CBP/TRS-310-16

Cover Crops Practices For Use in Phase 6.0 of the Chesapeake Bay Program Watershed Model

Chesapeake Bay Program
Science. Restoration. Partnership.

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Prepared for

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Contents

ACRONYMS AND ABBREVIATIONS 8

SUMMARY OF RECOMMENDATIONS 10

1 INTRODUCTION 10

2 PRACTICE DEFINITIONS 10

3 EFFECTIVENESS ESTIMATES 12

3.1 Summary of Effectiveness Estimates 12
3.2 Examples of Application of Revised Effectiveness Estimates 14

4 REVIEW OF LITERATURE AND DATA GAPS 16

5 APPLICATION OF PRACTICE ESTIMATES 21

5.1 Load Sources 21
5.2 Practice Baseline 21
5.3 Hydrologic Conditions 22
5.4 Sediment 22
5.5 Species of Nitrogen and Phosphorus 22
The Panel recommended reduction efficiencies only for total N, total P, and total sediment. 22
5.6 Geographic Considerations 22
5.7 Temporal Considerations 22
5.8 Practice Limitations 22
5.9 Potential Interactions with other Practices 22

6 PRACTICE MONITORING AND REPORTING 23

6.1 Phase 6.0 Cover Crops Tracking, Verification, and Reporting 23
6.2 Future Verification of Cover Crops Practices 24

7 REFERENCES 26

APPENDIX A: TECHNICAL REQUIREMENTS FOR REPORTING AND SIMULATING COVER CROP BMPS IN THE PHASE 6 WATERSHED MODEL 29

APPENDIX B: METHODS TO ESTIMATE HISTORIC IMPLEMENTATION 34

APPENDIX C: COVER CROPS PHASE 6.0 EXPERT PANEL CHARGE DOCUMENT 35

APPENDIX D: APPROVED COVER CROPS EXPERT PANEL MEETING MINUTES 39

APPENDIX E: CONSOLIDATED RESPONSE TO COMMENTS: 58

PA SCC & DEP: PAGE 8 – PLEASE PROVIDE FURTHER EXPLANATION REGARDING THE STATEMENT MADE IN THE REPORT, AS QUOTED BELOW: 58

"THE PANEL CONSIDERED OPTIONS FOR REVISING COVER CROP P REDUCTION CREDITS BUT AT THIS TIME RECOMMENDS EFFECTIVENESS ESTIMATES ONLY FOR NITROGEN (N) FOR TWO PRINCIPAL REASONS. FIRST, COVER CROPS PRIMARILY FUNCTION TO TRAP OR SEQUESTER N, WITH ONLY MINOR REDUCTIONS FOR PHOSPHORUS (P) AND SEDIMENT. SECOND, AS OF PUBLICATION OF THIS REPORT, SUFFICIENT DATA ARE NOT AVAILABLE ON THE EFFECT OF COVER CROPS ON P AND SEDIMENT. THE PANEL RECOMMENDS THAT CONSIDERATION OF P AND SEDIMENT REDUCTIONS FOR THE NEW COVER CROP BMPS BE UNDERTAKEN AT A LATER TIME AND THAT PLACEHOLDER EFFICIENCY VALUES OF ZERO BE MAINTAINED FOR P AND SEDIMENT UNTIL REASONABLE ESTIMATES CAN BE DERIVED FROM BEST AVAILABLE DATA OR AN INDEPENDENT AGRICULTURAL MODEL SUCH AS

APEX." 58

WE RESPECTFULLY REQUEST AN EXPLANATION AS TO HOW THE CONCLUSION WAS MADE THAT THERE ARE ONLY MINOR REDUCTIONS IN P AND SEDIMENT, WHEN SOIL EROSION IS ONE OF THE PRIMARY CONSIDERATIONS IN THE NRCS COVER CROP STANDARD. ON PAGE 7, THE REPORT STATES THE FOLLOWING, "THIS PRACTICE WILL ONLY BE CREDITED WHERE LOCAL USDA-NRCS REVIEW CONSIDERS THE PLANTING ADEQUATE TO PROVIDE THE LEVEL OF SOIL COVER NEEDED TO PREVENT SOIL EROSION." THIS MAKES SENSE, AS USDA-NRCS COVER CROP STANDARD (340) INCLUDES REDUCTION OF SOIL EROSION FROM WIND AND WATER AS ONE OF THE PURPOSES. PENNSYLVANIA USDA-NRCS1 STATES, "COVER CROPS REDUCE RUNOFF, BUILD SOIL ORGANIC MATTER, RETAIN NUTRIENTS, FIX ATMOSPHERIC NITROGEN, REDUCE AND ALLEVIATE COMPACTION, PROVIDE WEED CONTROL, AND IMPROVE SOIL HEALTH." THE BEST DESCRIPTION OF THE BENEFITS OF COVER CROP THAT WE FOUND IS FROM THE NEW YORK USDA-NRCS2 WEBSITE: 58

"THE PROTECTIVE CANOPY FORMED BY A COVER CROP REDUCES THE IMPACT OF RAIN DROPS ON THE SOIL SURFACE THEREBY DECREASING THE BREAKDOWN OF SOILS AGGREGATES. THIS GREATLY REDUCES SOIL EROSION AND RUNOFF, AND INCREASES INFILTRATION. DECREASED SOIL LOSS AND RUNOFF TRANSLATES TO REDUCED TRANSPORT OF VALUABLE NUTRIENTS, PESTICIDES, HERBICIDES, AND HARMFUL PATHOGENS ASSOCIATED WITH MANURE FROM FARMLAND THAT DEGRADE THE QUALITY OF STREAMS, RIVERS AND WATER BODIES AND POSE A THREAT TO HUMAN HEALTH. A COVER CROP SLOWS THE VELOCITY OF RUNOFF FROM RAINFALL AND SNOWMELT, REDUCING SOIL LOSS DUE TO SHEET AND RILL EROSION. OVER TIME, A COVER CROP REGIMEN WILL INCREASE SOIL ORGANIC MATTER, LEADING TO IMPROVEMENTS IN SOIL STRUCTURE, STABILITY, AND INCREASED MOISTURE AND NUTRIENT HOLDING CAPACITY FOR PLANT GROWTH. THESE PROPERTIES WILL REDUCE RUNOFF THROUGH IMPROVED INFILTRATION (MOVEMENT OF WATER THROUGH THE SOIL SURFACE) AND PERCOLATION (MOVEMENT OF WATER THROUGH THE SOIL PROFILE)." 58

IN THE TABLES, THERE ARE MANY 0 AND NA VALUES ASSOCIATED WITH THE PHOSPHORUS AND SEDIMENT EFFICIENCY ESTIMATES. AS STATED IN THE REPORT, THE PANEL SUGGESTED PLACEHOLDERS (0) FOR P AND SEDIMENT. WOULD ALL OF THE NA VALUES BE PROVIDED THAT PLACEHOLDER VALUE (0) AS WELL? 58

WE ALSO REQUEST AN EXPLANATION REGARDING THE STATEMENT OF INSUFFICIENT DATA TO PROVIDE UPDATES ON THE PHOSPHORUS AND SEDIMENT EFFICIENCY VALUES. WE WOULD SURMISE THAT THERE IS RESEARCH TO SUPPORT THE CLAIMS MADE BY USDA-NRCS, LAND GRANT UNIVERSITIES, AND OTHERS ON THE BENEFITS OF COVER CROP, INCLUDING THE REDUCTION OF PHOSPHORUS AND SEDIMENT. 58

IN A VERY LIMITED LITERATURE SEARCH, WE WERE ABLE TO FIND SOME RESEARCH DONE BY STAFF AT USDA-ARS IN THE MID-WEST AND OTHER REGIONS OF THE US THAT MAY BE USEFUL IN DETERMINING ESTIMATES OF SEDIMENT REDUCTION EFFICIENCIES : 59

- **DABNEY, S.M., J.A. DELGADO AND D.W. REEVES. 2001. USING WINTER COVER CROPS TO IMPROVE SOIL AND WATER QUALITY. COMMUN SOIL SCI. PLANT ANAL.. 32(7-8): 1221-1250. ... 59**
- **DABNEY, S.M., GUMIERE, S.J. 2013. EROSION BY WATER: VEGETATIVE CONTROL. ENCYCLOPEDIA OF ENVIRONMENTAL MANAGEMENT. S.E. JORGENSEN, ED. TAYLOR & FRANCIS: NEW YORK, II:1036-1043. ..... 59**
- **KASPAR, T. COVER CROPS FOR SOIL AND WATER QUALITY. USDA-ARS, NATIONAL LABORATORY FOR AGRICULTURE AND THE ENVIRONMENT. AMES, IA HTTPS://WWW.AGRY.PURDUE.EDU/CCA/2009/CCA%202009/PROCEEDINGS/KASPARCOVER%20CROPS%20FOR%20SOIL%20AND%20WATER%20QUALITY%2010-23-092%20FINAL%20VERSION%2011-24.PDF 59**
- **KASPAR, T.C., SINGER, J.W. 2011. THE USE OF COVER CROPS TO MANAGE SOIL. IN:**

HATFIELD, J.L., SAUER, T.J., EDITORS. SOIL MANAGEMENT: BUILDING A STABLE BASE FOR AGRICULTURE. MADISON, WI: AMERICAN SOCIETY OF AGRONOMY AND SOIL SCIENCE SOCIETY OF AMERICA. P. 321-337. 59

- **LANGDALE, G.W., BLEVINS, R.L., KARLEN, D.L., MCCOOL, D.K., NEARING, M.A., SKIDMORE, E.L., THOMAS, A.W., TYLER, D.D., AND WILLIAMS, J.R. 1991. COVER CROP EFFECTS ON SOIL EROSION BY WIND AND WATER. IN: HARGROVE, W.L. (ED) COVER CROPS FOR CLEAN WATER. PROCEEDINGS INTERNATIONAL CONFERENCE, APRIL 9-11, 1991, JACKSON, TN. SOIL AND WATER CONSERVATION SOCIETY OF AMERICA, ANKENY, IA. HTTPS://WWW.ARS.USDA.GOV/ARSUSERFILES/30200525/91-%20COVER%20CROP%20EFFECTS%20ON%20SOIL%20EROSION.PDF "A PRINCIPAL FUNCTION OF COVER CROPS IS TO PREVENT LAND DEGRADATION BY WIND AND WATER EROSION." 59**

- **MOORE, E.B., KASPAR, T.C., WIEDENHOEFT, M.H., CAMBARDELLA, C.A. 2014. RYE COVER CROP EFFECTS ON SOIL QUALITY IN NO-TILL CORN SILAGE-SOYBEAN CROPPING SYSTEMS. SOIL SCIENCE SOCIETY OF AMERICA JOURNAL. 78(3):968-976. DOI: 10.2136/SSSAJ2013.09.0401. . 59**

- **NAIR, A., KASPAR, T.C. 2015. COVER CROPS IN VEGETABLE PRODUCTION SYSTEMS. EXTENSION PUBLICATIONS. HORT 3026. IOWA STATE UNIVERSITY EXTENSION AND OUTREACH. 59**

- **SHARPLEY, A.N., SMITH, S.J. EFFECTS OF COVER CROPS ON SURFACE WATER QUALITY. USDA-ARS, NATIONAL AGRICULTURAL LABORATORY, DURANT, OK. HTTP://WWW.SWCS.ORG/DOCUMENTS/FILELIBRARY/CCCW3SURFACE_79CEC411D2D30.PDF . 59**

THE PANEL WAS BROUGHT TOGETHER IN AUGUST, 2015 AND THE PANEL CHARGE AND SCOPE (PAGE 25) INCLUDED ADDRESSING COVER CROP REDUCTION EFFICIENCIES FOR N, P AND SEDIMENT. AT SOME POINT, THE DECISION WAS MADE TO FOCUS SOLELY ON N EFFICIENCIES. IT SEEMS THAT THE LIMITED TIME FRAME BY WHICH THE PANEL HAD FOR DEVELOPMENT OF RECOMMENDATIONS MAY HAVE BEEN THE ISSUE, NOT THE LACK OF SUFFICIENT DATA. 59

