged from 0.7 in to 1.2 in (n = 7); those dominated by soil group C ranged from 1.2 in to 1.3 in (n = 2); and group D watersheds were 0.5 in to 2.4 in (n = 7). The one watershed examined that was dominated by group E (sandy) soils had a comparatively low average winter runoff volume of 0.3 in.

The fall soil condition factors are adapted from the Soil Fall Conditions Factors in the Minnesota P Index (Moncrief et al, 2006) with modifications based on an analysis of the volume of water that can potentially be stored in tillage induced soil surface depressions during the winter with various tillage systems and slopes using a formula developed by Molling et al. (2005). Please note that, although we have a good basis for assessing the *relative* effects of management, particularly surface roughness, on runoff for the fall soil condition factor, the base winter runoff values represent the runoff from aggregate land uses in the gauged watersheds. It is therefore not possible to determine a set of "average" land management conditions that each of the runoff volumes represents. In assigning the fall soil condition factors, we made an initial assumption that fields with smooth surfaces (alfalfa and no-till) have two times the annual base runoff.

Factors	Source or equation
Base winter runoff (in) – *Long-term average runoff volumes for agricultural watersheds by Wisconsin soil group*	"Base" winter runoff is assigned by Wisconsin soil group as follows:

Soil Group	Base winter runoff (in)
A and B (Southern medium and fine-texture soils)	0.9
C (Red medium and fine-textured soils)	1.3
D (Northern and central medium and fine-textured soils)	1.1
E (Sands and loamy sands) and O (mucks and peats)	0.3

Fall soil condition factors

Snap-Plus/RUSLE2 tillage	contour	slope	Factor for adjusting winter runoff volume
Fall chisel plow (with or without spring disking)	no		1.2
	yes	<2	0.2
	yes	2 - 6	0.4
	yes	≥6	0.8
Fall moldboard plow	no		0.6
	yes	<6	0.1
	yes	≥6	0.4
No-till, strip-till, all spring tillages and all managements with an over-wintering small grain or cover crop	no		2
	yes		1.5
All established alfalfa and all other over-wintering crops with tillages labeled "none" in Snap-Plus			2

Calculating Frost-Free-Period Runoff Volumes

We calculate average annual rainfall runoff volumes using an adaptation of the standard NRCS runoff curve number method for calculating the total annual runoff as the sum of the runoff from a series of individual storms, an approach recommended by Dr. Ken Potter (UW-Madison Engineering Department). Frost-free period 24-hour rainfall volume histograms were created from 20-year daily precipitation records for nine sites in Wisconsin (see Appendix). The rainfall data used for analysis was provided by the Wisconsin State Climatology Office, Madison, Wisconsin, http://www.aos.wisc.edu/~sco/ . For histogram development, the frost-free (non-winter) period was assumed to be April 1 through Nov. 30 in southern and central Wisconsin and April 15 through Nov. 30 in northern Wisconsin. Runoff volume calculations use the histogram for the closest of the nine weather stations assigned by county (see Appendix).

The runoff volume calculations use field-specific frost-free period runoff curve numbers (CN) generated by RUSLE2. We use RUSLE2 CN because they are field-specific and are more sensitive to differences in soil type, residue, and tillage than are CN found in published planning tables.

Factors	Source or equation
Non-winter runoff volume (in)	A. Select the appropriate rainfall volume histogram for the county using the county link and rainfall runoff histogram tables (see Appendix) B. The appropriate annual field rainfall runoff curve number for the frost-free period is obtained from RUSLE2 (RUSLE2 parameter WI_SNAP_PTR:WI_SNAP_FROST_FREE_YEARLY_CN) and is used to calculate runoff for a storm with P at mid-point of each rainfall range in the histogram according to the following formula: P= accumulated precipitation, calculate for midpoint of each rainfall range Q= accumulated runoff volume $S = (1000/CN) - 10$ Calculate for midpoint Ps where P>0.2S $Q = (P-0.2S)^2/(P+0.8S)$ C. The resulting runoff volume for each mid-range storm is multiplied by the number of storms per year in that range. D. The results of step C are summed to arrive at inches of rainfall runoff for an average year.

<u>Calculating Runoff Dissolved P Concentrations</u>

Runoff dissolved P concentrations are controlled by the surface soil P concentration (as indicated by routine soil test P) unless manure or fertilizer is applied to the soil surface (Andraski and Bundy, 2003; Andraski et al., 2003). To identify the relationship between soil test P and water-soluble P in soils, we sampled 106 sites representing the predominant agricultural soils throughout Wisconsin. Sites were chosen to include a range of soil test P (Bray P1) values for each soil type. The relationship between soil test P and water-extractable P (WEP) in solution (dissolved reactive P in a 1 soil:20 water, 1 hour extraction) appeared to best be described by splitting the sites into two populations. To characterize the populations, we again used the soil groups defined in Laboski, et al. (2006). The relationship for the A, B, and C groups (Southern and red-colored medium and fine textured soils) was strong (WEP in solution = 0.012 x Bray P, $r^2 = 0.79$). For the D and E groups, (Northern medium and fine textured soils and sandy coarse-textured soils) the relationship was not as strong and the slope was approximately half (WEP in solution = 0.0065, $r^2 = 0.47$). When examined alone, the D group of soils had the weakest relationship between soil test P and WEP ($r^2 = 0.45$) with some samples that appeared to overlap with the A, B, and C group. This indicates that soil group alone is not adequate for defining the soluble P characteristics of group D soils, but we have found no better method yet.

In addition to soil test P concentration, many other factors are know to influence the dissolved P concentrations in water interacting with soil, including the soil:water ratio, temperature, and time of interaction. Dissolved P (DP) as measured in rainfall runoff from a given plot or field tends to vary somewhat from storm-to-storm. For the purpose of the WPI, we were looking for an indicator of the average DP concentration in runoff water over the course of a year. Remarkably, the relationship between soil test P and runoff DP concentrations in 43 small natural runoff plots (B group soils) in corn monitored in Wisconsin was very similar to the relationship described above for soil test P and WEP in 1 soil: 20 water extraction solutions (DP =0.011 Bray P, $r^2 = 0.73$). In previous versions of the WPI, runoff DP concentrations for A, B and C group soils were estimated using the runoff regression equation from these natural runoff small plot experiments and an equation having half of that slope was used for the D and E soil groups. These factors have been changed due to the results of in-field monitoring described below.

In the Wisconsin field runoff dataset used for P Index validation, there were 25 site years on fields with no manure or surface P fertilizer applications during that year. The relationship between estimated surface soil test P (see p. 17) and annual flow volume weighted dissolved reactive P for these sites was roughly half of that observed in the small plot runoff experiments (DP = 0.006 Adjusted Surface Bray P1, $r^2 = 0.40$). For this reason, the factor for relating surface soil test P to runoff DP concentrations for Soil groups A, B, and C has been reduced to 0.006. Unfortunately, there were no D or E soils in the field runoff dataset without P applications. The only representatives of the D soil group in the dataset were fields at Marshfield, which received incorporated manure in the fall. During events that were prior to manure application or several months after manure application, the relationship between soil test P and dissolved P was quite low compared to the prior value of 0.0055; this factor has been adjusted to 0.002 as that gave the best model fit for these sites. This is also consistent with the factor used for all soils in Vadas et al. 2009 and Vadas et al. 2005b.

In the absence of fall or winter manure applications, the in-field monitoring data in Wisconsin did not show consistently significant differences in runoff dissolved P concentrations between the frozen and non-frozen soil periods. However, fall manure applications that increased soil surface P concentrations prior to freezing do appear to have resulted in increases in snowmelt dissolved P concentrations. Consequently, the WPI frozen soil period runoff dissolved P concentration is calculated using a surface soil test P value that is adjusted to account for P in fall manure or fertilizer applications. The non-winter rainfall runoff dissolved P is estimated using soil surface P adjusted for all crop-year manure and fertilizer applications. The process for adjusting soil test P to account for manure and fertilizer applications is explained on page 17. Dissolved P losses that come directly from manure or fertilizer on the soil surface are accounted for in the acute losses calculations described in the next section.

Factors	Source or equation
Winter Runoff Dissolved P (mg P L^{-1} runoff)	Soil group — Equation A, B, C, O — *Runoff D P = 0.006 x* **Surface Bray P1 adjusted for fall-applied P** * D, E — *Runoff D P = 0.002 x* **Surface Bray P1 adjusted for fall-applied P** * * Adjusted for all fall manure and fertilizer applications (see p.17)
Non-winter runoff dissolved P concentration (mg P L^{-1} runoff))	Soil Group — Equation A, B, C, O — *Runoff D P = 0.006 x* **Adjusted surface Bray P1*** D, E — *Runoff D P = 0.002 x* **Adjusted surface Bray P1*** * Adjusted for all crop year manure and fertilizer applications (see p.17)

Calculating Dissolved P in Direct Runoff from Surface-Applied Manure or Fertilizer

$$\mathbf{DP_{manure} = \Sigma_{manure\ apps}\ Season\ 1\ DP_{manure} + Season\ 2\ DP_{manure} + Season\ 3\ DP_{manure}}$$

$$\mathbf{Season\ \textit{n}\ DP_{manure} = Soluble\ P\ from\ surface\text{-}applied\ manure_{\ season\ \textit{n}} \times Runoff\ to\ precipitation\ ratio_{\ season\ \textit{n}} \times Phosphorus\ Distribution\ Factor_{\ season\ \textit{n}}}$$

$$\mathbf{Phosphorus\ Distribution\ Factor_{\ season\ \textit{n}} = (Runoff\ to\ precipitation\ ratio_{\ season\ \textit{n}})^{0.225}}$$

When manure or P-containing fertilizers are present on the soil surface during a runoff event, release of soluble P from the manure or fertilizers usually results in elevated runoff dissolved P concentrations. The WPI estimates the dissolved P from unincorporated manure and fertilizer applications using simplified forms of formulas developed to estimate the release of dissolved P from unincorporated manures and fertilizers in daily time-step runoff models (Vadas et al, 2009, Vadas et al 2007, Vadas et al 2008). These formulas take into account the field and weather conditions that determine the likelihood that there will be runoff following the application. This version of the WPI has been revised to allow for continued release of water soluble P from manure remaining at the soil surface during the second and third season after application. This change was made to obtain a better fit with the observed Wisconsin field runoff database and is consistent with the model developed by Vadas et al (2009).

- In the first season following application, all of the manure water-soluble P on the soil surface is considered to be available to runoff or leaching. Water-soluble P is defined here as P that can be extracted with a 1 hour shaking in deionized water with a 1:250 extraction ratio (Vadas et al., 2007). All of this water-soluble P at the surface is assumed to be dissolved by precipitation over the course of the season of application. In the second season following application, 20% of the manure total P remaining on the soil surface is expected to become water soluble. Finally, in the third season following application, 5% of the total P remaining on the soil surface is expected to become water soluble.