MIGHT THE PANEL RECOMMEND USING RUSLE2 TO PROVIDE ESTIMATES ON RELATIVE EFFECT OF COVER CROP ON SEDIMENT REDUCTIONS? AS STATED ON THE RUSLE2 WEBSITE3: 59

"RUSLE2 WAS DEVELOPED PRIMARILY TO GUIDE CONSERVATION PLANNING, INVENTORY EROSION RATES AND ESTIMATE SEDIMENT DELIVERY. VALUES COMPUTED BY RUSLE2 ARE SUPPORTED BY ACCEPTED SCIENTIFIC KNOWLEDGE AND TECHNICAL JUDGMENT, ARE CONSISTENT WITH SOUND PRINCIPLES OF CONSERVATION PLANNING, AND RESULT IN GOOD CONSERVATION PLANS. RUSLE2 IS ALSO BASED ON ADDITIONAL ANALYSIS AND KNOWLEDGE THAT WERE NOT AVAILABLE WHEN RUSLE1 WAS DEVELOPED. RUSLE2 IS BASED ON SCIENCE AND JUDGMENT THAT IS SUPERIOR TO THAT OF RUSLE1. WE LEARNED THINGS FROM RUSLE1 THAT ARE INCORPORATED INTO RUSLE2. 59

RUSLE2 HAS EVOLVED FROM A SERIES OF PREVIOUS EROSION PREDICTION TECHNOLOGIES. THE USLE WAS ENTIRELY AN EMPIRICALLY BASED EQUATION AND WAS LIMITED IN ITS APPLICATION TO CONDITIONS WHERE EXPERIMENTAL DATA WERE AVAILABLE FOR DERIVING FACTOR VALUES. A MAJOR ADVANCEMENT IN RUSLE1 WAS THE USE OF SUBFACTOR RELATIONSHIPS TO COMPUTE C FACTOR VALUES FROM BASIC FEATURES OF COVER-MANAGEMENT SYSTEMS. WHILE RUSLE1 RETAINED THE BASIC STRUCTURE OF THE USLE, PROCESS-BASED RELATIONSHIPS WERE ADDED WHERE EMPIRICAL DATA AND RELATIONSHIPS WERE INADEQUATE, SUCH AS COMPUTING THE EFFECT OF STRIP CROPPING FOR MODERN CONSERVATION TILLAGE SYSTEMS." 60

RUSLE2 ALLOWS THE USER TO CHOOSE DIFFERENT COVER CROPS AND SEEDING OPTIONS, TIME OF SEEDING, ETC. THAT WILL FALL IN LINE WITH THE THREE TYPES THAT THE PANEL LAID OUT. ESTIMATES CAN SURELY BE DEVISED USING DIFFERENT SCENARIOS IN RUSLE2. 60

THERE MAY NOT BE SUFFICIENT TIME FOR THIS TO OCCUR WITH THE CURRENT PHASE 6.0 COVER CROP EXPERT PANEL REPORT; HOWEVER, THE OPTION DESCRIBED ABOVE, OR SOME OTHER ACCEPTABLE OPTION TO ESTIMATE COVER CROP SEDIMENT AND/OR PHOSPHORUS REDUCTIONS, SHOULD BE TAKEN UP WITHIN THE NEXT YEAR AS A MEANS OF DETERMINING ESTIMATES TO FILL IN THE RECOMMENDED PLACEHOLDER VALUES. 60

1. USDA-PA HTTPS://WWW.NRCS.USDA.GOV/WPS/PORTAL/NRCS/DETAIL/PA/SOILS/HEALTH/?CID=NRCSEPRD1221425..... 60

2. USDA-NY HTTPS://WWW.NRCS.USDA.GOV/WPS/PORTAL/NRCS/DETAIL/NY/TECHNICAL/?CID=NRCS144P2_027252..... 60

3. RUSLE2 HTTP://FARGO.NSERL.PURDUE.EDU/RUSLE2_DATAWEB/ABOUT_RUSLE2_TECHNOLOGY.HTM 60

RESPONSE: 60

THE PRIMARY TECHNICAL COMMENT RELATES TO AN ERROR IN THE TEXT OF THE DRAFT REPORT ON PAGE 7 THAT STATES 60

SEDIMENT AND P REDUCTION CREDITS FOR COVER CROPS WILL BE 0 FOR ALL CASES IN PHASE 6 UNTIL FURTHER ANALYSIS CAN BE CONDUCTED. THE SPREADSHEET WITH THE ACTUAL REDUCTION CREDIT VALUES ACCURATELY DEPICTS THE PANEL'S RECOMMENDATIONS ON SEDIMENT AND P REDUCTION CREDITS. REDUCTION CREDIT VALUES WERE NOT CHANGED FROM EXISTING VALUES, BUT BECAUSE OF CHANGES IN THE WAY LAND USES ARE IDENTIFIED IN PHASE 6, AND WITH THE DEVELOPMENT OF THE CONSERVATION TILLAGE BMP FOR PHASE 6, THE SEDIMENT AND P REDUCTION CREDITS ARE APPLIED TO SUBSET OF LAND USES, RATHER THAN TO THE HIGH TILL LAND USE THAT EXISTED WHEN PREVIOUS COVER CROP REDUCTION CREDITS WERE DEVELOPED. IN ADDITION TO THE SEDIMENT AND P REDUCTION CREDITS SPECIFIED IN THIS REPORT, COVER CROPS ALSO WILL PLAY A ROLE IN ACHIEVING HIGHER SEDIMENT AND P REDUCTION CREDITS IN THE CONSERVATION TILLAGE BMP. THE TEXT ON PAGE 7 WAS CORRECTED TO ACCURATELY REPRESENT THE TABLE VALUES, AND ALSO TO DESCRIBE THE RATIONALE FOR THE CHANGES. 60

PA SCC & DEP: PAGE 16 – PRACTICE MONITORING AND REPORTING 60

HAS THERE BEEN ANY THOUGHT TO GROUPING COVER CROPS TOGETHER FOR NEIEN REPORTING? THE PHASE 5.3.2 CAST SOURCE TABLE CURRENTLY HAS ROUGHLY 130 CHOICES FOR REPORTING "TRADITIONAL" COVER CROP, 130 CHOICES FOR COMMODITY COVER CROP, AND WE CAN ASSUME THAT MORE ARE BEING PROPOSED THROUGH THIS EXPERT PANEL REPORT. WE RECOMMEND THAT IF EFFICIENCY VALUES ARE THE SAME, THOSE INDIVIDUAL COVER CROP PRACTICES SHOULD BE COMMINGLED TOGETHER UNDER ONE REPORTABLE PRACTICE AND THEN, IN THE DEFINITION, THE INDIVIDUAL PRACTICES WILL BE IDENTIFIED..... 60

HAVING MANY DIFFERENT SUB-CATEGORIES OF THE SAME PRACTICE TO CHOOSE FROM IS NOT ONLY CONFUSING FOR OUR PRACTITIONERS AND THOSE WHO REPORT THE PRACTICE, BUT ALSO UNNECESSARY. WE DO NOT TAKE AWAY FROM ANY JURISDICTION THAT HAS THE NEED TO INTERNALLY TRACK THE MANY DIFFERENT COVER CROP PRACTICES FOR COST-SHARE AND OTHER PURPOSES, HOWEVER IF THERE ARE EFFICIENCY VALUES THAT ARE THE SAME, THEN THEY SHOULD BE GROUPED TOGETHER FOR NEIEN REPORTING FOR CONSISTENCY AND GENERAL EASE OF USE. 60

RESPONSE: 61

THE COMMENT WILL BE ADDRESSED IN THE APPENDIX A OF THE PANEL REPORT, WHICH IS

THE RESPONSIBILITY OF THE CBPO MODELING TEAM AND THE WATERSHED TECHNICAL WORKGROUP AS PART OF THE FINAL PANEL REPORT APPROVAL PROCESS. 61

CBF: 61

RESPONSE: 62

THE PANEL ONLY DEALT WITH CHANGES IN NUTRIENT LOSSES ASSOCIATED WITH MIXTURES, AND NOT OTHER BENEFITS SUCH AS SOIL QUALITY, INCREASED POLLINATOR HABITAT AND ECONOMIC RETURNS TO FARMERS, ETC. THE DECISIONS ON MIXTURES HAD TO BE MADE BASED MOSTLY ON ABOVE GROUND BIOMASS DATA, WHICH IS A PROXY FOR UPTAKE OF SOIL NITRATE, BUT NOT A DIRECT MEASURE OF CHANGES IN NITRATE LEACHING. MIXTURES WITH LEGUMES PRESENT A COMPLEX SITUATION AS IN SEVERAL STUDIES, THE TOTAL BIOMASS WAS NOT BROKEN DOWN INTO SPECIES COMPONENTS SO ABOVE GROUND BIOMASS WAS PARTLY UPTAKE OF SOIL NITRATE, AND PARTLY N FIXATION BY LEGUMES. CLEARLY, UNDER FAVORABLE FALL CONDITIONS WHERE LEACHING IS DELAYED AND EXTENSIVE GROWTH OCCURS BEFORE WINTER CONDITIONS SET IN, AND WHERE SOIL NITRATE LEVELS ARE MODERATE, LOWER GRASS PLANTING RATES IN MIXTURES OR ALONE CAN TAKE UP THE SAME QUANTITY OF NITRATE AS FULL RATE PLANTINGS WHICH OFTEN BECOME N LIMITED, ESPECIALLY FOR EARLY PLANTING DATES. HOWEVER, THE PANEL HAD TO RELY SOMEWHAT ON FIRST PRINCIPLES SINCE ONLY PROXY DATA WERE AVAILABLE TO ASSESS MIXTURE EFFECTS ON N LOSSES. A KEY FIRST PRINCIPLE IS THAT AS PLANTING RATES DECREASE, DEPLETION OF SOIL NITRATE WILL OCCUR MORE SLOWLY, INCREASING THE RISK THAT NITRATE WILL BE LEACHED OUT OF REACH OF COVER CROP ROOTS BEFORE UPTAKE CAN OCCUR. WHILE THE PANEL HAS NO ARGUMENT WITH THE MANY BENEFITS OF MIXTURES, WE MAINTAIN THAT THE INCREASE IN MIXTURE N REDUCTION CREDITS THAT WE RECOMMENDED, NOT BE INCREASED ANY FURTHER. IT ALSO IS IMPORTANT TO SPECIFY THAT THE PANEL ANALYZED THE N LOSS REDUCTION POTENTIAL OF WINTER COVER CROPS RELATED TO SCAVENGING OF SOLUBLE N FORMS, AND NOT EFFECTS RELATED TO CHANGES IN FERTILIZER N APPLICATIONS AS A RESULT OF N FIXATION BY LEGUME COVER CROPS. SUCH AN ANALYSIS WOULD REQUIRE A SYSTEMS LEVEL, LONGER TERM PERSPECTIVE POSSIBLY BEST ADDRESSED UNDER NUTRIENT MANAGEMENT BMPS WHICH DEAL WITH RATE, TIMING AND PLACEMENT OF N SOURCES. 62

APPENDIX F: CONFORMITY WITH WQGIT BMP PROTOCOL..... 63

Table 1. CBP Phase 6.0 Nutrient Management Expert Panel Membership.....10
Table 2. Land Uses to Which the Cover Crop Practices Apply.....13

Cover photo: Cereal rye (abruzzi type) on January 3, 2016 that was no-till drilled following full season soybeans on October 25, 2015 in the upper Tuckahoe Creek basin, Queen Anne's county, MD.

Acronyms and Abbreviations

ac.	Acre
AgWG	Agriculture Workgroup
ARS	USDA Agricultural Research Service
BMP	Best Management Practice
bu.	Bushel
bu./ac.	Bushels per Acre
CBP	Chesapeake Bay Program
CBPO	Chesapeake Bay Program Office
CBPWM	Chesapeake Bay Program Watershed Model
CBW	Chesapeake Bay Watershed
CRC	Chesapeake Research Consortium
DE	Delaware
EOF	Edge of Field
ft.	Feet
ha	Hectare
HUC	Hydrologic Unit Code
kg	Kilogram
lbs.	Pounds
LGU	Land-Grant University
MD	Maryland
N	Nitrogen
NEIEN	National Environmental Information Exchange Network
NO_3-N	Nitrate N
NRCS	USDA Natural Resources Conservation Service
NY	New York
P	Phosphorus
PA	Pennsylvania

PAN	Plant available nitrogen
Panel	Cover Crop Expert Panel
QAPP	Quality Assurance Project Plan
TN	Total Nitrogen
TP	Total Phosphorus
USDA	U.S. Department of Agriculture
VA	Virginia
WTWG	Watershed Technical Workgroup
WQGIT	Water Quality Goal Implementation Team
WV	West Virginia

Summary of Recommendations

1 Introduction

This document summarizes the recommendations of the Phase 6 Cover Crops Expert Panel (the Panel) for revised definitions and credits for cover crop practices. The Panel, whose members are identified in Table 1, proposes that the Chesapeake Bay Program's (CBP) existing definitions associated with cover crop BMPs be replaced by the new annual practices defined below.

Table 1. CBP Phase 6.0 Nutrient Management Expert Panel Membership

Name	Jurisdiction	Affiliation	Role
Ken Staver	Maryland	University of Maryland	Panel Chair
Charlie White	Pennsylvania	Penn State University	Panel Member
Jack Meisinger	Maryland	USDA-Agriculture Research Service	Panel Member
Paul Salon		USDA – Natural Resources Conservation Service	Panel Member
Wade Thomason	Virginia	Virginia Tech University	Panel Member
Jason Keppler		Maryland Department of Agriculture	Watershed Technical Workgroup representative
David Wood		CBPO	Modeling Team representative
Technical support provided by Mark Dubin (University of Maryland, CBPO), Lindsey Gordon (CRC Staffer), and Don Meals (Tetra Tech).			

CBPO – Chesapeake Bay Program Office; CRC – Chesapeake Research Consortium; USDA – U.S. Department of Agriculture

2 Practice Definitions

A cover crop is generally defined as a short term crop grown after the main cropping season to reduce nutrient
losses to ground and surface water by sequestering excess nutrients. No additional nutrients are applied in the fall, however additional nutrients can be applied in the spring and the commodity cover crop can be harvested. Important elements of the practice include selection of the cover crop species, the planting time, and the seeding method. Cover crops are one of the most valuable management practices available for protecting water quality, especially groundwater quality, which is a difficult resource to protect from non-point sources of soluble nutrients like nitrate N.

The previous 2007 cover crop practice was revised in 2015 for the Chesapeake Bay Program Watershed Model (CBPWM) Phase 5.3.2 to include new cover crop species such as annual legumes, brassicas, forage radish, and oats, as well as cover crop mixtures, in order to capture

the diversity and extent of current cover crop practices being used in the Chesapeake Bay Watershed (CBW).

Because of changes in the CBPWM moving to Phase 6, and the expanded use of cover crops beyond the cover crop BMP defined by the Phase 5.3.2 Cover Crop Expert Panel Report, a Phase 6 Cover Crop Expert Panel was formed to address three primary modifications/additions to previous Panel recommendations:

1. Review of nutrient removal efficiencies of the grass/legume mixture cover crop category that were previously handled as simple average of component species;

2. Expansion of the traditional cover crop BMP to include cropland where manure is applied in the fall following harvest of the summer crop. Previously, this cropland was not considered eligible for cover crops; and

3. Review of the commodity cover crop BMP, which was not addressed by the previous Panel. This practice involves modification of nutrient applications to winter cereal production fields to reduce nutrient losses by maximizing the nitrogen scavenging function of traditional cover crops. The commodity cover crop practice is unique among cover crops in that the baseline is winter cereal production using standard nutrient application practices while the baseline for the traditional cover crop BMP is winter fallow conditions.

Practice Name(s)

- Traditional Cover Crops
- Commodity Cover Crops

3 Effectiveness Estimates

3.1 Summary of Effectiveness Estimates

Recommended nitrogen, phosphorus, and sediment efficiency estimates for combinations of CBW regions, cover crop species, and planting conditions are provided in the attached Excel table (*P6_CC_effectiveness coefficient summary.xls).*

Although interest in cover crops has increased nationally in recent years, and the cover crop research base in the Chesapeake Bay watershed is expanding, comprehensive studies on nutrient losses conducted across the range of climate conditions, physical settings, and agricultural production systems that exist in the CBW remain scarce for the many cover crop options that now are used and were considered by this Panel. Most cover crop studies contain pieces of information that help judge relative effectiveness, but few contain full year estimates of reductions in nutrient losses. Four consistent results from the studies considered relevant to this Panel's effort have emerged:

1. Winter cereals respond to higher soil N availability, producing more biomass and moving more soil nitrate-N into above-ground biomass as soil N availability increases.

2. The reference cover crop used in past panel reports (cereal rye planted at 2 bushels/acre; 112 lb/acre) when planted during the early or standard planting periods is capable of taking more N out of the soil than is generally available post-harvest in summer annual row crop settings.

3. Reducing cover crop uptake potential by reducing planting rates, or delaying planting, increases the likelihood that nitrate will be leached out of reach of cover crop roots before uptake can occur.

4. Increasing the fall soil N nitrate pool by applying manure or inorganic N will increase winter cereal N uptake but also increase the potential for nitrate leaching.

The Panel relied on the body of information developed by previous panels, information from new studies, and consideration of the mechanistic mode of action of cover crops to make the following recommendations on the three topics named above:

1. The definition of grass/legume mixtures that were assigned reduction credits in the Phase 5.3.2 Cover Crop Expert Panel report should be modified to include mixtures that include at least 25% of the recommended planting rate of grass cover, a reduction from 50% of the full rate of the grass component. A second grass/legume mixture category should be added for mixtures documented to contain at least 50% of the full grass planting rate. The N reduction efficiency for this category should be 70 % of the full grass efficiency, or the average grass reduction efficiency if no grass is specified. Grass/legume mixtures remain eligible for credit only in the early and standard planting date categories[1]. The panel also

[1] Early is more than two weeks before the average frost date, Standard is between the average frost date and two weeks before that date, Late is within three weeks after the average frost date. These dates correspond approximately

recommends that monoculture grass cover crops planted between 50 and 100 % of the full grass rate be included in this category, being considered as 70% as effective as full rate grass plantings for early and standard planting dates. This practice will only be credited where local USDA-NRCS review considers the planting adequate to provide the level of soil cover needed to prevent soil erosion.

2. The panel recommends that the traditional cover crop practice be applicable to crop land that receives unavoidable fall manure applications due to limits on storage capacity at rates not to exceed 50 lb plant available N (PAN)/acre. Cover crops planted on cropland where manure is applied following harvest of the summer crops and prior to cover crop planting should be credited for N reductions at 70% of the table values currently used for traditional cover crops planted where no manure is applied in the fall. The reduction credit is less than for traditional cover crops because increases in the soil N pool reduce the potential for cover crop uptake before leaching occurs. This option only is available for full rate grass and brassica cover crop options, or grass and brassica mixtures.

3. The commodity cover crop BMP, in which winter cereals are planted for harvest but which are not fertilized in the fall as has been standard practice, should receive a 5, 10, and 15% N reduction credit for the early, normal, and late planting period. This credit should be applied to the summer annual land use where the winter cereal was planted. Commodity cover crops are equally effective at taking up soil nitrate as traditional cover crops, but the credit is reduced because the baseline condition is standard winter cereal production with a fall N fertilizer application. Although comprehensive data are lacking, the panel assumed that past standard practice for winter cereal production included a 30 lb/acre N application just prior to fall planting. This panel is not addressing the effect of the commodity cover crop practice related to delaying winter nutrient applications since this change in nutrient applications will be addressed within the winter cereal land uses that will exist in the Phase 6 CBPWM.

The panel also considered changes in the Phase 6 CBPWM that will affect the cover crop practice. The most important change will be the identification of distinct crop land uses with varying N loss rates. This will make it possible to apply cover crop reduction efficiencies to specific crop land uses, which will support efforts to target cover crop implementation to crop land uses with the greatest potential for nutrient losses. As a result, a cover crop practice applied to high loss potential land uses will produce a greater total load reduction than if applied to lower loss potential crop land, or average loss potential crop land. This is viewed as a positive change that will make the CBPWM, which is the planning and accounting system for achieving nutrient reduction goals, more consistent with cost-effective nutrient reduction strategies.

The Panel considered options for revising cover crop P reduction credits but at this time recommends additions and revisions only for nitrogen (N). P reduction credit values will be unchanged from values used in the Phase 5.3.2 CBPWSM but because of how land uses have been redefined moving to Phase 6 of the model, how the P reduction credits are applied will be somewhat changed. Prior to Phase 6, crop land uses were divided into high till and low till categories and sediment and P reduction credits were only applied to high till land uses. The

to 1000, 700, and 400 base 40F heat units.

rationale was that erosion and P losses were primarily controlled by reduced tillage and resulting high residue conditions in the low till land uses. Because of greater potential for erosion losses in high till land uses, cover crops were given sediment and related P reduction credits as a result of increased soil cover during fall through early spring. The reduction credit was decreased proportionately with N reduction credits moving from earlier to later cover crop planting dates to reflect lower above ground biomass production.

In the Phase 6 CBPWM, tillage/residue cover will be a BMP that can be applied to all crop land uses to account for reduced erosion previously captured by the low till land use. Cover crops will be part of this BMP, and contribute to achieving greater residue cover and higher sediment and P reduction credits. Giving additional sediment and P reduction credits for cover crop BMPs creates a potential double counting scenario since the modeling process cannot exclude one BMP based on application of another. However, a small subset of land uses are known to have low residue cover conditions which would preclude them from achieving higher level Conservation Tillage BMP status. Cover crops would be valuable for providing winter soil cover in these land uses and reducing erosion and associated P losses with little risk of double counting. The panel recommends that the previously established High till sediment and P cover crop reduction credits be applied to the corn silage, high intensity specialty, and other row crops land uses, and the 0 credit values previously applied to the Low till land uses be applied to all other land uses that are eligible for the highest Conservation Tillage BMP credit category. Full description of the Conservation Tillage BMP is available in the report being prepared simultaneously with this report. Since soil erosion potential and associated P losses is highly site specific depending on soil type, slope and soil P concentrations which vary widely locally and regionally, the panel felt that assigning more detailed sediment reduction credits for cover crops was not warranted given the lack of spatial detail in the CBPWM relating to erosion potential.