- The seasonal runoff to precipitation ratio defines the proportion of the precipitation coming into contact with the surface-applied P that runs off instead of infiltrating into the soil during each season following manure application.
- The third term, the Phosphorus Distribution Factor, is calculated as (Runoff to precipitation ratio)$^{0.225}$ and was developed by Vadas et al. (2005a, 2007) to distribute dissolved P that leaches out of manure between infiltration and runoff. During a storm, a longer time to between the start of rain and the start of runoff means more rain has a chance to interact with manure and infiltrate manure P into the soil before runoff begins. Because dissolved P concentrations released from manure during a rain event are greatest at the beginning of the event and decrease with time, this means a longer time to runoff should result in lower dissolved P concentrations in runoff. The distribution factor accounts for this process. These calculations assume that dissolved P concentrations across a season are distributed similarly to those within a single storm. A Phosphorus Distribution Factor is calculated for the season during manure application and for the two following seasons using the Runoff to precipitation ratios for those seasons.

The results of the nearly 600 simulated rainfall runoff trials conducted by Dr. Larry Bundy's research group (*http://www.soils.wisc.edu/extension/nonpoint/SimulatedMethods2007.pdf*) indicate that manure solids as well as dissolved constituents can be present in runoff following unincorporated manure applications. WPI calculations do not account for direct transport of manure particulates in runoff. The increase in soil surface total P following manure application and the consequent increase in calculated eroded sediment P concentration described on page 3 is intended to account for manure particulate P losses.

$$\mathbf{DP_{fertilizer} = \Sigma_{fertilizer\ apps}\ Soluble\ P\ in\ surface\text{-}applied\ fertilizer \times Runoff\ to\ precipitation\ ratio_{season\ 1} \times 0.034\ exp\ [(3.4)\ (Runoff\ to\ precipitation\ ratio_{season\ 1})]}$$

All the P in fertilizer is assumed to be soluble. The seasonal runoff to precipitation ratio used here is the same as that for DP_{manure} calculations. The third term is analogous to the Phosphorus Distribution Factor for manure and is empirically derived (Vadas et al., 2008).

Calculating Surface Water-Soluble P Following Manure or Fertilizer Application

$$\mathbf{Soluble\ P\ in\ surface\text{-}applied\ manure_{season\ 1} = Total\ P\ in\ applied\ manure \times Water\text{-}solubility\ factor \times Fraction\ of\ application\ on\ surface}$$

$$\mathbf{Soluble\ P\ in\ surface\text{-}applied\ manure_{season\ 2} = (Total\ P\ in\ applied\ manure - Soluble\ P\ in\ surface\text{-}applied\ manure_{season\ 1}) \times Incorporation\ factor_{season\ 2} \times 0.2}$$

$$\mathbf{Soluble\ P\ in\ surface\text{-}applied\ manure_{season\ 3} = (Total\ P\ in\ applied\ manure - Soluble\ P\ in\ surface\text{-}applied\ manure_{season\ 1} - Soluble\ P\ in\ surface\ applied\ manure_{season\ 2}) \times Incorporation\ factor_{season\ 3} \times 0.05}$$

Total P and Soluble P in applied manure in these calculations are in lb acre^{-1}.

<table>
<tr><th>Factors</th><th>Source or equation</th></tr>
<tr><td>Water solubility factor
Proportion of manure total P that will be released into solution in a 1 hour 1:250 manure: water extraction</td><td>
<table>
<tr><th>Snap-Plus manure types</th><th>Water-solubility factor</th></tr>
<tr><td>Solid, semi-solid and grazing manures</td><td></td></tr>
<tr><td>Beef</td><td>0.4[a,b]</td></tr>
<tr><td>Chicken</td><td>0.25[a,b]</td></tr>
<tr><td>Dairy</td><td>0.4[a,b]</td></tr>
<tr><td>Duck</td><td>0.4[c]</td></tr>
<tr><td>Horse</td><td>0.2[c]</td></tr>
<tr><td>Sheep</td><td>0.2[c]</td></tr>
<tr><td>Swine</td><td>0.55[d]</td></tr>
<tr><td>Turkey</td><td>0.5[a]</td></tr>
<tr><td>Liquid manures</td><td></td></tr>
<tr><td>Beef</td><td>0.4[a,b]</td></tr>
<tr><td>Dairy</td><td>0.4[a,b]</td></tr>
<tr><td>Poultry</td><td>0.5[c]</td></tr>
<tr><td>Swine</td><td>0.5[e]</td></tr>
<tr><td>Veal calf</td><td>0.4[a,b]</td></tr>
</table>
Sources:
[a.] Studnicka, 2005.
[b] Good, 2002.
[c] No data. Used information from similar species and/or handling situations. For sheep and horse solid manure, low estimate is based on an assumption of high bedding rates, partial composting.
[d.] Weinhold and Miller, 2004.
[e.] Baxter et al, 2003.
</td></tr>
<tr><td>Incorporation factor$_{season\ 2}$</td><td>If there is any primary or secondary tillage during the second season following a manure application, this factor is 0.4 (see incorporation explanation for Total P added to surface on p. 3). With no tillage, it is 1.</td></tr>
<tr><td>Incorporation factor$_{season\ 3}$</td><td>If there is any primary or secondary tillage during the third season following a manure application, this factor is 0.4 (see incorporation explanation for Total P added to surface on p. 3). With no tillage, it is 1.</td></tr>
</table>

Fraction of application on surface *Proportion of manure or fertilizer particulates on the soil surface*	**Fractions left on surface by manure type and Snap-Plus application method** **Liquid manures (application units gallons per acre)** The equation for the fraction of liquid manure left on the surface is empirically derived from the data published by Vadas (2006) to account for a decreasing fraction of total P leaching into the soil with increasing application rate. ***Unincorporated:*** Fraction left on surface is 0.0041 x (liquid application rate in lb/acre)$^{0.4127}$ ***Incorporated:*** Fraction left on surface is 0.4 x 0.0041 x (liquid application rate in lb/acre)$^{0.4127}$ **Solid and semi solid manures (application units are tons/acre)** Not Incorporated /Grazing 1 Incorporated 0.4 **Dry fertilizer** Unincorporated 1 Incorporated 0.4 Subsurface 0 **Liquid fertilizer** Unincorporated 0 Incorporated 0 Subsurface 0

- The Water-solubility factor represents the proportion of amendment total P that will dissolve in water. There can be a wide range in the total P and water-soluble P in manures from a single animal species (Studnicka, 2005; Good, 2002). In view of this variability and to avoid extreme under-estimations, the water-solubility factors were set within the range of values measured in Wisconsin, but above the mean. Literature values were used for manure types without Wisconsin datasets. As none of the manure water-soluble P determinations used to set the water-solubility factor were actually conducted with a 1:250 manure:water extraction ratio, the factors were adjusted to represent probable 1:250 extractable P (Vadas et al. 2005a, Vadas and Kleinman 2006). Again, all of the P in fertilizer is assumed to be completely soluble. We are unaware of any slowly soluble P fertilizers in common use in Wisconsin.
- The Fraction of application on surface factor uses the same proportion of the application remaining on the surface as was used for calculating soil P increases following manure application (page 3). It also accounts for some manure particulate infiltration into the soil at application time and at the initiation of rainfall for manures applied as liquids. In soil column experiments, Vadas (2006) found about 20% of manure slurry solids infiltrated within 96 hour following application. Liquid fertilizers are assumed to infiltrate completely when applied to the surface.

Calculating Non-Winter Runoff to Precipitation Ratios

For calculating seasonal runoff volumes for fall, spring or summer manure applications, we use the same modification of the standard NRCS runoff CN method that was used for calculating non-winter runoff volumes (page 6). The seasonal rainfall histograms were constructed from 20 years of 24-hour rainfall data for the same nine sites and are also included in the Appendix. Rainfall data were again provided by the Wisconsin State Climatology Office, Madison, Wisconsin, http://www.aos.wisc.edu/~sco/ .

The CN used in the calculations is the RUSLE2-generated daily CN for the day following the manure application. In Snap-Plus, a season of application is chosen for each planned manure application. For Snap-Plus RUSLE2 soil loss calculations, fall manure applications are assumed to occur on November 1. In the cases when there are tillage or planting operations after September 1 and prior to November 1, the manure is assumed to be applied immediately before the first of these operations in the RUSLE2 calculations. Winter manure applications are assumed to be on January 15; spring applications are on April 25 or immediately prior to any April tillage or planting, and summer applications are on July 21. Depending on manure dry matter content, whether or not the manure is incorporated, and the type of tillage used, manure applications can decrease RUSLE2 CNs, indicating that it will take a larger storm to cause runoff following the application than prior to it.

Factors	Source or equation
Seasonal run-off to precipi-tation ratio	**Runoff (in)** for season of manure application/**Rainfall for season of manure application (in)**
Runoff (in) for season of manure application	A. Select the appropriate seasonal rainfall volume histogram for the county using the county link and the season of application. (See Appendix). B. Obtain the appropriate daily rainfall runoff curve number for the day of the manure application "SEG_SIM_DAY_CN" from RUSLE2 Use it to calculate runoff for a storm with P at mid-point of each rainfall range in the histogram according to the following formula: P= accumulated precipitation, calculate for midpoint of each rainfall range Q= accumulated runoff volume S = $(1000/CN) - 10$ Calculate for midpoint Ps where P>0.2S $Q = (P-0.2S)^2/(P+0.8S)$ C. The resulting runoff volume for each mid-point storm is multiplied by the number of storms per season in that range. D. The results of step C are summed to arrive at average inches of rainfall runoff for that season.

Factors	Source or equation
Rainfall for season of manure application (in)	**Average precipitation by season for selected rainfall stations in Wisconsin.**

	Fall[a]	Winter[b]	Spring[c]	Summer[d]
Blair	6.0	6.3	10.0	12.9
Burlington	6.7	7.8	8.6	10.0
Chilton	6.2	6.6	7.8	10.1
Crivitz	6.9	6.5	7.1	9.8
Hancock	6.0	6.2	9.3	12.6
Madison	5.9	7.2	9.3	12.6
Richland Center	6.3	6.6	10.3	14.6
Spooner	6.8	6.9	6.8	12.3
Willow	6.6	6.9	6.3	11.4

[a]Fall: September 15 to November 30, average for 20-years from 4/1/1988 to 3/31/2008.
[b]Winter: November 15 to April 1 or April 15 frost-in period used for agricultural watershed average frost-in runoff volume determination (10-year average from 1992-2002). Note that the fall periods have overlap with the frost-in period. As the purpose of this factor is to account for the risk of runoff during the time of manure application, a wide time-frame was used to include storms over the range of times when manure would be applied if the ground was not frozen.
[c]Spring: April 1 to June 14 for all sites except Spooner and Willow, for which it is April 15 to June 14, average for 20-years from 4/1/1988 to 3/31/2008.
[d]Summer: June 15 to September 14, average for 20-years from 4/1/1988 to 3/31/2008.

Counties represented by each site:
Blair -Buffalo, Chippewa, Clark, Dunn, Eau Claire, Jackson, LaCrosse, Monroe, Pepin, Pierce, St.Croix, Trempealeau
Burlington - Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, Waukesha
Chilton - Brown, Calumet, Door, Fond du Lac, Kewaunee, Manitowoc, Outagamie, Sheboygan, Winnebago
Crivitz - Florence, Forest, Marinette Oconto
Hancock: Adams, Green Lake, Juneau, Marathon, Marquette, Menominee, Portage, Shawano, Waupaca, Waushara, Wood
Madison - Columbia, Dane, Dodge, Green, Jefferson, Rock
Richland Center - Crawford, Grant, Iowa, Lafayette, Richland, Sauk, Vernon
Spooner - Barron, Bayfield, Burnett, Douglas, Polk, Rusk, Sawyer, Washburn
Willow -Ashland, Iron, Langlade, Lincoln, Oneida, Price, Taylor, Vilas

Calculating the Runoff to Rainfall Ratio for the Frozen Ground Acute Loss Index

We use the same dissolved P loss equation for manure on frozen as for non-frozen soil, and soluble P in surface-applied manures is calculated the same regardless of season of application. Phosphorus fertilizer applications to frozen soils are not allowed under Wisconsin Nutrient Management Standard 590. The difference between frozen and non-frozen soil manure dissolved P loss calculations is in the source of the runoff factor and that all winter-applied manures are assumed to have a Fraction left on surface value of 1.

Factors	Source or equation
Winter runoff (in)	This is the same Winter runoff volume as we are using for the Soluble P Index (see page 4)
Winter precipitation (in)	Select these values from the table showing “Average precipitation by season for selected rainfall stations in Wisconsin” on page 13.

On the Snap-Plus cropping screen for each field where the Annual Total PI components are displayed (under “details”), the Acute loss (frozen) PI is in a separate row below the Soluble PI. The Soluble P I displayed there includes all Soluble PI components except for the Frozen Ground Acute Loss Index, so if you add those two together, you will get the complete Soluble P Index. One reason for the separate display is to make it apparent when there are high losses due to winter applications. In many typical Wisconsin fall and spring manure application scenarios, calculated runoff-to-rainfall ratios are low due to low RUSLE2 daily runoff CN following the manure application. Consequently, calculated direct manure dissolved P losses from non-frozen soil usually contribute only a small fraction of the total annual P loss risk. In contrast to fall and spring applications, manure on frozen soil often contributes a significant proportion of the total annual P loss risk. Another reason that the Frozen Ground Acute Loss PI is shown separately is that the Wisconsin NR 243 rules governing manure applications for animal feeding operations require the use of this value for planning in specific winter-spreading situations.

Total P Delivery Ratio

In the WPI, phosphorus delivery is estimated to the edge of the field as particulate or dissolved P and then these losses are multiplied by the appropriate total P delivery factor for the length and slope of the flow path from the field to a perennial stream or lake. The table of total P delivery factors used in the WPI is shown below. The slope classes are designed to match with soil mapping unit names, so the predominate slope between the field and the stream can easily be picked off a soil map. As you can see, the categories for distance to stream are very broad and therefore also easily estimated from a soil map. The slope and length of the flow path from the field to the nearest surface water is the only "extra" information the P Index uses in Snap-Plus beyond what is required for regular nutrient management planning and conservation planning.

Pull-down menu options for Snap-Plus

Dominant slope	Distance from stream	TP delivery factor
0-2%	0- 300 ft	1
	300 -1,000 ft.	0.95
	1,001-5,000 ft	0.87
	5,001 -10, 000 ft	0.72
	10,001 - 20,000 ft.	0.55
	> 20,000 ft.	0.45
2-6%	0- 300 ft	1
	300 -1,000 ft.	0.96
	1,001-5,000 ft	0.91
	5,001-10, 000 ft	0.79
	10,001 - 20,000 ft.	0.65
	> 20,000 ft.	0.56
6-12%	0- 300 ft	1
	300 -1,000 ft.	0.98
	1,001-5,000 ft	0.92
	5,001-10, 000 ft	0.81
	10,001 - 20,000 ft.	0.69
	> 20,000 ft.	0.61
> 12%	0- 300 ft	1
	300 -1,000 ft.	0.98
	1,001-5,000 ft	0.93
	5,001-10, 000 ft	0.83
	10,001 - 20,000 ft.	0.71
	> 20,000 ft.	0.64

This table is based on modeling work conducted using APEX (ARS Temple, TX) and P8 (W.W. Walker). The delivery modeling assumed a drainage system comprised of a field drained via a trapezoidal grassed waterway to a receiving stream. The channel transport routines within P8 and APEX were used to evaluate the potential of fine (< 50 µm) particles to settle during transport. Various channel slope and length conditions were evaluated using continuous daily simulation. Model output was then fit using regression analysis to develop a set of equations for use in the WPI. A 20-year modeling time period was used to better account for temporal variability. The edge-of-field particle size and P distribution by particle size used in the modeling analysis were those monitored for corn productions systems in Dane County (Panuska 2006).

The total P delivery ratio does not distinguish between the forms of P delivered. It is applied equally to the dissolved and particulate P transported from the field. Note that on the Snap-Plus cropping screen where details are provided about the WPI components, each of the component indices has already been adjusted independently using the total P delivery ratio.

Adjusting reported plow layer soil test P levels to represent surface soil test P over consecutive crop years

Wisconsin's Nutrient Management Standard 590 requires routine plow layer soil testing every four years for every field under nutrient management planning. The WPI calculations adjust these plow layer soil test P values to better represent surface soil test P values during the crop year by accounting for P stratification in the plow layer and for the effects of that year's P fertilizer and manure amendments. At the end of a crop year, the original plow layer soil test P is readjusted using the assumption that the effects of any P amendments and crop P removal will be distributed evenly throughout the plow layer by that time. This new plow layer Bray P1 value is then passed on to the next year. The adjusted values continue to be passed from crop year to crop year until the field is resampled and new soil test results are entered. The factors used for this adjustment are described below.

Step 1. Accounting for soil P stratification

This step adjusts the plow layer soil test P value to account for the likelihood of greater P concentrations at the soil surface than in the rest of the plow layer. The soil test P value is multiplied by a factor based on soil group as defined in Laboski et al. (2006) and on tillage to arrive at the "initial surface Bray P1".

Initial surface Bray P1 = *Initial plow layer Bray P (ppm) x Stratification Factor*

Subsoil Fertility Group	Stratification Factor	
A, B, C, D	Stratification factor depends on tillage:	
	Fall moldboard plow	0.9
	Fall chisel plow	1.2
	Spring tillage (moldboard, chisel, disk, field cultivate)	1.3
	No-till or zone-till	1.4
	Continuous no-till or zone-till (at least 4 prior years)	1.6
	Pasture	1.4
	Established legume or grass hay	1.4
	Anything else	1.3
E	Any tillage	1.1
O	Any tillage	1

The stratification factors for row crops for the A, B, C, and D soil groups represent the mean values for the ratio of Bray P1 in the surface one inch of soil to that in the 6-inch plow layer found by sampling 80 fields in the spring of 2008. All fields had been in corn in 2007. Unlike a previous study, this sampling project did not find a significant difference in stratification between soil group C soils and the other groups with medium to fine-textured soils (http://www.soils.wisc.edu/extension/onfarmdemo/). The stratification factors for grass hay and pasture came from another 2008 sampling project conducted by Nick Schneider of 150 fields in grazed pasture or grasses in Winnebago County. The stratification factors for established alfalfa and for the E soil group (sands and loamy sands) are the means found in a 2002-2003 sampling study for soils from throughout Wisconsin (unpublished data).

Step 2. Accounting for new additions of P to the soil to adjust soil test P

Surface total P additions are calculated using the assumption that 100% of unincorporated applications and 40% of incorporated applications remain on the surface (page 3). These calculations use the soil P buffer capacities, or the pounds of P_2O_5 equivalents required to increase plow layer (6 in or 15 cm) soil test P by 1 ppm, listed in Table 7.3 of Laboski et al. (2006). For A, B,C, D, and O soil groups, the plow layer P buffer capacity is18 lb P_2O_5 equivalent (7.9 lb P) per acre, and for group E (sandy) soils, it is 12 lb P_2O_5 equivalent (5.3 lb P per acre). This surface soil test P adjustment assumes that all of the surface-applied P is mixed with soil to a depth of just 0.8 in (2 cm), rather than the whole plow layer, for the duration of the crop year of application. With these assumptions, a 1 ppm increase in Bray P at the surface for A, B. C, D, and O soil groups will require 1.1 lb P per acre and for E soil groups will require 0.7 lb P per acre applied to the surface.

Fall adjusted surface Bray P and Crop year adjusted surface Bray P

Fall adjusted and Crop year adjusted surface Bray P use the same equation but account for P additions during different time periods. The fall adjusted surface Bray P is used in calculating the winter runoff dissolved P concentration and the "Total P added to the surface" includes only fall applications. In contrast, the crop year adjusted surface Bray P is used in calculating the frost-free period runoff dissolved P and "Total P added to the surface" includes all P applied throughout the crop year.

All soils except sands (E soil group):

Adjusted surface Bray P 1 (ppm) = Initial Surface Bray P (ppm) + (Total P added to the surface in lb $acre^{-1}$ / 1.1)

E soil group:

Adjusted surface Bray P 1 (ppm) = Initial Surface Bray P (ppm) + (Total P added to the surface in lb $acre^{-1}$ /0.7)

You may note that the 2 cm depth of mixing here is greater than the 1 cm assumed when calculating changes in surface soil total P. This is because the loss of soluble P released directly from manure dry matter left on the surface during the season of application is accounted for by a separate set of component equations within the Soluble P Index, while there is as of yet no mechanism within the Particulate P Index for accounting for direct loss of eroded manure particles in addition to sediment. In addition, some of the particulate components of manure are expected to infiltrate less rapidly than the soluble manure P.

Step 3. Accounting for the effects of plow layer P inputs and crop removal at the end of the cropping season

At the end of the cropping season, before being passed along to the next crop year in the program, the plow layer soil test P is adjusted for inputs and crop removal, again using the soil group P buffer capacity. Calculation of P removal by crops is based on UW-Extension soil fertility guidelines (Laboski et al., 2006).

Step 2 assumed that P applied with surface applications of manure or fertilizer remained in the surface 2 cm during the crop year. Analysis of the soil testing project data discussed in Step 1 above suggested that surface-applied P is distributed throughout the plow layer over the course of the crop year, even in no-till systems, to achieve a soil surface P to plow-layer P stratification ratio that is soil-dependent rather than tillage- or P-amendment-dependent. Thus this procedure assumes that all of the current crop year's P inputs and removals were evenly distributed throughout the plow layer.

<u>All soils except E soil group (sands):</u>

Adjusted end of crop year plow layer Bray P (ppm) = Initial plow layer Bray P (ppm) + (Total P added in manures and fertilizer by all methods in lb $acre^{-1}$/7.9) + (Total P removed in crops in lb $acre^{-1}$/7.9)

<u>E soil group (sands):</u>

All soils except sands (E soil group):

Adjusted end of crop year plow layer Bray P (ppm) = Initial plow layer Bray P (ppm) + (Total P added in manures and fertilizer by all methods in lb $acre^{-1}$/5.3) + (Total P removed in crops in lb $acre^{-1}$/5.3)

This end-of-crop-year plow layer P value will be multiplied by the stratification factor (step 1) for the beginning of the next year's adjustment calculations.

1 This document altered from original version to correct typographical errors on p. 9 in the "Fraction of application left on surface" equations. In the original version, the liquid manure application rate used on the equations was previously given as gallons/acre and has been corrected to lb/acre.

References

Andraski, T.W., and L.G. Bundy. 2003. Relationships between phosphorus levels in soil and in runoff from corn production systems. J. Environ. Qual. 32:310-316.

Andraski, T.W., L.G. Bundy, and K.C. Kilian. 2003. Manure history and long-term tillage effects on soil properties and phosphorus losses in runoff. J. Environ. Qual. 32:1782-1789.