3.2 Examples of Application of Revised Effectiveness Estimates

3.2.1 Grass-legume mixtures

The grass-legume mixture N reduction credits developed by the Phase 5.3.2 cover crop expert panel will be left unchanged but the definition of the practice will be changed to apply to mixtures that contain at least 25%, but not more than 50% of the full rate of the grass component of the mixture as defined by NRCS (Practice Standard 340). For cereal rye, the full rate planting is 2 bu/ac or 112 lb/ac of seed. so the credit for this mixture category would be for mixtures that include 0.5 -1.0 bu/ac or 28-56 lb/ac of rye seed plus an annual legume. As described in the Phase 5.3.2 cover crop report, the N reduction credit for this practice would be the average of the full rate grass reduction credit and the annual legume credit. For example, in the Coastal Plain/Piedmont an early-drilled rye traditional cover crop receives an N reduction credit of 0.45 and the annual legume a credit of 0.07, yielding an average N reduction credit of 0.26 for mixtures that include 0.5 -1.0 bu/ac of rye seed. In addition to this revision in the definition of the current mixture credits, the panel also is recommending the addition of a mixture category for cover crop plantings that contain least 50%, but less than 100% of the full rate of the grass component of the mixture as defined by the NRCS (Practice Standard 340) that receives an N reduction credit that is 0.7 of the full rate grass component in the mixture. Again using cereal rye as in example, mixtures in this category would need to contain at least 1 bu/ac or 56 lb/ac of rye seed. For mixtures with 1.0 -2.0 bu/ac of rye seed early drilled in the Coastal Plain

Piedmont, the N reduction credit would be 0.7 of the full rate reduction credit for rye of 0.45, or 0.31. Credits in this category also would apply to monoculture grass cover crops planted at a rate of between 50 and 100% of the full planting rate where local USDA-NRCS review considers the planting adequate to provide the level of soil cover needed to prevent soil erosion. All mixtures and reduced rate monocultures only are eligible to receive credit when planted in the early and standard planting windows and are not eligible for use following fall manure applications.

3.2.2 Traditional cover crops following fall manure applications

Determining the credit for a traditional cover crop planted following a fall manure application is simply a matter of multiplying the appropriate traditional cover crop N reduction credit times 0.7. For the case of early drilled rye in the Coastal Plain/Piedmont region, the current N reduction credit is 0.45 for settings where no manure is applied in the fall. Previously, no cover crop practice was eligible for use on crop land where manure was applied in the fall. In Phase 6, early drilled rye following a manure application will receive an N reduction credit of 0.7 x 0.45, or 0.31. All traditional full rate grass and brassica cover crop options, and grass/brassica mixtures currently identified will be eligible for N reduction credit where manure is applied in the fall with the adjustment being 0.7 in all cases. This cover crop practice will be applied to Phase 6 land uses identified as eligible for manure applications.

3.2.3 Commodity cover crops

The commodity cover crop N reduction credit developed by this panel will be applied to the land use where the winter cereal crop was planted, and only addresses the impact of N losses due to withholding of a fall N application. Previous N reduction credits for the commodity cover crop practice covered all aspects of the practice and the full winter cereal production cycle. In Phase 6, changes in management related to nutrient applications after January 1 will be addressed in the winter cereal land uses that have been identified in Phase 6 of CBPWM but which were not broken out as distinct land uses in previous phases of the model. The planting periods will be the same as those used for the traditional cover crop practice: early, normal and late. A change from the past will be that the Phase 6 commodity cover crop practice will not be covered by the traditional cover crop N credit matrix; a single N reduction credit will be given for all the winter cereal species in a given planting period. For any early planted winter cereal crop not receiving a fall N application, an N reduction credit of 5% will be applied to the land use where that crop was planted. Winter cereal planting usually follows corn or soybean production but the reduction credit does not vary by preceding crop or winter cereal type. The same approach will be used for winter cereals planted in the normal and late planting windows, except the N reduction credit applied will be 10% and 15% respectively. These reduction credits will replace those used in previous versions of the CBPWM for the commodity cover crop practice.

4 Review of Literature and Data Gaps

There is a large and expanding research base in the CBW covering a wide range of cover crop effects on nutrient loss, soil quality and crop production. Multiple studies from CBW states have provided findings relevant to the cover crop practices being considered by this Panel, but none explicitly quantify annual reductions in N losses for these cover crop options. Nevertheless, multiple studies provide information that collectively is useful in assigning nutrient reduction credits to the cover crop options being considered. A consistent finding throughout the watershed is that winter cereals respond dramatically to differences in root zone nitrate availability, with above-ground N content increasing up to fivefold in response to increasing N availability. This has been found to be the case where fall soil N varied do to natural variability in summer weather that affected soil nitrate levels following the summer crop (Staver and Brinsfield 1998), where spring N applications to a summer crop were varied experimentally (Staver and Brinsfield 1990, Shipley et al. 1992, Coale et al. 2001), where a summer legume crop was plowed down (Poffenbarger et al. 2015), and where either inorganic N fertilizer (Monks et al. 1997, Pavuluri et al. 2014, Meisinger et al. 2015) or biosolids (Staver and Brinsfield 1998a, Bamber et al. 2016) or manure (Ort et al. 2013) were applied in the fall when the winter cereal was planted. Total winter cereal N uptake under conditions of high N availability has been reported in several of the above and other studies (Dean and Weil 2008, Hoover et al. 2013, Finney et al. 2016) to exceed 100 kg/ha. Fall N uptake by triticale planted prior to September 20 following corn silage has been found to average 70 kg/ha in NY (Q. Ketterings, pers. comm. 2016).

The responsiveness of winter cereals to additional N availability is highly relevant to the cover crop practices being considered by this panel. The other relevant factor is the typical fall root zone pool in CBW cropland and the size of the fall soil nitrate pool relative to the uptake potential of winter cereals. While many of the studies cited were small scale plot studies, several looked at fall root zone N availability in commercial scale production settings. Staver and Brinsfield (1998) reported 9-year average post-harvest 0-30 cm field average root zone nitrate-N pools of 33.2 and 25.5 kg/ha under continuous conventional and no-till corn production, respectively. All values fell close to the mean except for one extreme value (110 kg/ha) when corn yields were less than half the yield goal due to drought. Fall sampling in private farm fields in Virginia following corn grain harvest indicated a 0-30 cm nitrate-N pool ranging from 10-50 kg/ha (Pavuluri et al. 2014) and 28-200 kg/ha (Bamber et al. 2016) although in the latter study 7 of 10 fields had values under 50 kg/ha. Staver (2001a) reported post-harvest 0-60 cm nitrate-N pools in private farm fields in the Choptank River basin in MD of 43.7 kg/ha following corn fertilized with inorganic N and 18.4 kg/ha following soybean harvest. In a five year study sampling both research plots and private fields Forrestal et al. (2013) reported 0-30 cm fall nitrate-N for corn research plots receiving recommended rates of fertilizer N and private fields ranging from 8-177 kg/ha with 7 of the 8 private fields having values ranging from 7-42 kg/ha. Most of the values reported for the research plots also were in this range.

The magnitude of typical root zone nitrate-N pools where no fall nutrients are applied in comparison to potential N uptake by winter cereals in excess of 100 kg/ha explains why winter

cereals typically respond dramatically to fall N applications. It also indicates that winter cereals planted in early and standard planting periods typically are N limited and capable of taking up much more nitrate than is available in well managed cropland settings. In addition, widespread implementation of nutrient management planning and a shift towards P based applications of organic nutrient sources would suggest that fall root zone nitrate pools have decreased since the Bay restoration effort began, but little measured data exists to directly support this concept. However, numerous studies in the Bay watershed have shown that post-harvest soil nitrate concentrations increase with increasing N application rates to the proceeding corn crop (Staver and Brinsfield 1990, Coale et al. 2001, Forrestal et al. 2013) suggesting that fall root zone nitrate concentrations have likely decreased since the Bay restoration effort began as a result of widespread efforts to implement nutrient management and minimize N applications beyond crop needs. This would suggest that moving forward, fall root zone nitrate availability will tend to be well below winter cereal uptake potential which has implications for all of the revisions being considered by this Panel.

In the case of grass-legume mixtures, the capacity of full rate winter cereal cover crops to take up well in excess of typical fall root zone nitrate pools suggests that cutting the grass planting in rate in half in a mixture will not cut the N reduction efficiency of the mixture practice in half, as was the basic approach used for mixtures by the 5.3.2 Cover Crop Expert Panel. The approach currently in place averages the grass and legume reduction values but because the annual legume N credit is so low (0.06-0.07) the credit for mixtures currently is approximately half of the value of the full rate credit for the grass in the mixture (specifically, the credit is half of the full rate for the grass in the mixture plus 0.03). The most direct support of the proposed change is from recent studies in PA (Poffenbarger et al. 2015) that reported N uptake by rye in mixture only decreasing marginally when the rye planting rate in a mixture was reduced from 2.7 to approximately 1 bu/ac. Rye cover crop total N uptake in these studies exceeded 100 kg/ha in two of the site years considered. In the four site-years considered, the sharpest drop in N uptake as planting rate decreased occurred when planting was delayed until October 10, supporting the approach taken by the Phase 5.3.2 cover crop panel that mixtures should only be credited in the early and normal planting date categories. In studies in VA under lower N status conditions, Thomason et al. (2015) reported mixture N accumulation to remain little changed when rye planting rates were cut to approximately 75% of the full planting rate in a mixture, and also when planting dates were delayed from mid-September to mid-October. Other studies of cover crop mixtures conducted at multiple sites in VA (Fleming and Thomason 2015) found mixture biomass and N uptake to be as a high or higher than full rate single species winter cereal cover crops although N uptake by the component species in the mixtures was not determined. One management factor supporting mixtures is that legume survival is enhanced by earlier planting dates, which also allows the grass component in the mixture more time to take up root zone nitrate before leaching occurs. A second supporting factor is that the legume N fixation function of mixtures is likely most desirable to producers who don't have access to manure as grass in mixtures tends to outcompete legumes when soil N status is high (Clark 2007). This means that mixtures usually will be planted on sites with relatively low N status, increasing the likelihood that the grass component of the mixture can take up most of the root zone nitrate pool before leaching occurs. The Panel proposes adding a second category for mixtures that allows down to 25% of the full grass planting rate because these types of mixtures are being promoted as part of the nationwide effort primarily focused on soil quality that

promotes diverse cover crop mixtures (Finney and Kaye 2016). These mixtures have been shown to be useful for N uptake in the northern part of the watershed (Ketterings et al. 2011) following winter cereal grain harvest. South of central PA planting of soybeans after winter cereal grain harvest is widespread eliminating the growing window for many potential cover crop species. Again, the studies by Poffenbarger et al. (2015) are the main direct support of this additional category as rye N uptake down to panting rates approximately 25% (0.54 bu/ac) of the full rate were evaluated and never found to reduce rye N uptake to below 50% of that by full rate monoculture rye plantings. The consensus of the Panel is that mixtures containing 25 - 50% of the full grass planting rate should receive the N reduction credit developed for mixtures in the 5.3.2 Cover Crop Expert Panel report that is the average of the credit for the credit of grass component of the mixture and the credit for annual legumes. Mixtures containing at least 50% of the full grass planting rate should receive an N reduction credit of 0.7 of the full grass planting rate as currently specified. Mixtures with less than 25% of the full grass planting rate should not receive a reduction credit beyond those currently specified for annual legumes. Mixtures and reduced planting rate monocultures should not receive credit except in the early and standard planting date categories.