Arnold, J.G.,P.M. Allen, R.S. Muttiah and G. Bernhardt. 1995. Automated base flow separation and recession analysis techniques. Groundwater 33(6) 1010 - 1018.

Baxter, C. A., B. C. Joern, D. Ragland, J. S. Sands, and O. Adeola. 2003. Phytase, high-available-phosphorus corn and storage effects on phosphorus levels in pig excreta. J. Environ. Qual. 32:1481-1489.

Bohl, N. L. 2006. Runoff phosphorus measurements at the plot and subwatershed scale. Thesis. Department of Soil Science, University of Wisconsin-Madison.

Bonilla, C.A., D.G. Kroll, J. M. Norman, D.C. Yoder, C.C. Molling. P.S. Miller, J.C. Panuska, J. B. Topel, P.L. Wakeman, and K.G. Karthikeyan. 2006. Instrumentation for measuring runoff, sediment, and chemical losses from agricultural fields. Journal of Environmental Quality 35:216-223.

Bundy, L. G., A. P. Mallarino, and L. W. Good. 2008. Field-Scale Tools for Reducing Nutrient Losses to Water Resources. Pp. 159-170 in Final Report: Gulf Hypoxia and Local Water Quality Concerns Workshop. September 26-28, 2005, Ames, Iowa. Sponsored by Iowa State University and EPA.Organized by the MRSHNC, Upper Mississippi River Sub-basin Hypoxia Nutrient Committee. St. Joseph,Michigan:

Ebeling, A.M., L.G. Bundy, J.M. Powell, and T.W. Andraski. 2002. Dairy diet phosphorus effects on phosphorus losses in runoff from land-applied manure. Soil Sci. Soc. Am. J. 66:284-291.

Good, L.W. 2002. Mechanisms controlling phosphorus loss to water from animal manures and manure-amended soils. Dissertation. Department of Soil Science, University of Wisconsin-Madison.

Jokela, W.E. and M. D. Casler. 2010. Transport of phosphorus and nitrogen in surface runoff in a corn silage system: paired watershed methodology and calibration periods results. Journal of Great Lakes Research. In press.

Laboski, A. M., J. B. Peters, and L. G. Bundy. 2006. A2809 Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin. University of Wisconsin Extension. Madison, Wisconsin.

Molling, C. C., J. C. Strikwerda, J. M. Norman, C. A. Rodgers, R. Wayne, C. L. S. Morgan, G. R. Diak, and J. R. Mecikalski, 2005: Distributed runoff formulation designed for a precision agricultural-landscape modeling system. Journal of the American Water Resources Association. 41(6):1289-1313.

Moncrief, J., P. Bloom, N. Hansen, D. Mulla, P. Bierman, A. Birr, and M. Mozaffari. 2006. Minnesota Phosphorus Site Risk Index. Worksheet User's Guide. Department of Soil Water and Climate, University of Minnesota. Available at http://www.mnpi.umn.edu/.

Panuska, J. C. 2006. Dissolved and particulate phosphorus losses in rainfall and snowmelt runoff from corn fields. Dissertation. Department of Biological Systems Engineering, University of Wisconsin-Madison.

Panuska, J. C. and K. G. Karthikeyan. 2010. Phosphorus and organic matter enrichment in snowmelt and rainfall-runoff from three corn management systems. Geoderma 154: 253-260.

Roberson, T., L. G. Bundy, T. W. Andraski. 2007. Freezing and drying effects on potential plant contributions to phosphorus in runoff. J. Environ. Qual. 36:532-539.

Stuntebeck, T.D., M.J. Komiskey, D.W. Owens, and D.W. Hall. 2008. Methods of data collection, sample processing and data analysis for edge-of-field, streamgaging, subsurface tile, and meterological stations at Discovery Farms and Pioneer Farm in Wisconsin, 2001-7. U.S. Geological Survey Open File report 2008-1015. 51 p.

Studnicka, J. S. 2005. Factors affecting water extractable phosphorus in manure and its relationship to phosphorus losses in runoff. Master's thesis. Department of Soil Science. University of Wisconsin-Madison. Madison, Wisconsin.

USDA-Agricultural Research Service. 2006. RUSLE2 (November 13 2006). Available from http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm .

Vadas, P.A., L.B. Owens, and A.N. Sharpley. 2008. An empirical model for dissolved phosphorus in runoff from surface-applied fertilizers. Agric. Ecosys. Environ. 127-59-65.

Vadas, P.A., L.W. Good, P. A. Moore Jr., and N. Widman. 2009. Estimating phosphorus loss in runoff from manure and fertilizer for a phosphorus loss quantification tool. J. Environ. Qual. 38:1645-1653.

Vadas, P. A. and P. J. A. Kleinman. 2006. Effect of methodology in estimating and interpreting water-extractable phosphorus in animal manures. J. Environ. Qual. 35: 1151-1159.

Vadas, P.A., W.J. Gburek, A.N. Sharpley, P. J. Kleinamn, P. A. Morre, Jr., M. L. Cabrera, and R. D. Harmel. 2007. A model for phosphorus transformations and runoff loss for surface-applied manures. J. Environ. Qual. 36:324-332.

Vadas, P.A. 2006. Distribution of phosphorus in manure slurry and its infiltration after application to soils. J. Environ. Qual. 35:542-547.

Vadas, P. A., B. E. Haggard and W. J. Gburek. 2005. Predicting dissolved phosphorus in runoff from manured field plots. J. Environ. Qual. 34: 1447-1353.

Vadas, P.A., P.J.A. Kleinman, and A.N. Sharpley. 2005. Relating soil phosphorus to dissolved phosphorus in runoff: A single extraction coefficient for water quality modeling. J. Environ. Qual. 34:572-580.

Wienhold, B. J. and P. S. Miller. 2004. Phosphorus fractionation in manure from swine fed traditional and low-phytate corn diets. J. Environ. Qual. 33:389-393.

Wolkowski, R.P. 2003. Tillage Management for Manured Cropland. New Horizons in Soil Science, 2003, Issue 3. Department of Soil Science, University of Wisconsin-Madison.

Appendix
Frost-Free Period and Seasonal Rainfall Runoff Histograms for the Wisconsin P Index

The following tables give the average number of 24-hour precipitation events that fall into a given volume bin for the entire frost-free period and for each of the frost-free seasons for nine Wisconsin sites with long-term precipitation records. The rainfall data used in constructing these histograms were provided by the Wisconsin State Climatology Office, Madison, Wisconsin, http://www.aos.wisc.edu/~sco/. These histograms give the average number of events in each bin size for a 20-year period from April 1 1988 through March 31 2008. The frost-free (non-winter) period is defined as April 1 through November 30 in southern and central Wisconsin and April 15 through November 30 in northern Wisconsin (Spooner and Willow). Fall is defined here as September 15 through November 30; spring is April 1 through June 14 for all sites except Spooner and Willow, for which it is April 15 through June 14; and summer is June 15 through September 14.

Counties represented by each site in the P Index runoff volume calculations:

Blair - Buffalo, Chippewa, Clark, Dunn, Eau Claire, Jackson, LaCrosse, Monroe, Pepin, Pierce, St.Croix, Trempealeau

Burlington - Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, Waukesha

Chilton - Brown, Calumet, Door, Fond du Lac, Kewaunee, Manitowoc, Outagamie, Sheboygan, Winnebago

Crivitz - Florence, Forest, Marinette Oconto

Hancock - Adams, Green Lake, Juneau, Marathon, Marquette, Menominee, Portage, Shawano, Waupaca, Waushara, Wood

Madison - Columbia, Dane, Dodge, Green, Jefferson, Rock

Richland Center - Crawford, Grant, Iowa, Lafayette, Richland, Sauk, Vernon

Spooner - Barron, Bayfield, Burnett, Douglas, Polk, Rusk, Sawyer, Washburn

Willow - Ashland, Iron, Langlade, Lincoln, Oneida, Price, Taylor, Vilas

24-hour Precip.		Blair # of events				Burlington # of events			
Bin (in)	**Mid-pt (in)**	**Frost Free**	**Fall**	**Spring**	**Summer**	**Frost free**	**Fall**	**Spring**	**Summer**
>0 - 0.05	0.03	18.90	6.1	5.75	7.05	23.6	8.6	7.2	7.8
0.05 - 0.1	0.08	11.20	3.8	3.65	3.75	9.7	2.7	3.75	3.25
0.1 - 0.15	0.13	5.85	1.5	1.85	2.5	6.2	2.1	1.95	2.15
0.15 - 0.2	0.18	5.10	1.45	1.65	2	5.25	2.15	1.6	1.5
0.2 - 0.25	0.23	4.40	1.1	1.65	1.65	4.1	1.25	2.05	0.8
0.25 - 0.3	0.28	3.05	0.9	0.9	1.25	4.05	1.15	1.5	1.4
0.3 - 0.35	0.33	2.50	0.6	0.7	1.2	3.1	0.85	1.05	1.2
0.35 - 0.4	0.38	2.70	0.7	1.1	0.9	3.3	0.85	1.2	1.25
0.4 - 0.45	0.43	2.95	0.45	1.05	1.45	2.3	0.7	0.7	0.9
0.45 - 0.5	0.48	2.40	0.7	0.95	0.75	1.15	0.5	0.25	0.4
0.5 - 0.55	0.53	1.70	0.45	0.8	0.45	1.4	0.45	0.55	0.4
0.55 - 0.6	0.58	1.05	0.1	0.3	0.65	0.9	0.15	0.45	0.3
0.6 - 0.65	0.63	1.35	0.25	0.55	0.55	1.3	0.35	0.45	0.5
0.65 - 0.7	0.68	1.10	0.05	0.4	0.65	0.95	0.1	0.45	0.4
0.7 - 0.75	0.73	1.45	0.25	0.65	0.55	1.05	0.25	0.4	0.4
0.75 - 0.8	0.78	1.20	0.45	0.35	0.4	0.7	0.3	0.2	0.2
0.8 - 0.85	0.83	0.95	0.25	0.6	0.1	0.75	0.1	0.25	0.4
0.85 - 0.9	0.88	0.60	0.15	0.25	0.2	1.1	0.3	0.25	0.55
0.9 - 0.95	0.93	0.80	0.3	0.25	0.25	0.4	0.2	0.2	0
0.95 - 1	0.98	0.50	0.15	0.2	0.15	0.95	0.25	0.4	0.3
1-1.05	1.03	0.55	0.15	0.3	0.1	0.55	0.1	0.25	0.2
1.05 - 1.1	1.08	0.70	0.15	0.35	0.2	0.45	0.1	0.15	0.2
1.1 - 1.15	1.13	0.60	0.15	0.1	0.35	0.35	0.05	0.1	0.2
1.15 - 1.2	1.18	0.80	0.15	0.2	0.45	0.45	0.2	0.05	0.2
1.2 - 1.25	1.23	0.55	0.05	0.15	0.35	0.3	0	0.1	0.2
1.25 - 1.3	1.28	0.30	0	0.05	0.25	0.25	0.05	0.05	0.15
1.3 - 1.35	1.33	0.30	0.05	0	0.25	0.4	0.1	0.05	0.25
1.35 - 1.4	1.38	0.60	0.15	0.25	0.2	0.6	0.1	0.15	0.35
1.4 - 1.45	1.43	0.00	0	0	0	0	0	0	0
1.45 - 1.5	1.48	0.20	0.05	0.05	0.1	0.15	0.05	0.05	0.05
1.5 - 1.55	1.53	0.15	0	0.1	0.05	0.05	0	0.05	0
1.55 - 1.6	1.58	0.10	0	0.1	0	0.2	0.1	0.1	0
1.6 - 1.65	1.63	0.20	0	0.05	0.15	0.15	0	0.05	0.1
1.65 - 1.7	1.68	0.30	0	0.1	0.2	0.15	0.05	0.05	0.05
1.7 - 1.75	1.73	0.15	0	0.05	0.1	0	0	0	0
1.75 - 1.8	1.78	0.25	0	0.1	0.15	0.15	0.05	0.05	0.05
1.8 - 1.85	1.83	0.05	0	0	0.05	0.3	0	0.1	0.2
1.85 - 1.9	1.88	0.30	0.05	0.1	0.15	0.1	0	0	0.1
1.9 - 1.95	1.93	0.00	0	0	0	0.35	0.2	0.1	0.05
1.95 - 2	1.98	0.10	0.05	0	0.05	0.1	0.05	0	0.05
2 - 2.05	2.03	0.10	0.05	0	0.05	0.2	0.05	0.1	0.05
2.05 - 2.1	2.08	0.10	0	0	0.1	0.15	0	0.05	0.1
2.1 - 2.15	2.13	0.00	0	0	0	0.05	0	0	0.05
2.15 - 2.2	2.18	0.05	0	0	0.05	0	0	0	0
2.2 - 2.25	2.23	0.00	0	0	0	0	0	0	0
2.25 - 2.3	2.28	0.00	0	0	0	0	0	0	0
2.3 - 2.35	2.33	0.05	0	0	0.05	0.05	0	0	0.05
2.35 - 2.4	2.38	0.05	0	0.05	0	0.1	0.05	0.05	0
2.4 - 2.45	2.43	0.00	0	0	0	0	0	0	0
2.45 - 2.5	2.48	0.00	0	0	0	0.1	0	0	0.1
2.5 - 2.55	2.53	0.00	0	0	0	0.05	0	0	0.05
2.55 - 2.6	2.58	0.05	0	0	0.05	0	0	0	0
2.6 - 2.65	2.63	0.05	0	0	0.05	0.05	0	0.05	0
2.65 - 2.7	2.68	0.05	0	0.05	0	0	0	0	0
2.7 - 2.75	2.73	0.05	0	0.05	0	0	0	0	0
2.75 - 2.8	2.78	0.05	0	0.05	0	0.05	0.05	0	0
2.8 - 2.85	2.83	0.05	0	0.05	0	0	0	0	0

		Blair # of events				Burlington # of events			
Bin (in)	**Avg**	**Frost Free**	**Fall**	**Spring**	**Summer**	**Frost free**	**Fall**	**Spring**	**Summer**
2.85 - 2.9	2.88	0.00	0	0	0	0.05	0	0.05	0
2.9 - 2.95	2.93	0.00	0	0	0	0	0	0	0
2.95 - 3	2.98	0.00	0	0	0	0	0	0	0
3. -3.05	3.03	0.05	0	0	0.05	0	0	0	0
3.05 - 3.1	3.08	0.05	0	0	0.05	0	0	0	0
3.1 - 3.15	3.13	0.10	0	0.05	0.05	0	0	0	0
3.15 - 3.2	3.18	0.00	0	0	0	0.05	0	0.05	0
3.2 - 3.25	3.23	0.00	0	0	0	0	0	0	0
3.25 - 3.3	3.28	0.00	0	0	0	0	0	0	0
3.3 - 3.35	3.33	0.00	0	0	0	0	0	0	0
3.35 - 3.4	3.38	0.05	0.05	0	0	0	0	0	0
3.4 - 3.45	3.43	0.05	0	0.05	0	0	0	0	0
3.45 - 3.5	3.48	0.00	0	0	0	0.05	0	0	0.05
3.5 - 3.55	3.53	0.00	0	0	0	0	0	0	0
3.55 - 3.6	3.58	0.05	0	0	0.05	0	0	0	0
3.6 - 3.65	3.63	0.00	0	0	0	0	0	0	0
3.65 - 3.7	3.68	0.00	0	0	0	0	0	0	0
3.7 - 3.75	3.73	0.05	0	0	0.05	0	0	0	0
3.75 - 3.8	3.78	0.00	0	0	0	0	0	0	0
3.8 - 3.85	3.83	0.00	0	0	0	0	0	0	0
3.85 - 3.9	3.88	0.00	0	0	0	0	0	0	0
3.9 - 3.95	3.93	0.00	0	0	0	0	0	0	0
3.95 - 4	3.98	0.00	0	0	0	0	0	0	0
4.0-4.05	4.03	0.00	0	0	0	0	0	0	0
4.05-4.1	4.08	0.00	0	0	0	0	0	0	0
4.1 - 4.15	4.13	0.00	0	0	0	0	0	0	0
4.15 - 4.2	4.18	0.00	0	0	0	0	0	0	0
4.2 - 4.25	4.23	0.00	0	0	0	0	0	0	0
4.25 - 4.3	4.28	0.00	0	0	0	0	0	0	0
4.3 - 4.35	4.33	0.00	0	0	0	0	0	0	0
4.35 - 4.4	4.38	0.00	0	0	0	0	0	0	0
4.4 - 4.45	4.43	0.00	0	0	0	0	0	0	0
4.45 - 4.5	4.48	0.00	0	0	0	0	0	0	0
4.5 - 4.55	4.53	0.00	0	0	0	0	0	0	0
4.55 - 4.6	4.58	0.00	0	0	0	0	0	0	0
4.6 - 4.65	4.63	0.00	0	0	0	0	0	0	0
4.65 - 4.7	4.68	0.00	0	0	0	0	0	0	0
4.7 - 4.75	4.73	0.00	0	0	0	0	0	0	0
4.75 - 4.8	4.78	0.00	0	0	0	0	0	0	0
4.8 - 4.85	4.83	0.00	0	0	0	0	0	0	0
4.85 - 4.9	4.88	0.00	0	0	0	0	0	0	0
4.9 - 4.95	4.93	0.00	0	0	0	0	0	0	0
4.95 - 5	4.98	0.00	0	0	0	0	0	0	0
5.25 - 5.3	5.28	0.05	0.05	0	0	0	0	0	0
5.3 -5.35	5.33	0.05	0	0	0.05	0	0	0	0
5.35-5.4	5.38	0.00	0.00	0.00	0.00	0	0	0	0
5.4 - 5.45	5.43	0.00	0	0	0	0	0	0	0
5.65 - 5.7	5.68	0.05	0	0	0.05	0	0	0	0
5.7 - 5.75	5.73	0.00	0	0	0	0	0	0	0
6.05 -6.1	6.08	0.00	0	0	0	0	0	0	0
9.4 - 9.45	9.43	0.00	0	0	0	0	0	0	0

24-hour Precip.		Chilton # of events				Crivitz # of events			
Bin (in)	**Mid-pt (in)**	**Frost Free**	**Fall**	**Spring**	**Summer**	**Frost free**	**Fall**	**Spring**	**Summer**
>0 - 0.05	0.03	22.8	7.75	7.3	7.75	15.25	4.56	5.05	5.63
0.05 - 0.1	0.08	12.2	4	4.25	3.95	8.32	3.38	2.26	2.68
0.1 - 0.15	0.13	7.45	2.4	2.1	2.95	5.79	1.69	1.37	2.74
0.15 - 0.2	0.18	6.2	2.05	1.9	2.25	5.02	1.44	1.53	2.05
0.2 - 0.25	0.23	5.05	1.75	1.5	1.8	4.10	1.31	1.32	1.47
0.25 - 0.3	0.28	3.85	0.95	1.35	1.55	3.26	0.63	1.05	1.58
0.3 - 0.35	0.33	3.65	1	1.25	1.4	3.03	0.88	0.74	1.42
0.35 - 0.4	0.38	3.15	1.1	1.2	0.85	2.27	0.69	0.68	0.89
0.4 - 0.45	0.43	2.05	0.7	0.55	0.8	2.07	0.44	0.79	0.84
0.45 - 0.5	0.48	2.3	0.6	0.85	0.85	1.86	0.75	0.53	0.58
0.5 - 0.55	0.53	1.6	0.4	0.65	0.55	1.89	0.63	0.47	0.79
0.55 - 0.6	0.58	1.4	0.45	0.45	0.5	1.06	0.38	0.32	0.37
0.6 - 0.65	0.63	1.55	0.5	0.45	0.6	1.31	0.31	0.47	0.53
0.65 - 0.7	0.68	0.95	0.3	0.2	0.45	1.27	0.38	0.16	0.74
0.7 - 0.75	0.73	0.85	0.25	0.25	0.35	1.20	0.25	0.37	0.58
0.75 - 0.8	0.78	0.9	0.1	0.3	0.5	1.08	0.50	0.21	0.37
0.8 - 0.85	0.83	0.7	0.05	0.45	0.2	0.94	0.31	0.37	0.26
0.85 - 0.9	0.88	0.8	0.25	0.2	0.35	0.65	0.13	0.32	0.21
0.9 - 0.95	0.93	0.35	0	0.1	0.25	0.77	0.19	0.21	0.37
0.95 - 1	0.98	0.45	0.05	0.2	0.2	0.49	0.13	0.16	0.21
1-1.05	1.03	0.35	0.1	0	0.25	0.44	0.13	0.11	0.21
1.05 - 1.1	1.08	0.3	0.1	0.15	0.05	0.77	0.19	0.32	0.26
1.1 - 1.15	1.13	0.55	0.1	0.25	0.2	0.65	0.13	0.00	0.53
1.15 - 1.2	1.18	0.25	0.05	0.05	0.15	0.80	0.38	0.26	0.16
1.2 - 1.25	1.23	0.25	0.05	0.15	0.05	0.32	0.00	0.21	0.11
1.25 - 1.3	1.28	0.25	0.05	0.05	0.15	0.17	0.06	0.11	0.00
1.3 - 1.35	1.33	0.25	0.1	0	0.15	0.11	0.00	0.05	0.05
1.35 - 1.4	1.38	0.4	0.1	0.05	0.25	0.55	0.13	0.11	0.32
1.4 - 1.45	1.43	0	0	0	0	0.00	0.00	0.00	0.00
1.45 - 1.5	1.48	0.2	0	0.05	0.15	0.16	0.00	0.05	0.11
1.5 - 1.55	1.53	0.45	0.15	0.15	0.15	0.17	0.06	0.11	0.00
1.55 - 1.6	1.58	0.15	0.05	0	0.1	0.16	0.00	0.00	0.16
1.6 - 1.65	1.63	0.05	0	0	0.05	0.06	0.06	0.00	0.00
1.65 - 1.7	1.68	0.1	0	0.1	0	0.17	0.06	0.11	0.00
1.7 - 1.75	1.73	0.25	0	0.15	0.1	0.05	0.00	0.05	0.00
1.75 - 1.8	1.78	0.2	0.05	0.05	0.1	0.17	0.06	0.00	0.11
1.8 - 1.85	1.83	0.05	0	0.05	0	0.00	0.00	0.00	0.00
1.85 - 1.9	1.88	0.05	0	0.05	0	0.05	0.00	0.05	0.00
1.9 - 1.95	1.93	0.05	0	0.05	0	0.00	0.00	0.00	0.00
1.95 - 2	1.98	0.05	0.05	0	0	0.06	0.06	0.00	0.00
2 - 2.05	2.03	0	0	0	0	0.00	0.00	0.00	0.00
2.05 - 2.1	2.08	0	0	0	0	0.05	0.00	0.05	0.00
2.1 - 2.15	2.13	0.05	0	0.05	0	0.00	0.00	0.00	0.00
2.15 - 2.2	2.18	0	0	0	0	0.00	0.00	0.00	0.00
2.2 - 2.25	2.23	0	0	0	0	0.06	0.06	0.00	0.00
2.25 - 2.3	2.28	0.1	0.05	0	0.05	0.00	0.00	0.00	0.00
2.3 - 2.35	2.33	0	0	0	0	0.11	0.00	0.00	0.11
2.35 - 2.4	2.38	0.05	0	0.05	0	0.00	0.00	0.00	0.00
2.4 - 2.45	2.43	0.1	0	0	0.1	0.00	0.00	0.00	0.00
2.45 - 2.5	2.48	0.05	0	0	0.05	0.05	0.00	0.00	0.05
2.5 - 2.55	2.53	0.05	0	0	0.05	0.05	0.00	0.00	0.05
2.55 - 2.6	2.58	0.05	0	0	0.05	0.05	0.00	0.00	0.05
2.6 - 2.65	2.63	0.05	0	0	0.05	0.00	0.00	0.00	0.00
2.65 - 2.7	2.68	0	0	0	0	0.00	0.00	0.00	0.00
2.7 - 2.75	2.73	0	0	0	0	0.06	0.06	0.00	0.00
2.75 - 2.8	2.78	0	0	0	0	0.00	0.00	0.00	0.00
2.8 - 2.85	2.83	0	0	0	0	0.00	0.00	0.00	0.00