In the case of fall manure applications, winter cereal cover crops have the potential to take up a large fraction of the increased nitrate available due to the manure application and reduce leachate nitrate concentrations nearly to the same levels as where no manure was applied (Staver and Brinsfield 1998a, Staver 2001). In studies of cover crop N uptake following corn silage in NY, Ort et al. (2013) reported highest biomass production by triticale following the highest manure application rates and the lowest cover crop N uptake where no manure was applied ("more manure, more uptake"). Coale et al. (2001) reported much higher cover crop N uptake by winter cereals where previous poultry manure applications produced elevated nitrate availability, although the manure applications were in the spring rather than the fall. Fall manure applications necessary because of storage limitations are limited to 50 lb PAN/ac in MD and recommended not to exceed that level in NY (Van es et al. 2002). As described above, post-harvest root zone nitrate-N typically is less than 40 kg/ha following corn except for drought conditions and less than 30 kg/ha following soybeans. Except in drought years, the added nitrate-N from a from a fall manure application will not increase the root zone nitrate pool beyond the uptake capacity of winter cereal cover crops planted in the early and standard planting periods. Nevertheless, increasing the soil nitrate pool will increase the likelihood of nitrate being lost before cover crop uptake occurs. Forrestal et al. (2013) described how leaching of nitrate varies from year to year due to varying precipitation relative to soil water holding capacity. In years with dry or average precipitation conditions nitrate remains available for uptake for a longer period while in years with above average fall precipitation nitrate can be leached out of the root zone before uptake occurs, especially on coarse-textured soils. This suggests that the effectiveness of cover crops to reduce nitrate leaching on sites receiving fall manure applications will be little reduced in dry autumns, but will be reduced when leaching occurs early in the fall due to above average precipitation. Comprehensive data are not available on the change in cover crop effectiveness for reducing N losses as the root zone nitrate pool is increased across a range of fall weather conditions but the Panel settled on a value of 0.7 of the current N reduction credits for settings where no fall N is applied. Evidence is compelling that cover crops are a critical tool for reducing N losses due to fall manure applications and the overall impact of cover crops in this setting can be very high and result in

large reductions in overall N losses in concentrated dairy producing regions of the CBW.

The commodity cover crop N reduction credit also is related to the relative magnitude of the soil nitrate pool and the uptake potential of winter cereals. This Panel is only considering the elimination of a fall N application at the time of planting of a winter cereal that was a standard practice historically, although not precisely quantified. This Panel is assuming that fall N applications were 30 lb/ac (33.4 kg/ha). In the past the commodity cover crop practice also has included delaying mid and late winter N applications until just prior to spring growth but this aspect is not being considered by this Panel, but will be addressed as part of the winter cereal land uses that are now identified in Phase 6 of the CBPWM. This Panel is considering the effect of the commodity cover crop practice as the reduction in annual N losses from the crop land use where the winter cereal was planted as a result of eliminating a fall N application of 30 lb/ac. As discussed earlier, root zone nitrate-N availability typically falls in the range of 20-40 kg/ha (18-36 lb/ac) except following summer droughts or in cases where manure is applied. This means that elimination of the fall N application will approximately reduce the pool of nitrate available for uptake and leaching by 50 %. One complicating factor in this analysis is that nitrate can be stored in the soil profile below the region of the soil routinely sampled, but still be available for uptake by crops including winter cereals. Multiple studies in the CBW have reported varying and potentially significant quantities of nitrate present in fall in the 30-90 cm depth interval of the soil profile depending on past management and precipitation patterns (Staver and Brinsfield 1998, Coale et al. 2001, Forrestal et al. 2013). Some fraction of this nitrate also is available for uptake by winter cereals, and winter wheat production guides in the CB watershed have recommended sampling to a depth of 3 ft (90 cm) to assess N availability to the crop (Alley et al. 1993). More nitrate may be available for uptake than indicated by 0-30 cm sampling results and the elimination of a 30 lb fall N application may represent less than a 50 % reduction in N availability for a winter cereal crop. Nevertheless, reducing the available N pool will increase the likelihood that uptake by a winter cereal crop will remove nitrate from the root zone before leaching can occur. Because nitrate uptake potential by winter cereals decreases as planting dates get later in the fall, reducing the soil nitrate pool is actually more critical for later planted winter cereals. Specifically, the likelihood that withholding an N application will reduce nitrate leaching losses increases moving later in the fall because there is less potential for plant uptake of any added N. Opportunity for uptake of N applied earlier in the fall is greater so withholding N applications to early-planted winter cereals is less likely to reduce nitrate leaching losses. No direct data exist demonstrating nitrate leaching losses across a range of fall application scenarios but Meisinger et al. (2015) did demonstrate in lysimeter studies that soil water storage in the fall can minimize leaching of applied N while N applied in winter even to an existing wheat crop can be leached rapidly. Additional lysimeter studies with intact soil cores at Beltsville, MD indicated that elimination of fall N applications as specified under the commodity cover crop practices reduced nitrate leaching losses approximately 10 % (J. Meisinger, pers. comm. 2016). The summary statement of the Panel based on very limited direct data, but extensive data describing the general mechanism of nitrate leaching and nitrate uptake by winter cereals is that withholding fall N applications to winter cereal crops will increase the root zone nitrate scavenging efficiency by reducing the total nitrate pool, which in turn, will reduce the potential for nitrate leaching. This benefit will be least for early planted winter cereal crops that have a high potential for uptake of any added N, especially in dry warm falls with below average precipitation allowing uptake of nitrate to occur before leaching. As

planting dates get later, the potential for uptake of added N before leaching occurs is reduced, thus increasing the likelihood of increased N leaching losses due to applied N, and increasing the impact of withholding N on reducing N leaching losses. The Panels judgement is that the fall component of the commodity cover crop practice will reduce annual N losses from the Phase 6 land use where planting occurred (primarily corn and soybean land uses) by 5, 10, and 15 % for early, standard, and late planted winter cereal crops.

5 Application of Practice Estimates

5.1 Load Sources

Traditional and Commodity Cover Crop practices apply to the following partnership approved Phase 6 agricultural land uses with the following applications:

- **Traditional Cover Crops** including mixtures are applicable to all row crop land that do not include a fall planted crop that overwinters for harvest the following year. Because cover crops can be planted following the fall harvest of double cropped systems, double cropped systems are also eligible for applying Traditional Cover Crop BMPs. The adjusted reduction credits for where fall manure is applied will be for land uses with manure applications.

- **Commodity Cover Crops** also are applicable to all row crop land uses that do not include a fall planted crop that overwinters (e.g. spinach). This is based on the proposal that the N and P reduction efficiencies are being applied to the cover crop establishment year land use; e.g. corn, soybeans, etc.

Table 2. Land Uses to Which the Cover Crop Practices Apply

Land Use	Description
Full Season Soybeans	Soybeans ineligible for double cropping
Grain with Manure	Corn or sorghum for grain eligible for manure application and ineligible for double cropping
Grain without Manure	Corn or sorghum for grain ineligible for manure application and ineligible for double cropping
Silage with Manure	Corn or sorghum for silage eligible for manure application and ineligible for double cropping
Silage without Manure	Corn or sorghum for silage ineligible for manure application and ineligible for double cropping
Small Grains and Grains	Small grains and grains other than corn or sorghum eligible for manure and ineligible for double cropping
Small Grains and Soybeans	Soybeans double cropped with small grains and ineligible for manure
Specialty Crop High	Specialty crops with relatively high nutrient inputs with some crops eligible for manure
Specialty Crop Low	Specialty crops with relatively low nutrient inputs with some crops eligible for manure
Other Agronomic Crops	Other high commodity row crops such as tobacco, cotton, etc., with some crops eligible for manure

5.2 Practice Baseline

Identification of potential methods to estimate historical cover crops – especially commodity cover crops – is challenging. The Panel has discussed the fact that baseline conditions with respect to cover crops have never been fully laid out. Over the last several decades, changes in crop varieties, crop yields, the amount of N recommended or applied, the timing of nutrient applications, and tillage practices have changed so significantly that establishing historical cover crop implementation has been difficult.

5.3 Hydrologic Conditions
The Panel represented BMPs that can be applied across all hydrologic conditions in the CBW.

5.4 Sediment
Panel report provides reduction efficiencies for total sediment.

5.5 Species of Nitrogen and Phosphorus
The Panel recommended reduction efficiencies only for total N, total P, and total sediment.

5.6 Geographic Considerations
The Panel report represented BMPs that can be applied across all geographic areas of the CBW. The practices may have localized limitations on applicability, including steep slopes, stony soils, and wet conditions. Nitrogen reduction efficiencies are different for the Coastal Plain and the Uplands based on different runoff/infiltration partitioning coefficients. Phosphorus reduction efficiencies vary by the proportion of well-drained versus poorly drained eligible cropland.

5.7 Temporal Considerations
Cover crop reduction efficiencies depend on planting date, with greater reduction efficiencies attributed to early planting. Late planted cover crops receive lower reduction efficiencies than cover crops planted in the standard planting window.

5.8 Practice Limitations
There are no limitations to the application of BMPs. These practices may be applied to all agricultural land use categories in the CBW.

5.9 Potential Interactions with other Practices
The Panel recognizes that BMPs interact with all other agricultural practices for all agricultural land use categories in the CBW. Potential limiting interactions with other practices include conservation tillage and manure injection/incorporation.

6 Practice Monitoring and Reporting

6.1 Phase 6.0 Cover Crops Tracking, Verification, and Reporting

In Phase 6, states are responsible for reporting county acres or percentages for cover crop practices to the National Environmental Information Exchange Network (NEIEN) for all years. If a state does not currently have historic implementation information, they should consider obtaining historic BMP implementation information where possible, and tracking and reporting for future years. However, the full implementation of CBP BMP verification requirements in 2018 will necessitate the tracking and reporting of practice implementation data for future reduction credits.

The Panel recommends that cover crop practice implementation tracking, verification, and reporting on a county-by-county or state-by-state basis be based on the premise that the practices represent Visual Assessment (Single Year) BMPs. States will report BMP implementation annually to the CBPO as the number or percentage of acres meeting the definitions and qualifications set forth by the Panel in this report for traditional and commodity cover crop BMPs.

Cover crop BMPs represent an historic and expanding suite of BMPs for the CBP modeling tools over the history of the Program. As such, cover crop BMPs are included in the jurisdictions' verification plans that were submitted to the CBP in late 2015. As with all BMPs, the jurisdictions will be expected to document their verification protocols and procedures in their Quality Assurance Project Plans (QAPP) for cover crop BMPs that are reported to the CBPO for N crediting reductions. The jurisdictions will determine if modifications of those verification plans are required after this Expert Panel recommendation report is approved by the CBP partnership following the WQGIT BMP Protocol, and before the jurisdictions are able to start reporting these BMPs in the Phase 6 modeling tools for annual progress implementation. As the states consider how to verify cover crop BMPs and as they document those procedures in their QAPPs, state partners should follow the existing Agriculture Workgroup's (AgWG) BMP Verification Guidance (http://www.chesapeakebay.net/about/programs/bmp/additional_resources).

The current verification guidance from the AgWG organizes BMPs into three general categories: Visual Assessment BMPs (Single Year), Visual Assessment BMPs (Multi-Year), and Non-Visual Assessment BMPs. The complete AgWG guidance is quite extensive and is not restated in this section; the Panel refers to the AgWG guidance for additional detail and definitions of these assessment methods. The Panel is not proposing any new or unique aspects of BMP verification for purposes of the BMPs described in this report. This section simply explains how the recommended BMPs correspond to the existing BMP verification guidance.

Cover crop practices are often part of a larger conservation management system or plan that often involves multiple management and physical components (e.g., nutrient management plans, conservation plans, crop rotations) that can be visually assessed over time. Conservation practices as part of systems or plans also incorporate single year visual components (e.g., tillage

and crop residue management), in addition to other documentation as needed under applicable state or federal agricultural programs, and/or permits. Thus, cover crop BMPs can reasonably be verified using elements of the Visual Assessment (Single-Year) category described by the AgWG.

Each state will determine the most appropriate methods for verifying cover crop BMP implementation given their specific priorities, programs, needs, and capacity. For example, one state may leverage existing farm site visits to also verify that the operation meets applicable cover crop BMP definitions as recommended by the Panel. Another state may implement field transect surveys based on the CTIC standards to provide sufficient county-level verification, incorporating quality assurance and quality control (QA/QC) spot-checks. Ideally, states will leverage multiple existing and perhaps new avenues to verify that cover crop practices are sufficient to meet the BMP criteria as determined by a trained and/or certified independent third party, and that the data records are accurate and up-to-date.

Jurisdictions can follow the AgWG's guidance for Visual Assessment (Single Year) BMPs to verify the traditional and commodity cover crop BMPs recommended in this report for N reduction credits in the Phase 6 Chesapeake Bay Watershed Model. Verification for Visual Assessment (Single Year) BMPs depends more on an annual visual assessment of physical features than on oversight and checks on operational records or documentation.