Bin (in)	Avg	Chilton # of events Frost Free	Fall	Spring	Summer	Crivitz # of events Frost free	Fall	Spring	Summer
2.85 - 2.9	2.88	0	0	0	0	0.06	0.06	0.00	0.00
2.9 - 2.95	2.93	0	0	0	0	0.00	0.00	0.00	0.00
2.95 - 3	2.98	0	0	0	0	0.00	0.00	0.00	0.00
3. -3.05	3.03	0.05	0	0	0.05	0.00	0.00	0.00	0.00
3.05 - 3.1	3.08	0	0	0	0	0.00	0.00	0.00	0.00
3.1 - 3.15	3.13	0	0	0	0	0.00	0.00	0.00	0.00
3.15 - 3.2	3.18	0	0	0	0	0.00	0.00	0.00	0.00
3.2 - 3.25	3.23	0	0	0	0	0.05	0.00	0.05	0.00
3.25 - 3.3	3.28	0	0	0	0	0.00	0.00	0.00	0.00
3.3 - 3.35	3.33	0	0	0	0	0.00	0.00	0.00	0.00
3.35 - 3.4	3.38	0	0	0	0	0.00	0.00	0.00	0.00
3.4 - 3.45	3.43	0	0	0	0	0.00	0.00	0.00	0.00
3.45 - 3.5	3.48	0	0	0	0	0.00	0.00	0.00	0.00
3.5 - 3.55	3.53	0	0	0	0	0.11	0.00	0.05	0.05
3.55 - 3.6	3.58	0	0	0	0	0	0	0	0
3.6 - 3.65	3.63	0	0	0	0	0	0	0	0
3.65 - 3.7	3.68	0	0	0	0	0	0	0	0
3.7 - 3.75	3.73	0	0	0	0	0	0	0	0
3.75 - 3.8	3.78	0	0	0	0	0	0	0	0
3.8 - 3.85	3.83	0	0	0	0	0	0	0	0
3.85 - 3.9	3.88	0	0	0	0	0	0	0	0
3.9 - 3.95	3.93	0	0	0	0	0	0	0	0
3.95 - 4	3.98	0	0	0	0	0	0	0	0
4.0-4.05	4.03	0	0	0	0	0	0	0	0
4.05-4.1	4.08	0	0	0	0	0	0	0	0
4.1 - 4.15	4.13	0	0	0	0	0	0	0	0
4.15 - 4.2	4.18	0	0	0	0	0	0	0	0
4.2 - 4.25	4.23	0	0	0	0	0	0	0	0
4.25 - 4.3	4.28	0	0	0	0	0	0	0	0
4.3 - 4.35	4.33	0	0	0	0	0	0	0	0
4.35 - 4.4	4.38	0	0	0	0	0	0	0	0
4.4 - 4.45	4.43	0	0	0	0	0	0	0	0
4.45 - 4.5	4.48	0	0	0	0	0	0	0	0
4.5 - 4.55	4.53	0	0	0	0	0	0	0	0
4.55 - 4.6	4.58	0	0	0	0	0	0	0	0
4.6 - 4.65	4.63	0	0	0	0	0	0	0	0
4.65 - 4.7	4.68	0	0	0	0	0	0	0	0
4.7 - 4.75	4.73	0	0	0	0	0	0	0	0
4.75 - 4.8	4.78	0	0	0	0	0	0	0	0
4.8 - 4.85	4.83	0	0	0	0	0	0	0	0
4.85 - 4.9	4.88	0	0	0	0	0	0	0	0
4.9 - 4.95	4.93	0	0	0	0	0	0	0	0
4.95 - 5	4.98	0	0	0	0	0	0	0	0
5.25 - 5.3	5.28	0	0	0	0	0	0	0	0
5.3 -5.35	5.33	0	0	0	0	0	0	0	0
5.35-5.4	5.38	0	0	0	0	0	0	0	0
5.4 - 5.45	5.43	0	0	0	0	0	0	0	0
5.65 - 5.7	5.68	0	0	0	0	0	0	0	0
5.7 - 5.75	5.73	0	0	0	0	0	0	0	0
6.05 -6.1	6.08	0	0	0	0	0	0	0	0
9.4 - 9.45	9.43	0	0	0	0	0	0	0	0

24-hour Precip.		Hancock # of events				Madison # of events			
Bin (in)	Mid-pt (in)	Frost Free	Fall	Spring	Summer	Frost free	Fall	Spring	Summer
>0 - 0.05	0.03	17.55	5.8	6.3	5.45	26.4	8.95	8.9	8.55
0.05 - 0.1	0.08	10.9	3.45	3.7	3.75	9.25	3.55	3.1	2.6
0.1 - 0.15	0.13	7.3	2.55	2.2	2.55	6.8	2	2.85	1.95
0.15 - 0.2	0.18	6.3	1.55	2.35	2.4	5.25	1.55	1.85	1.85
0.2 - 0.25	0.23	4.9	1.75	1.65	1.5	5.35	1.7	1.8	1.85
0.25 - 0.3	0.28	3.65	1.05	1.45	1.15	4.7	1.45	1.8	1.45
0.3 - 0.35	0.33	3.6	1.35	0.95	1.3	3.2	0.45	1.35	1.4
0.35 - 0.4	0.38	2.4	0.8	0.85	0.75	2.65	0.55	1.2	0.9
0.4 - 0.45	0.43	2.2	0.7	0.85	0.65	2.1	0.75	0.7	0.65
0.45 - 0.5	0.48	2.55	0.9	0.8	0.85	1.85	0.5	0.8	0.55
0.5 - 0.55	0.53	2.75	0.3	0.95	1.5	1.4	0.2	0.35	0.85
0.55 - 0.6	0.58	1.45	0.4	0.5	0.55	1.25	0.4	0.65	0.2
0.6 - 0.65	0.63	1.75	0.5	0.4	0.85	1.85	0.65	0.4	0.8
0.65 - 0.7	0.68	1.3	0.35	0.65	0.3	1	0.2	0.2	0.6
0.7 - 0.75	0.73	1.2	0.15	0.6	0.45	1.1	0.3	0.4	0.4
0.75 - 0.8	0.78	0.95	0.15	0.35	0.45	0.95	0.15	0.35	0.45
0.8 - 0.85	0.83	1.25	0.35	0.5	0.4	0.95	0.2	0.4	0.35
0.85 - 0.9	0.88	0.65	0.05	0.15	0.45	0.75	0.2	0.2	0.35
0.9 - 0.95	0.93	0.4	0.1	0.1	0.2	0.8	0.1	0.5	0.2
0.95 - 1	0.98	0.4	0	0.2	0.2	0.5	0.05	0.25	0.2
1-1.05	1.03	0.6	0.05	0.05	0.5	0.55	0.05	0.25	0.25
1.05 - 1.1	1.08	0.55	0.05	0.2	0.3	0.35	0.15	0.1	0.1
1.1 - 1.15	1.13	0.3	0.05	0.1	0.15	0.55	0.1	0.15	0.3
1.15 - 1.2	1.18	0.4	0.1	0.1	0.2	0.45	0.1	0.05	0.3
1.2 - 1.25	1.23	0.3	0.05	0.15	0.1	0.15	0	0.05	0.1
1.25 - 1.3	1.28	0.55	0.15	0	0.4	0.4	0	0.15	0.25
1.3 - 1.35	1.33	0.3	0	0.1	0.2	0.15	0.1	0.05	0
1.35 - 1.4	1.38	0.8	0.05	0.25	0.5	0.65	0.2	0.2	0.25
1.4 - 1.45	1.43	0	0	0	0	0	0	0	0
1.45 - 1.5	1.48	0.2	0	0.1	0.1	0.1	0	0.05	0.05
1.5 - 1.55	1.53	0.3	0.05	0.05	0.2	0.25	0.05	0.15	0.05
1.55 - 1.6	1.58	0	0	0	0	0.2	0	0.05	0.15
1.6 - 1.65	1.63	0	0	0	0	0.2	0	0.05	0.15
1.65 - 1.7	1.68	0.15	0.05	0	0.1	0.2	0.05	0.05	0.1
1.7 - 1.75	1.73	0.05	0	0	0.05	0.1	0.05	0	0.05
1.75 - 1.8	1.78	0.15	0	0.05	0.1	0.05	0	0	0.05
1.8 - 1.85	1.83	0.1	0	0.1	0	0.1	0	0	0.1
1.85 - 1.9	1.88	0.05	0	0.05	0	0.3	0.05	0.05	0.2
1.9 - 1.95	1.93	0	0	0	0	0.15	0	0	0.15
1.95 - 2	1.98	0.05	0	0.05	0	0.1	0	0	0.1
2 - 2.05	2.03	0	0	0	0	0.05	0	0.05	0
2.05 - 2.1	2.08	0.1	0	0.05	0.05	0.05	0	0.05	0
2.1 - 2.15	2.13	0.05	0.05	0	0	0.1	0	0	0.1
2.15 - 2.2	2.18	0.1	0	0.1	0	0.05	0	0	0.05
2.2 - 2.25	2.23	0.1	0	0	0.1	0.2	0	0.05	0.15
2.25 - 2.3	2.28	0.1	0.05	0.05	0	0.1	0	0	0.1
2.3 - 2.35	2.33	0.05	0	0.05	0	0.1	0	0.05	0.05
2.35 - 2.4	2.38	0	0	0	0	0	0	0	0
2.4 - 2.45	2.43	0.05	0.05	0	0	0.05	0	0	0.05
2.45 - 2.5	2.48	0.05	0	0	0.05	0.05	0.05	0	0
2.5 - 2.55	2.53	0	0	0	0	0	0	0	0
2.55 - 2.6	2.58	0.05	0	0	0.05	0.05	0	0.05	0
2.6 - 2.65	2.63	0	0	0	0	0	0	0	0
2.65 - 2.7	2.68	0	0	0	0	0.1	0	0	0.1
2.7 - 2.75	2.73	0	0	0	0	0	0	0	0
2.75 - 2.8	2.78	0	0	0	0	0	0	0	0
2.8 - 2.85	2.83	0.05	0	0.05	0	0	0	0	0

		Hancock # of events				Madison # of events			
Bin (in)	**Avg**	**Frost Free**	**Fall**	**Spring**	**Summer**	**Frost free**	**Fall**	**Spring**	**Summer**
2.85 - 2.9	2.88	0	0	0	0	0	0	0	0
2.9 - 2.95	2.93	0	0	0	0	0	0	0	0
2.95 - 3	2.98	0	0	0	0	0.05	0	0	0.05
3. -3.05	3.03	0	0	0	0	0	0	0	0
3.05 - 3.1	3.08	0	0	0	0	0.05	0	0.05	0
3.1 - 3.15	3.13	0	0	0	0	0	0	0	0
3.15 - 3.2	3.18	0	0	0	0	0.05	0	0	0.05
3.2 - 3.25	3.23	0.05	0	0.05	0	0	0	0	0
3.25 - 3.3	3.28	0	0	0	0	0	0	0	0
3.3 - 3.35	3.33	0	0	0	0	0	0	0	0
3.35 - 3.4	3.38	0.05	0	0.05	0	0.1	0	0	0.1
3.4 - 3.45	3.43	0	0	0	0	0.05	0.05	0	0
3.45 - 3.5	3.48	0	0	0	0	0.05	0	0.05	0
3.5 - 3.55	3.53	0.05	0	0	0.05	0	0	0	0
3.55 - 3.6	3.58	0	0	0	0	0	0	0	0
3.6 - 3.65	3.63	0	0	0	0	0	0	0	0
3.65 - 3.7	3.68	0	0	0	0	0.05	0	0.05	0
3.7 - 3.75	3.73	0.1	0	0	0.1	0.05	0	0	0.05
3.75 - 3.8	3.78	0	0	0	0	0	0	0	0
3.8 - 3.85	3.83	0	0	0	0	0	0	0	0
3.85 - 3.9	3.88	0	0	0	0	0	0	0	0
3.9 - 3.95	3.93	0	0	0	0	0	0	0	0
3.95 - 4	3.98	0	0	0	0	0	0	0	0
4.0-4.05	4.03	0	0	0	0	0	0	0	0
4.05-4.1	4.08	0	0	0	0	0	0	0	0
4.1 - 4.15	4.13	0	0	0	0	0	0	0	0
4.15 - 4.2	4.18	0	0	0	0	0	0	0	0
4.2 - 4.25	4.23	0	0	0	0	0	0	0	0
4.25 - 4.3	4.28	0	0	0	0	0	0	0	0
4.3 - 4.35	4.33	0	0	0	0	0	0	0	0
4.35 - 4.4	4.38	0	0	0	0	0	0	0	0
4.4 - 4.45	4.43	0	0	0	0	0	0	0	0
4.45 - 4.5	4.48	0	0	0	0	0	0	0	0
4.5 - 4.55	4.53	0	0	0	0	0.05	0	0	0.05
4.55 - 4.6	4.58	0	0	0	0	0	0	0	0
4.6 - 4.65	4.63	0	0	0	0	0	0	0	0
4.65 - 4.7	4.68	0	0	0	0	0	0	0	0
4.7 - 4.75	4.73	0	0	0	0	0	0	0	0
4.75 - 4.8	4.78	0	0	0	0	0	0	0	0
4.8 - 4.85	4.83	0	0	0	0	0	0	0	0
4.85 - 4.9	4.88	0	0	0	0	0	0	0	0
4.9 - 4.95	4.93	0	0	0	0	0	0	0	0
4.95 - 5	4.98	0	0	0	0	0	0	0	0
5.25 - 5.3	5.28	0	0	0	0	0	0	0	0
5.3 -5.35	5.33	0	0	0	0	0	0	0	0
5.35-5.4	5.38	0	0	0	0	0	0	0	0
5.4 - 5.45	5.43	0	0	0	0	0	0	0	0
5.65 - 5.7	5.68	0	0	0	0	0	0	0	0
5.7 - 5.75	5.73	0.05	0	0	0.05	0	0	0	0
6.05 -6.1	6.08	0	0	0	0	0	0	0	0
9.4 - 9.45	9.43	0.05	0	0	0.05	0	0	0	0

24-hour Precip.		Richland Center # of events				Spooner # of events			
Bin (in)	**Mid-pt (in)**	**Frost Free**	**Fall**	**Spring**	**Summer**	**Frost free**	**Fall**	**Spring**	**Summer**
>0 - 0.05	0.03	23.38	8.32	7.22	7.84	22.2	7.4	6.2	8.6
0.05 - 0.1	0.08	10.18	3.32	3.39	3.47	10	3.05	3.1	3.85
0.1 - 0.15	0.13	6.28	1.84	2.39	2.05	7.45	2.8	2.25	2.4
0.15 - 0.2	0.18	4.73	1.21	1.83	1.68	5.1	1.45	1.65	2
0.2 - 0.25	0.23	4.51	1.32	1.67	1.53	3.85	1.15	1.25	1.45
0.25 - 0.3	0.28	3.64	1.21	1.11	1.32	3.35	1.05	1.15	1.15
0.3 - 0.35	0.33	3.34	1.00	1.44	0.89	3.6	1.25	1.15	1.2
0.35 - 0.4	0.38	2.84	0.84	1.00	1.00	1.95	0.45	0.65	0.85
0.4 - 0.45	0.43	2.20	0.53	0.72	0.95	1.75	0.4	0.55	0.8
0.45 - 0.5	0.48	1.83	0.32	0.72	0.79	2.45	0.6	0.5	1.35
0.5 - 0.55	0.53	1.45	0.42	0.50	0.53	2.35	0.55	1.05	0.75
0.55 - 0.6	0.58	1.51	0.53	0.72	0.26	1.55	0.5	0.3	0.75
0.6 - 0.65	0.63	1.38	0.32	0.22	0.84	1.6	0.55	0.45	0.6
0.65 - 0.7	0.68	1.13	0.21	0.50	0.42	1	0.2	0.35	0.45
0.7 - 0.75	0.73	1.07	0.05	0.39	0.63	0.75	0.2	0.1	0.45
0.75 - 0.8	0.78	1.17	0.37	0.28	0.53	0.9	0.2	0.25	0.45
0.8 - 0.85	0.83	1.08	0.26	0.44	0.37	1.25	0.2	0.35	0.7
0.85 - 0.9	0.88	0.75	0.21	0.28	0.26	0.9	0.2	0.15	0.55
0.9 - 0.95	0.93	0.80	0.37	0.28	0.16	0.35	0.05	0.1	0.2
0.95 - 1	0.98	0.96	0.26	0.17	0.53	0.65	0.2	0.15	0.3
1-1.05	1.03	0.48	0.16	0.11	0.21	0.4	0.15	0	0.25
1.05 - 1.1	1.08	0.32	0.00	0.11	0.21	0.35	0.05	0.05	0.25
1.1 - 1.15	1.13	0.64	0.00	0.22	0.42	0.6	0.15	0.25	0.2
1.15 - 1.2	1.18	0.64	0.05	0.11	0.47	0.55	0.2	0.2	0.15
1.2 - 1.25	1.23	0.48	0.11	0.17	0.21	0.35	0.15	0.1	0.1
1.25 - 1.3	1.28	0.54	0.00	0.17	0.37	0.35	0	0.1	0.25
1.3 - 1.35	1.33	0.42	0.05	0.06	0.32	0.3	0.05	0.1	0.15
1.35 - 1.4	1.38	0.38	0.11	0.17	0.11	0.35	0.05	0.05	0.25
1.4 - 1.45	1.43	0.00	0.00	0.00	0.00	0	0	0	0
1.45 - 1.5	1.48	0.27	0.16	0.06	0.05	0.35	0	0.15	0.2
1.5 - 1.55	1.53	0.43	0.00	0.17	0.26	0.15	0	0	0.15
1.55 - 1.6	1.58	0.27	0.05	0.11	0.11	0.1	0	0.05	0.05
1.6 - 1.65	1.63	0.11	0.00	0.00	0.11	0.1	0.05	0	0.05
1.65 - 1.7	1.68	0.32	0.00	0.17	0.16	0.1	0	0.05	0.05
1.7 - 1.75	1.73	0.27	0.05	0.06	0.16	0.05	0	0	0.05
1.75 - 1.8	1.78	0.21	0.05	0.06	0.11	0.05	0	0	0.05
1.8 - 1.85	1.83	0.11	0.00	0.06	0.05	0.05	0.05	0	0
1.85 - 1.9	1.88	0.11	0.00	0.06	0.05	0.1	0	0	0.1
1.9 - 1.95	1.93	0.16	0.05	0.00	0.11	0.1	0	0	0.1
1.95 - 2	1.98	0.27	0.00	0.17	0.11	0.15	0	0	0.15
2 - 2.05	2.03	0.05	0.00	0.00	0.05	0.05	0.05	0	0
2.05 - 2.1	2.08	0.21	0.00	0.06	0.16	0.05	0.05	0	0
2.1 - 2.15	2.13	0.05	0.00	0.00	0.05	0.05	0	0.05	0
2.15 - 2.2	2.18	0.05	0.00	0.00	0.05	0.1	0	0	0.1
2.2 - 2.25	2.23	0.05	0.00	0.00	0.05	0.05	0.05	0	0
2.25 - 2.3	2.28	0.05	0.00	0.00	0.05	0.05	0	0	0.05
2.3 - 2.35	2.33	0.05	0.00	0.00	0.05	0.05	0	0	0.05
2.35 - 2.4	2.38	0.06	0.00	0.06	0.00	0	0	0	0
2.4 - 2.45	2.43	0.00	0.00	0.00	0.00	0.05	0	0.05	0
2.45 - 2.5	2.48	0.05	0.00	0.00	0.05	0.1	0	0.1	0
2.5 - 2.55	2.53	0.16	0.00	0.06	0.11	0.05	0.05	0	0
2.55 - 2.6	2.58	0.11	0.00	0.06	0.05	0	0	0	0
2.6 - 2.65	2.63	0.05	0.00	0.00	0.05	0.05	0.05	0	0
2.65 - 2.7	2.68	0.05	0.05	0.00	0.00	0.05	0	0	0.05
2.7 - 2.75	2.73	0.05	0.05	0.00	0.00	0.1	0.05	0	0.05
2.75 - 2.8	2.78	0.00	0.00	0.00	0.00	0	0	0	0
2.8 - 2.85	2.83	0.11	0.00	0.06	0.05	0	0	0	0