The N reductions for cover crop BMPs described in this report are to be based on the verified required elements of the cover crop BMPs following the AgWG's guidance for Visual Assessment (Single Year) BMPs. Because cover crops are an annually reported BMP, the most important criteria (i.e., species, planting date, planting method, nutrient applications and timing, termination method) could be documented in records available to the applicable state agency. Given the close association between cover crops and other CBP-approved BMPs (e.g., conservation planning, conservation tillage, nutrient management) the state agency can potentially use relevant data or associated verification methods for other reported BMPs to verify the type and acres that were managed via one of the cover crop BMPs described by the Panel. If the state agency finds that this basic information cannot be verified through its spot-checks, transect surveys, or other annual BMP verification procedures described in its QAPP, then the BMP cannot satisfy the definitions and expected N reductions described in this report.

For more information about the CBP Partnership's BMP Verification Framework
The full CBP partnership BMP Verification Framework is available online at http://www.chesapeakebay.net/about/programs/bmp/additional_resources (scroll down to October 2014 Basinwide BMP Verification Framework Document).
The current AgWG's BMP Verification Guidance is included in Appendix B of the full Framework Document, available at http://www.chesapeakebay.net/documents/Appendix%20B%20-Ag%20BMP%20Verification%20Guidance%20Final.pdf.

6.2 Future Verification of Cover Crops Practices

The Panel envisions that potential opportunities may exist in the future for utilizing alternative forms of BMP verification, such as remote sensing from satellite, aerial, and drone imagery.

7 References

Alley, M.M., D. E. Brann, E. L. Stromberg, E. S. Hagood, A. Herbert, E. C. Jones, W. K. Griffith. 1993. Intensive soft red winter wheat production, a management guide. Virginia Cooperative Extension, Pub. 424-803.

Bamber, K. W., G. K. Evanylo and W. E. Thomason. 2016. Importance of soil properties on recommended biosolids management for winter wheat. *Soil Science Society of America Journal* 80: 919-929.

Clark, A. 2007. Managing cover crop profitably, 3rd edition. Published by Sustainable Agriculture Network, Beltsville, MD.

Coale, F. J., J. M. Costa, G. A. Bollero and S. P. Schlosnagle. 2001. Small grain winter cover crops for conservation of residual soil nitrogen in the mid-Atlantic coastal plain. *American Journal of Alternative Agriculture* 16 (2): 66-72.

Dean, J.E. and R.R. Weil. 2009. Brassica cover crops for nitrogen retention in the Mid-Atlantic coastal plain. *Journal of Environmental Quality* 38:520-528.

Finney, D. M. and J. P. Kaye. 2016. Functional diversity in cover crop polycultures increases multifunctionality of an agricultural system. *Journal of Applied Ecology* doi:10.1111/1365-2664.12765.

Finney, D. M., C. M. White and J. P. Kaye. 2016. Biomass production and carbon/nitrogen ratio influence ecosystem services from cover crop mixtures. *Agronomy Journal* 108 (1): 39-52.

Fleming, C. and W. Thomason. 2015. Cover crop performance evaluation in field and controlled studies. In: Virginia Cover Crop Fact Sheet Series, Virginia Cooperative Extension, No. 2.

Forrestal, P., J. Meisinger, R. Kratochvil. 2013. Winter wheat starter nitrogen management: A preplant soil nitrate test and site-specific nitrogen loss potential. *Soil Science Society of America Journal* 78: 1021-1034.

Hargrove, W.L. [ed] 1991. Cover crops for clean water: Proceedings of an international conference, West Tennessee Experiment Station, April 9-11, 1991, Jackson, TN, Soil and Water Conservation Society, Ankeny, IA.

Ketterings, Q. M., J. Kingston, S. McIlvennie, E. Long, G. Godwin, S. Gami, M. Stanyard and K. Czymmek. 2011. Cover crop carbon and nitrogen content: Fall of 2010 sampling. In: *What's Cropping Up?* A newsletter for New York Field Crops & Soils, Cornell University Cooperative Extension 21 (3), September – October.

Meisinger, J. J., R. E. Palmer and D. J. Timlin. 2015. Effects of tillage practices on drainage and nitrate leaching from winter wheat in the northern Atlantic coastal-plain USA. *Soil & Tillage Research* 151: 18-27.

Meisinger, J. J. and J. A. Delgado (2002). Principles for managing nitrogen leaching. *Journal of Soil and Water Conservation*, 57(6): 485-498.

Meisinger, J. J., W. L. Hargrove, R. L. Mikkelsen, J. R. Williams and V. W. Benson. 1991. Effects of cover crops on groundwater quality. Pp 57-68. In: Hargrove, W. L. (ed.) C*over crops for clean water.* Proceedings international conference, April 9-11, 1991, Jackson, TN. Soil and Water Conservation Society of America, Ankeny, IA.

Monks, C. D., T. Basden, J. L. Hatton, M. L. McFarland, S. M. Poland, and E. Rayburn. 1997. Cover crop response to late-season planting and nitrogen application. *Journal of Production Agriculture* 10(2) 289-293.

Ort, S. B., Q. M. Ketterings, K. J. Czymmek, G. S. Godwin, S. N. Swink and S. K. Gami. 2013. Carbon and nitrogen uptake of cereal cover crops following corn silage. In: What's Cropping Up? A newsletter for New York Field Crops & Soils, Cornell University Cooperative Extension 23(2): 5-6.

Pavuluri, K., M. S. Reiter, M. Balota, C. A. Griffey, and W. E. Thomason. 2014. Commodity cover crop nitrogen management effects on winter barley in the mid-Atlantic coastal plain. *Agronomy Journal* 106(2): 577-584.

Poffenbarger, H. J., S. B. Mirsky, R. R. Weil, J. E. Maul, M. Kramer, J. T. Spargo, and M. A. Cavigelli. 2015. Biomass and nitrogen content of hairy vetch-cereal rye cover crop mixtures as influenced by species proportions. *Agronomy Journal* 107(6):2069-2082.

Schipanski, M. E., M. Barbercheck, M. R. Douglas, D. M. Finney, K. Haider, J. P. Kaye, A. R. Kemanian, D. A. Mortensen, M. R. Ryan, J. Tooker and C. White. 2014. A framework for evaluating ecosystem services provided by cover crops in agroecosystems. *Agricultural Systems* 125:12-22.

Shipley, P. R., J. J. Meisinger, and A. M. Decker. 1992. Conserving residual corn fertilizer nitrogen with winter cover crops. *Agronomy Journal* 84(5):869-876.

Staver, K. W. 2001. Increasing N retention in coastal plain agricultural watersheds. In optimizing nitrogen management in food and energy production and environmental protection: Proceedings of the 2nd International Nitrogen Conference on Science and Policy. *The Scientific World* 1:207-215.

Staver, K.W. 2001a. The effect of agricultural best management practices on subsurface nitrogen transport in the German Branch watershed. Final Report submitted to Maryland Department of Natural Resources Coastal Zone Management Division, Project 14-198-346czm025.

Staver, K. W. and R. B. Brinsfield. 1990. Patterns of soil nitrate availability in corn production systems: Implications for reducing groundwater contamination. *Journal of Soil and Water Conservation* 45(2):318-323.

Staver, K. W. and R. B. Brinsfield. 1998. Using cereal grain winter cover crops to reduce groundwater nitrate contamination in the mid-Atlantic coastal plain. *Journal of Soil and Water Conservation* 53(3):230-240.

Staver, K.W. and R. Brinsfield. 1998a. Crop management systems for reduction of hydrologic nutrient transport. Final Report Maryland Department of Agriculture (Governor's Council on Chesapeake Bay Research). 121 p.

Staver, K. W. and R. Brinsfield. 2000. Evaluating changes in subsurface nitrogen discharge from an agricultural watershed into Chesapeake Bay after implementation of a groundwater protection strategy. Final Report Maryland Depart. Environ., Section 319 Grant. Project 14-98-340-EPA-029. 92 p.

Thomason, W. E., T. K. Black, J. S. Reiter, R. A. Clark, P. H. Davis and M. S. Reiter. 2015. Effect of seeding date on interseeded winter annual cover crop growth and nitrogen uptake. In Internal Annual Meetings Abstracts. *ASA, CSSA, and SSSA*, Madison, WI.

van Es, H. M., K. J. Czymmek and Q. M. Ketterings. 2002. Management effects on nitrogen leaching and guidelines for a nitrogen leaching index in New York. *Journal of Soil and Water Conservation* 57(6):499-504.

Appendix A: Technical Requirements for Reporting and Simulating Cover Crop BMPs in the Phase 6 Watershed Model

Background: In June, 2013 the Water Quality Goal Implementation Team (WQGIT) agreed that each BMP expert panel would work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop a technical appendix for each expert report. The purpose of the technical appendix is to describe how the expert panel's recommendations will be integrated into the modeling tools including NEIEN, Scenario Builder and the Watershed Model.

Q1. What are the definitions of the cover crop practice types?

A1. The panel recommended three types of cover crop practices for credit in the Phase 6 Model. Definitions for each type are included below.

Traditional Cover Crop – A short-term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering nutrients. This type of cover crop may not receive nutrients in the fall, and may not be harvested in the spring.

Traditional Cover Crop with Fall Nutrient Applications – A short-term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering nutrients. This type of cover crop is planted upon cropland where manure is applied following the harvest of a summer crop and prior to cover crop planting. The crop may not be harvested in the spring.

Commodity Cover Crop – A winter cereal crop planted for harvest in the spring which does not receive nutrient applications in the fall. Any winter cereal crop which did receive applications in the fall is not eligible for nutrient reductions.

Q2. What are the nutrient and sediment reductions associated with each practice?

A2. The panel recommended 104 unique combinations of cover crop type, species, planting method and planting date. Each of the unique combinations has associated nutrient and sediment reductions. These can be found in Figure 1 below.

Q3. Which land uses can receive nutrient and sediment reductions for each cover crop practice type?

A3. Traditional Cover Crops and Traditional Cover Crops with Fall Nutrient Applications may be submitted upon any of the following row crop land uses:

- Silage with Manure
- Silage without Manure
- Specialty Crop High
- Specialty Crop Low
- Other Agronomic Crops
- Full Season Soybeans
- Grain with Manure

- Grain without Manure
- Small Grains
- Double-Cropped
- Specialty Crop Low

Commodity Cover Crops represent winter cereal production and thus, may only be applied to the Small Grains and the Double Cropped land uses.

Q4. Are the cover crop practices considered annual practices for NEIEN reporting purposes?

A4. Yes. States should submit acres which qualify under each practice each year.

Q5. Can cover crops be combined with other practices to treat runoff from agricultural land uses?

A5. Yes. For example, a single acre of cropland could be eligible for reduction credits from conservation tillage, manure injection, nutrient management, cover crops and upslope reductions from buffers.

Q6. How did the panel isolate the benefits of cover crops to reducing soil runoff from the benefits of residue management (conservation tillage) practices?

A6. The panel provided phosphorus and sediment reductions only for those land uses which are most likely to remain in a low residue (high tillage) category. Those are: Silage with Manure, Silage without Manure, Specialty Crop High and Other Agronomic Crops. The panel assumed that phosphorus and sediment reductions from cover crops were inherently considered in the residue management practices. Additionally, traditional spring transect residue surveys should indicate whether a field had cover crops or not, and the resulting residue cover, allowing states to report both practices on the same field.

Q7. What information should a state report to NEIEN in order to receive credit for cover crop practices?

A7. States should report the following information to NEIEN.