		Richland Center # of events				Spooner # of events			
Bin (in)	**Avg**	**Frost Free**	**Fall**	**Spring**	**Summer**	**Frost free**	**Fall**	**Spring**	**Summer**
2.85 - 2.9	2.88	0.00	0.00	0.00	0.00	0	0	0	0
2.9 - 2.95	2.93	0.00	0.00	0.00	0.00	0	0	0	0
2.95 - 3	2.98	0.16	0.00	0.11	0.05	0	0	0	0
3. -3.05	3.03	0.05	0.00	0.00	0.05	0.05	0.05	0	0
3.05 - 3.1	3.08	0.00	0.00	0.00	0.00	0.05	0	0	0.05
3.1 - 3.15	3.13	0.00	0.00	0.00	0.00	0	0	0	0
3.15 - 3.2	3.18	0.00	0.00	0.00	0.00	0	0	0	0
3.2 - 3.25	3.23	0.00	0.00	0.00	0.00	0	0	0	0
3.25 - 3.3	3.28	0.00	0.00	0.00	0.00	0	0	0	0
3.3 - 3.35	3.33	0.00	0.00	0.00	0.00	0.05	0	0	0.05
3.35 - 3.4	3.38	0.00	0.00	0.00	0.00	0	0	0	0
3.4 - 3.45	3.43	0.00	0.00	0.00	0.00	0	0	0	0
3.45 - 3.5	3.48	0.00	0.00	0.00	0.00	0.05	0	0	0.05
3.5 - 3.55	3.53	0.00	0.00	0.00	0.00	0	0	0	0
3.55 - 3.6	3.58	0.00	0.00	0.00	0.00	0	0	0	0
3.6 - 3.65	3.63	0.00	0.00	0.00	0.00	0	0	0	0
3.65 - 3.7	3.68	0.06	0.00	0.06	0.00	0.05	0	0	0.05
3.7 - 3.75	3.73	0.05	0.00	0.00	0.05	0	0	0	0
3.75 - 3.8	3.78	0.00	0.00	0.00	0.00	0	0	0	0
3.8 - 3.85	3.83	0.00	0.00	0.00	0.00	0	0	0	0
3.85 - 3.9	3.88	0.05	0.00	0.00	0.05	0.05	0.05	0	0
3.9 - 3.95	3.93	0.06	0.00	0.06	0.00	0	0	0	0
3.95 - 4	3.98	0.00	0.00	0.00	0.00	0	0	0	0
4.0-4.05	4.03	0.00	0.00	0.00	0.00	0	0	0	0
4.05-4.1	4.08	0.00	0.00	0.00	0.00	0	0	0	0
4.1 - 4.15	4.13	0.00	0.00	0.00	0.00	0	0	0	0
4.15 - 4.2	4.18	0.00	0.00	0.00	0.00	0	0	0	0
4.2 - 4.25	4.23	0.00	0.00	0.00	0.00	0	0	0	0
4.25 - 4.3	4.28	0.00	0.00	0.00	0.00	0	0	0	0
4.3 - 4.35	4.33	0.00	0.00	0.00	0.00	0	0	0	0
4.35 - 4.4	4.38	0.00	0.00	0.00	0.00	0	0	0	0
4.4 - 4.45	4.43	0.00	0.00	0.00	0.00	0	0	0	0
4.45 - 4.5	4.48	0.00	0.00	0.00	0.00	0	0	0	0
4.5 - 4.55	4.53	0.00	0.00	0.00	0.00	0	0	0	0
4.55 - 4.6	4.58	0.00	0.00	0.00	0.00	0	0	0	0
4.6 - 4.65	4.63	0.00	0.00	0.00	0.00	0	0	0	0
4.65 - 4.7	4.68	0.00	0.00	0.00	0.00	0	0	0	0
4.7 - 4.75	4.73	0.00	0.00	0.00	0.00	0	0	0	0
4.75 - 4.8	4.78	0.00	0.00	0.00	0.00	0	0	0	0
4.8 - 4.85	4.83	0.00	0.00	0.00	0.00	0	0	0	0
4.85 - 4.9	4.88	0.00	0.00	0.00	0.00	0	0	0	0
4.9 - 4.95	4.93	0.00	0.00	0.00	0.00	0	0	0	0
4.95 - 5	4.98	0.00	0.00	0.00	0.00	0	0	0	0
5.25 - 5.3	5.28	0.00	0.00	0.00	0.00	0	0	0	0
5.3 -5.35	5.33	0.00	0.00	0.00	0.00	0	0	0	0
5.35-5.4	5.38	0.05	0.00	0.00	0.05	0	0	0	0
5.4 - 5.45	5.43	0.05	0.00	0.00	0.05	0	0	0	0
5.65 - 5.7	5.68	0.00	0.00	0.00	0.00	0	0	0	0
5.7 - 5.75	5.73	0.00	0.00	0.00	0.00	0	0	0	0
6.05 -6.1	6.08	0.00	0.00	0.00	0.00	0	0	0	0
9.4 - 9.45	9.43	0.00	0	0	0.00	0	0	0	0

24-hour Precip.		Willow # of events			
Bin (in)	Mid-pt (in)	Frost Free	Fall	Spring	Summer
>0 - 0.05	0.03	14.4	5.4	4.15	4.85
0.05 - 0.1	0.08	11.35	4.45	3.1	3.8
0.1 - 0.15	0.13	8.75	3.35	2.5	2.9
0.15 - 0.2	0.18	4.9	1.45	1.6	1.85
0.2 - 0.25	0.23	5.35	1.6	1.35	2.4
0.25 - 0.3	0.28	2.5	0.95	0.6	0.95
0.3 - 0.35	0.33	3.7	1.05	1.15	1.5
0.35 - 0.4	0.38	3.45	1.05	0.9	1.5
0.4 - 0.45	0.43	2.65	0.6	0.85	1.2
0.45 - 0.5	0.48	2.5	0.4	0.85	1.25
0.5 - 0.55	0.53	2	0.45	0.6	0.95
0.55 - 0.6	0.58	1.55	0.45	0.4	0.7
0.6 - 0.65	0.63	1.25	0.5	0.4	0.35
0.65 - 0.7	0.68	0.95	0.25	0.2	0.5
0.7 - 0.75	0.73	0.9	0.15	0.3	0.45
0.75 - 0.8	0.78	0.9	0.25	0.3	0.35
0.8 - 0.85	0.83	0.4	0.2	0.05	0.15
0.85 - 0.9	0.88	0.35	0.1	0.1	0.15
0.9 - 0.95	0.93	0.75	0.15	0.4	0.2
0.95 - 1	0.98	0.65	0.1	0.25	0.3
1-1.05	1.03	0.7	0.1	0.25	0.35
1.05 - 1.1	1.08	0.35	0.2	0	0.15
1.1 - 1.15	1.13	0.55	0.25	0.05	0.25
1.15 - 1.2	1.18	0.35	0	0.1	0.25
1.2 - 1.25	1.23	0.4	0.1	0.15	0.15
1.25 - 1.3	1.28	0.3	0.1	0	0.2
1.3 - 1.35	1.33	0.2	0.05	0.05	0.1
1.35 - 1.4	1.38	0.25	0.1	0	0.15
1.4 - 1.45	1.43	0	0	0	0
1.45 - 1.5	1.48	0.15	0	0.05	0.1
1.5 - 1.55	1.53	0.25	0.05	0.1	0.1
1.55 - 1.6	1.58	0	0	0	0
1.6 - 1.65	1.63	0	0	0	0
1.65 - 1.7	1.68	0.1	0.05	0	0.05
1.7 - 1.75	1.73	0.1	0	0	0.1
1.75 - 1.8	1.78	0.1	0	0	0.1
1.8 - 1.85	1.83	0.1	0	0	0.1
1.85 - 1.9	1.88	0	0	0	0
1.9 - 1.95	1.93	0	0	0	0
1.95 - 2	1.98	0.05	0	0	0.05
2 - 2.05	2.03	0.1	0.05	0	0.05
2.05 - 2.1	2.08	0.1	0	0	0.1
2.1 - 2.15	2.13	0	0	0	0
2.15 - 2.2	2.18	0.05	0	0	0.05
2.2 - 2.25	2.23	0.05	0	0	0.05
2.25 - 2.3	2.28	0.1	0	0	0.1
2.3 - 2.35	2.33	0	0	0	0
2.35 - 2.4	2.38	0.05	0	0	0.05
2.4 - 2.45	2.43	0.05	0	0	0.05
2.45 - 2.5	2.48	0.1	0	0	0.1
2.5 - 2.55	2.53	0.05	0	0.05	0
2.55 - 2.6	2.58	0.05	0	0	0.05
2.6 - 2.65	2.63	0	0	0	0
2.65 - 2.7	2.68	0	0	0	0
2.7 - 2.75	2.73	0.05	0	0	0.05
2.75 - 2.8	2.78	0	0	0	0
2.8 - 2.85	2.83	0.05	0.05	0	0

		Willow # of events			
Bin (in)	Avg	Frost Free	Fall	Spring	Summer
2.85 - 2.9	2.88	0.05	0	0.05	0
2.9 - 2.95	2.93	0	0	0	0
2.95 - 3	2.98	0	0	0	0
3. -3.05	3.03	0	0	0	0
3.05 - 3.1	3.08	0	0	0	0
3.1 - 3.15	3.13	0	0	0	0
3.15 - 3.2	3.18	0	0	0	0
3.2 - 3.25	3.23	0	0	0	0
3.25 - 3.3	3.28	0	0	0	0
3.3 - 3.35	3.33	0	0	0	0
3.35 - 3.4	3.38	0	0	0	0
3.4 - 3.45	3.43	0	0	0	0
3.45 - 3.5	3.48	0	0	0	0
3.5 - 3.55	3.53	0	0	0	0
3.55 - 3.6	3.58	0	0	0	0
3.6 - 3.65	3.63	0	0	0	0
3.65 - 3.7	3.68	0	0	0	0
3.7 - 3.75	3.73	0	0	0	0
3.75 - 3.8	3.78	0	0	0	0
3.8 - 3.85	3.83	0	0	0	0
3.85 - 3.9	3.88	0	0	0	0
3.9 - 3.95	3.93	0	0	0	0
3.95 - 4	3.98	0	0	0	0
4.0-4.05	4.03	0	0	0	0
4.05-4.1	4.08	0	0	0	0
4.1 - 4.15	4.13	0	0	0	0
4.15 - 4.2	4.18	0	0	0	0
4.2 - 4.25	4.23	0	0	0	0
4.25 - 4.3	4.28	0	0	0	0
4.3 - 4.35	4.33	0	0	0	0
4.35 - 4.4	4.38	0	0	0	0
4.4 - 4.45	4.43	0	0	0	0
4.45 - 4.5	4.48	0	0	0	0
4.5 - 4.55	4.53	0	0	0	0
4.55 - 4.6	4.58	0	0	0	0
4.6 - 4.65	4.63	0	0	0	0
4.65 - 4.7	4.68	0	0	0	0
4.7 - 4.75	4.73	0	0	0	0
4.75 - 4.8	4.78	0	0	0	0
4.8 - 4.85	4.83	0	0	0	0
4.85 - 4.9	4.88	0	0	0	0
4.9 - 4.95	4.93	0	0	0	0
4.95 - 5	4.98	0	0	0	0
5.25 - 5.3	5.28	0.05	0.05	0	0
5.3 -5.35	5.33	0	0	0	0
5.35-5.4	5.38	0	0	0	0
5.4 - 5.45	5.43	0	0	0	0
5.65 - 5.7	5.68	0	0	0	0
5.7 - 5.75	5.73	0	0	0	0
6.05 -6.1	6.08	0	0	0	0
9.4 - 9.45	9.43	0	0	0	0