- *BMP Name:* Please consult Phase 6 NEIEN Appendix for extensive listing.
- *Measurement Name:* Please consult Phase 6 NEIEN Appendix for extensive listing.
- *Land Use:* Approved NEIEN agricultural land use classes; if none are reported, the default will be CROP
- *Geographic Location:* Approved NEIEN geographies: County; County (CBW Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW Only)
- *Date of Implementation:* Year cover crop was planted

Figure 1. Nutrient and Sediment Reductions by Region and Land Use Types

	Coastal Plain/Piedmont Crystalline/Karst						Mesozoic Lowlands/Valley and Ridge Siliciclastic					
	Low-Till Land Uses			High-Till Land Uses			Low-Till Land Uses			High-Till Land Uses		
Long Name	**TN**	**TP**	**TSS**	**TN**	**TP**	**TSS**	**TN**	**TP**	**TSS**	**TN**	**TP**	**TSS**
Cover Crop Traditional Rye Early Drilled	0.45	0	0	0.45	0.15	0.2	0.34	0	0	0.34	0.15	0.2
Cover Crop Traditional Rye Early Other	0.38	0	0	0.38	0.15	0.2	0.29	0	0	0.29	0.15	0.2
Cover Crop Traditional Rye Early Aerial	0.25	0	0	0.25	0.15	0.2	0.19	0	0	0.19	0.15	0.2
Cover Crop Traditional Rye Normal Drilled	0.41	0	0	0.41	0.07	0.1	0.31	0	0	0.31	0.07	0.1
Cover Crop Traditional Rye Normal Other	0.35	0	0	0.35	0.07	0.1	0.27	0	0	0.27	0.07	0.1
Cover Crop Traditional Rye Late Drilled	0.19	0	0	0.19	0	0	0.15	0	0	0.15	0	0
Cover Crop Traditional Rye Late Other	0.16	0	0	0.16	0	0	0.12	0	0	0.12	0	0
Cover Crop Traditional Wheat Early Drilled	0.31	0	0	0.31	0.15	0.2	0.24	0	0	0.24	0.15	0.2
Cover Crop Traditional Wheat Early Other	0.27	0	0	0.27	0.15	0.2	0.2	0	0	0.2	0.15	0.2
Cover Crop Traditional Wheat Early Aerial	0.17	0	0	0.17	0.15	0.2	0.135	0	0	0.135	0.15	0.2
Cover Crop Traditional Wheat Normal Drilled	0.29	0	0	0.29	0.07	0.1	0.22	0	0	0.22	0.07	0.1
Cover Crop Traditional Wheat Normal Other	0.24	0	0	0.24	0.07	0.1	0.19	0	0	0.19	0.07	0.1
Cover Crop Traditional Wheat Late Drilled	0.13	0	0	0.13	0	0	0.1	0	0	0.1	0	0
Cover Crop Traditional Wheat Late Other	0.11	0	0	0.11	0	0	0.09	0	0	0.09	0	0
Cover Crop Traditional Barley Early Drilled	0.38	0	0	0.38	0.15	0.2	0.29	0	0	0.29	0.15	0.2
Cover Crop Traditional Barley Early Other	0.32	0	0	0.32	0.15	0.2	0.25	0	0	0.25	0.15	0.2
Cover Crop Traditional Barley Early Aerial	0.21	0	0	0.21	0.15	0.2	0.16	0	0	0.16	0.15	0.2
Cover Crop Traditional Barley Normal Drilled	0.29	0	0	0.29	0.07	0.1	0.22	0	0	0.22	0.07	0.1
Cover Crop Traditional Barley Normal Other	0.24	0	0	0.24	0.07	0.1	0.19	0	0	0.19	0.07	0.1
Cover Crop Traditional Forage Radish Early Drilled	0.26	0	0	0.26	0.06	0.09	0.2	0	0	0.2	0.06	0.09
Cover Crop Traditional Forage Radish Early Other	0.22	0	0	0.22	0.06	0.09	0.17	0	0	0.17	0.06	0.09
Cover Crop Traditional Forage Radish Early Aerial	0.14	0	0	0.14	0.06	0.09	0.11	0	0	0.11	0.06	0.09
Cover Crop Traditional Forage Radish Plus Early Drilled	0.29	0	0	0.29	0.08	0.12	0.22	0	0	0.22	0.08	0.12
Cover Crop Traditional Forage Radish Plus Early Other	0.25	0	0	0.25	0.08	0.12	0.19	0	0	0.19	0.08	0.12
Cover Crop Traditional Forage Radish Plus Early Aerial	0.16	0	0	0.16	0.08	0.12	0.12	0	0	0.12	0.08	0.12
Cover Crop Traditional Forage Radish Plus Normal Drilled	0.22	0	0	0.22	0.04	0.06	0.16	0	0	0.16	0.04	0.06
Cover Crop Traditional Forage Radish Plus Normal Other	0.18	0	0	0.18	0.04	0.06	0.14	0	0	0.14	0.04	0.06
Cover Crop Traditional Annual Legume Early Drilled	0.07	0	0	0.07	0.06	0.08	0.05	0	0	0.05	0.06	0.08
Cover Crop Traditional Annual Legume Early Other	0.06	0	0	0.06	0.06	0.08	0.05	0	0	0.05	0.06	0.08
Cover Crop Traditional Annual Legume Early Aerial	0.04	0	0	0.04	0.06	0.08	0.03	0	0	0.03	0.06	0.08
Cover Crop Traditional Annual Legume Normal Drilled	0.06	0	0	0.06	0.03	0.04	0.05	0	0	0.05	0.03	0.04
Cover Crop Traditional Annual Legume Normal Other	0.06	0	0	0.06	0.03	0.04	0.04	0	0	0.04	0.03	0.04
Cover Crop Traditional Legume Plus Grass 25-50% Early Drilled	0.2	0	0	0.2	0.1	0.15	0.15	0	0	0.15	0.1	0.15
Cover Crop Traditional Legume Plus Grass 25-50% Early Other	0.17	0	0	0.17	0.1	0.15	0.13	0	0	0.13	0.1	0.15
Cover Crop Traditional Legume Plus Grass 25-50% Early Aerial	0.11	0	0	0.11	0.1	0.15	0.08	0	0	0.08	0.1	0.15

Cover Crop Traditional Legume Plus Grass 25-50% Normal Drilled	0.19	0	0	0.19	0.05	0.07	0.14	0	0	0.14	0.05	0.07
Cover Crop Traditional Legume Plus Grass 25-50% Normal Other	0.16	0	0	0.16	0.05	0.07	0.12	0	0	0.12	0.05	0.07
Cover Crop Traditional Triticale Early Drilled	0.39	0	0	0.39	0.15	0.2	0.29	0	0	0.29	0.15	0.2
Cover Crop Traditional Triticale Early Other	0.33	0	0	0.33	0.15	0.2	0.25	0	0	0.25	0.15	0.2
Cover Crop Traditional Triticale Early Aerial	0.21	0	0	0.21	0.15	0.2	0.165	0	0	0.165	0.15	0.2
Cover Crop Traditional Triticale Normal Drilled	0.35	0	0	0.35	0.07	0.1	0.27	0	0	0.27	0.07	0.1
Cover Crop Traditional Triticale Normal Other	0.3	0	0	0.3	0.07	0.1	0.23	0	0	0.23	0.07	0.1
Cover Crop Traditional Triticale Late Drilled	0.16	0	0	0.16	0	0	0.13	0	0	0.13	0	0
Cover Crop Traditional Triticale Late Other	0.14	0	0	0.14	0	0	0.1	0	0	0.1	0	0
Cover Crop Traditional Annual Ryegrass Early Drilled	0.3	0	0	0.3	0.1	0.15	0.22	0	0	0.22	0.1	0.15
Cover Crop Traditional Annual Ryegrass Early Other	0.25	0	0	0.25	0.1	0.15	0.19	0	0	0.19	0.1	0.15
Cover Crop Traditional Annual Ryegrass Early Aerial	0.16	0	0	0.16	0.1	0.15	0.125	0	0	0.125	0.1	0.15
Cover Crop Traditional Annual Ryegrass Normal Drilled	0.27	0	0	0.27	0.05	0.07	0.2	0	0	0.2	0.05	0.07
Cover Crop Traditional Annual Ryegrass Normal Other	0.23	0	0	0.23	0.05	0.07	0.18	0	0	0.18	0.05	0.07
Cover Crop Traditional Oats, Winter Hardy Early Drilled	0.25	0	0	0.25	0.09	0.14	0.19	0	0	0.19	0.09	0.14
Cover Crop Traditional Oats, Winter Hardy Early Other	0.21	0	0	0.21	0.09	0.14	0.16	0	0	0.16	0.09	0.14
Cover Crop Traditional Oats, Winter Hardy Early Aerial	0.14	0	0	0.14	0.09	0.14	0.105	0	0	0.105	0.09	0.14
Cover Crop Traditional Oats, Winter Hardy Normal Drilled	0.23	0	0	0.23	0.04	0.07	0.17	0	0	0.17	0.04	0.07
Cover Crop Traditional Oats, Winter Hardy Normal Other	0.19	0	0	0.19	0.04	0.07	0.15	0	0	0.15	0.04	0.07
Cover Crop Traditional Oats, Winter Killed Early Drilled	0.18	0	0	0.18	0.06	0.08	0.14	0	0	0.14	0.06	0.08
Cover Crop Traditional Oats, Winter Killed Early Other	0.15	0	0	0.15	0.06	0.08	0.12	0	0	0.12	0.06	0.08
Cover Crop Traditional Oats, Winter Killed Early Aerial	0.1	0	0	0.1	0.06	0.08	0.08	0	0	0.08	0.06	0.08
Cover Crop Traditional Brassica Early Drilled	0.32	0	0	0.32	0.1	0.13	0.24	0	0	0.24	0.1	0.13
Cover Crop Traditional Brassica Early Other	0.27	0	0	0.27	0.1	0.13	0.2	0	0	0.2	0.1	0.13
Cover Crop Traditional Brassica Early Aerial	0.18	0	0	0.18	0.1	0.13	0.135	0	0	0.135	0.1	0.13
Cover Crop Traditional Legume Plus Grass 50% Early Drilled	0.26	0	0	0.26	0.1	0.15	0.2	0	0	0.2	0.1	0.15
Cover Crop Traditional Legume Plus Grass 50% Early Other	0.22	0	0	0.22	0.1	0.15	0.17	0	0	0.17	0.1	0.15
Cover Crop Traditional Legume Plus Grass 50% Early Aerial	0.14	0	0	0.14	0.1	0.15	0.11	0	0	0.11	0.1	0.15
Cover Crop Traditional Legume Plus Grass 50% Normal Drilled	0.25	0	0	0.25	0.05	0.07	0.19	0	0	0.19	0.05	0.07
Cover Crop Traditional Legume Plus Grass 50% Normal Other	0.21	0	0	0.21	0.05	0.07	0.16	0	0	0.16	0.05	0.07
Cover Crop Traditional with Fall Nutrients Rye Early Drilled	0.32	0	0	0.32	0.15	0.2	0.24	0	0	0.24	0.15	0.2
Cover Crop Traditional with Fall Nutrients Rye Early Other	0.27	0	0	0.27	0.15	0.2	0.2	0	0	0.2	0.15	0.2
Cover Crop Traditional with Fall Nutrients Rye Normal Drilled	0.29	0	0	0.29	0.07	0.1	0.22	0	0	0.22	0.07	0.1
Cover Crop Traditional with Fall Nutrients Rye Normal Other	0.25	0	0	0.25	0.07	0.1	0.19	0	0	0.19	0.07	0.1
Cover Crop Traditional with Fall Nutrients Rye Late Drilled	0.13	0	0	0.13	0	0	0.11	0	0	0.11	0	0
Cover Crop Traditional with Fall Nutrients Rye Late Other	0.11	0	0	0.11	0	0	0.08	0	0	0.08	0	0
Cover Crop Traditional with Fall Nutrients Wheat Early Drilled	0.22	0	0	0.22	0.15	0.2	0.17	0	0	0.17	0.15	0.2
Cover Crop Traditional with Fall Nutrients Wheat Early Other	0.19	0	0	0.19	0.15	0.2	0.14	0	0	0.14	0.15	0.2
Cover Crop Traditional with Fall Nutrients Wheat Normal Drilled	0.2	0	0	0.2	0.07	0.1	0.15	0	0	0.15	0.07	0.1

Cover Crop Traditional with Fall Nutrients Wheat Normal Other	0.17	0	0	0.17	0.07	0.1	0.13	0	0	0.13	0.07	0.1
Cover Crop Traditional with Fall Nutrients Wheat Late Drilled	0.09	0	0	0.09	0	0	0.07	0	0	0.07	0	0
Cover Crop Traditional with Fall Nutrients Wheat Late Other	0.08	0	0	0.08	0	0	0.06	0	0	0.06	0	0
Cover Crop Traditional with Fall Nutrients Barley Early Drilled	0.27	0	0	0.27	0.15	0.2	0.2	0	0	0.2	0.15	0.2
Cover Crop Traditional with Fall Nutrients Barley Early Other	0.22	0	0	0.22	0.15	0.2	0.18	0	0	0.18	0.15	0.2
Cover Crop Traditional with Fall Nutrients Barley Normal Drilled	0.2	0	0	0.2	0.07	0.1	0.15	0	0	0.15	0.07	0.1
Cover Crop Traditional with Fall Nutrients Barley Normal Other	0.17	0	0	0.17	0.07	0.1	0.13	0	0	0.13	0.07	0.1
Cover Crop Traditional with Fall Nutrients Forage Radish Plus Early Drilled	0.2	0	0	0.2	0.08	0.12	0.15	0	0	0.15	0.08	0.12
Cover Crop Traditional with Fall Nutrients Forage Radish Plus Early Other	0.17	0	0	0.17	0.08	0.12	0.13	0	0	0.13	0.08	0.12
Cover Crop Traditional with Fall Nutrients Forage Radish Plus Normal Drilled	0.15	0	0	0.15	0.04	0.06	0.12	0	0	0.12	0.04	0.06
Cover Crop Traditional with Fall Nutrients Forage Radish Plus Normal Other	0.13	0	0	0.13	0.04	0.06	0.1	0	0	0.1	0.04	0.06
Cover Crop Traditional with Fall Nutrients Triticale Early Drilled	0.27	0	0	0.27	0.15	0.17	0.2	0	0	0.2	0.12	0.17
Cover Crop Traditional with Fall Nutrients Triticale Early Other	0.23	0	0	0.23	0.15	0.17	0.17	0	0	0.17	0.12	0.17
Cover Crop Traditional with Fall Nutrients Triticale Normal Drilled	0.25	0	0	0.25	0.07	0.08	0.19	0	0	0.19	0.06	0.08
Cover Crop Traditional with Fall Nutrients Triticale Normal Other	0.21	0	0	0.21	0.07	0.08	0.16	0	0	0.16	0.06	0.08
Cover Crop Traditional with Fall Nutrients Triticale Late Drilled	0.11	0	0	0.11	0	0	0.09	0	0	0.09	0	0
Cover Crop Traditional with Fall Nutrients Triticale Late Other	0.1	0	0	0.1	0	0	0.07	0	0	0.07	0	0
Cover Crop Traditional with Fall Nutrients Annual Ryegrass Early Drilled	0.21	0	0	0.21	0.1	0.15	0.16	0	0	0.16	0.1	0.15
Cover Crop Traditional with Fall Nutrients Annual Ryegrass Early Other	0.18	0	0	0.18	0.1	0.15	0.13	0	0	0.13	0.1	0.15
Cover Crop Traditional with Fall Nutrients Annual Ryegrass Normal Drilled	0.19	0	0	0.19	0.05	0.07	0.14	0	0	0.14	0.05	0.07
Cover Crop Traditional with Fall Nutrients Annual Ryegrass Normal Other	0.16	0	0	0.16	0.05	0.07	0.12	0	0	0.12	0.05	0.07
Cover Crop Traditional with Fall Nutrients Oats, Winter Hardy Early Drilled	0.17	0	0	0.17	0.09	0.14	0.13	0	0	0.13	0.09	0.14
Cover Crop Traditional with Fall Nutrients Oats, Winter Hardy Early Other	0.15	0	0	0.15	0.09	0.14	0.11	0	0	0.11	0.09	0.14
Cover Crop Traditional with Fall Nutrients Oats, Winter Hardy Normal Drilled	0.16	0	0	0.16	0.04	0.07	0.12	0	0	0.12	0.04	0.07
Cover Crop Traditional with Fall Nutrients Oats, Winter Hardy Normal Other	0.14	0	0	0.14	0.04	0.07	0.1	0	0	0.1	0.04	0.07
Cover Crop Traditional with Fall Nutrients Brassica Early Drilled	0.22	0	0	0.22	0.1	0.13	0.17	0	0	0.17	0.1	0.13
Cover Crop Traditional with Fall Nutrients Brassica Early Other	0.19	0	0	0.19	0.1	0.13	0.14	0	0	0.14	0.1	0.13
Cover Crop Commodity Early	0.05	0	0	0.05	0	0	0.04	0	0	0.04	0	0
Cover Crop Commodity Normal	0.1	0	0	0.1	0	0	0.08	0	0	0.08	0	0
Cover Crop Commodity Late	0.15	0	0	0.15	0	0	0.12	0	0	0.12	0	0

Appendix B: Methods to Estimate Historic Implementation

Identification of potential methods to estimate historical cover crops – especially commodity cover crops – is challenging. The Panel has discussed the fact that baseline conditions with respect to cover crops have never been fully laid out. Over the last several decades, changes in crop varieties, crop yields, the amount of N recommended or applied, the timing of nutrient applications, and tillage practices have changed so significantly that establishing historical cover crop implementation has been difficult.

Appendix C: Cover Crops Phase 6.0 Expert Panel Charge Document

Charge and Scope of Work
Cover Crops Phase 6.0 Expert Panel

March 19, 2015

Background

Traditional and commodity cover crops are approved practices in the Phase 5.3.2 (P5.3.2) Chesapeake Bay Program Watershed Model. The Traditional Cover Crops BMP is currently defined as a short term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering excess nutrients. No additional nutrients are applied in either the fall or spring, and the cover crop is terminated without harvesting. The following traditional cover crop species have associated nitrogen (N), phosphorus (P), and sediment reduction efficiencies:

- Rye
- Wheat
- Barley
- Annual Ryegrass
- Annual Legumes
- Annual Legume plus Grass Mixtures
- Brassica (winter hardy)
- Forage Radish
- Forage Radish plus Grass Mixtures
- Triticale
- Oats (winter hardy)
- Oats (winter killed)

The Commodity Cover Crops BMP is currently defined as a short term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering excess nutrients. No additional nutrients are applied in the fall, however additional nutrients can be applied in the spring after March 1 and the commodity cover crop can be harvested. The following commodity cover crops have an associated N reduction efficiency:

- Rye
- Wheat
- Barley

Recommendations for Expert Panel Member Expertise

The AgWG expert panel organization process[1] directs that each expert panel is to include eight members, including one non-voting representative each from the Watershed Technical Workgroup (WTWG) and Chesapeake Bay Program modeling team. Panels are also expected to include three recognized topic experts and three individuals with expertise in environmental and water quality-related issues. A representative of USDA who is familiar with the USDA-Natural Resources Conservation Service (NRCS) conservation practice standards should be included as one of the six individuals who have topic- or other expertise.

In accordance with the July 13, 2015 Water Quality Goal Implementation Team BMP Expert Panel Protocol (BMP Protocol)[2], panel members should not represent entities with potential conflicts of interest, such as entities that could receive a financial benefit from Panel recommendations or where there is a conflict between the private interests and the official responsibilities of those entities. All Panelists are required to identify any potential financial or other conflicts of interest prior to serving on the Panel. These conditions will minimize the risk that Expert Panels are biased toward particular interests or regions.

The Agriculture Workgroup directs that the P6.0 Cover Crops Panel should include members with the following areas of expertise:

- An agronomist or soil scientist with experience with cover crops in the Chesapeake Bay watershed.
- Knowledge of how BMPs are tracked and reported, and the Chesapeake Bay Program partnership's modeling tools.
- Experience verifying cover crop practice implementation.
- Expertise in fate and transport of N, P, or sediment in cover cropped systems.
- Expertise in hydrology to address both surface water and ground water transport.
- Expertise in both grain and forage crops and operations with and without livestock.
- Knowledge of, and experience with, USDA-NRCS conservation practice standards and codes.

The collective expertise of panel members should cover the range of both the physiographic regions found and the cover crop species used within the Chesapeake Bay watershed.

Expert Panel Scope of Work

The general scope of work for the Cover Crops P6.0 Panel will be to define and configure the Cover Crops BMP in the P6.0 model. Specifically, the Agriculture Workgroup defines the following three charges with associated tasks for the P6.0 Cover Crops Panel:

1. Transition and translate all current cover crop reduction efficiencies from the P5.3.2 to the P6.0 model.
2. Review and update the definitions and reduction efficiencies of cover crops that are eligible for commodity cover crop status.
3. Panel will collaborate with the P6.0 conservation tillage Panel to address credits for winter cover crops that receive fall nutrients.

2 http://www.chesapeakebay.net/documents/CBP_BMP_Expert_Panel_Protocol_WQGIT_approved_7.13.15.pdf

The following two items are recommended for consideration if time allows, or if necessary within the context of addressing charges 1 and 2: 3

- Create a late-summer planting system for cover crops that are planted in mid- to late-August after a silage removal or short-season crop (e.g., vegetable).
- Consider a change from the current approach that uses average frost date for setting planting dates to one that uses heat units.

This scope of work addresses cover crop reduction efficiencies for N, P, and sediment.
The first charge is necessary because the P6.0 model features a change in land use categories, a possible change in the baseline condition, and some likely changes in how the cover crop BMPs will be applied to specific land uses.

The second charge is necessary to evaluate and update the commodity cover crop portion of the BMP that was not addressed by the Phase 5.3.2 Cover Crops Expert Panel. This evaluation and updating should include an evaluation of the current N reduction efficiencies and possible estimates of P and sediment reduction efficiencies for the existing commodity cover crops, identifying other cover crop species from the current traditional cover crop list that would be eligible for commodity cover crop status, and estimating the N, P, and sediment reduction efficiencies for each new commodity cover crop species.

The third charge is necessary to ensure that recommendations regarding a definition and credits for winter cover crops receiving fall nutrients are based on input from both Panels. The P6.0 Conservation Tillage Panel is charged with this task, but collaboration with this Panel is recommended to both ensure consistency between and take advantage of the expertise available in the two panels.

While the P6.0 Panel is charged only with items 1 through 3 and their associated tasks, it may choose to address the two additional items, if it has time or it is determined that addressing either or both of these items is essential to the successful completion of charges 1 and 2.

The first optional item is suggested to expand the scope of the cover crop BMP to address those covers planted after a summer-harvested crop. Such planting is much earlier than the frost date that is currently in use. In addition, some cover crops will be better suited for early planting (e.g., radishes, warm season grasses) while others will not (e.g., rye, cool season grasses). If the first optional item is undertaken, it will also require estimating the N, P, and sediment reduction efficiencies for each species in the new late-summer planting category. The second optional item is suggested because cover crop planting dates in the P5.3.2 model are based on average frost date, in order to adjust the reduction efficiencies across the whole Bay Watershed. The second optional item recommends that the P6.0 Panel consider the usefulness and practicality of using a heat unit based planting date system. It is recognized that a heat-unit approach would require significant additional data-base work, but the benefits may warrant such effort.

The Panel will follow the process described in the 2015 BMP Protocol for all activities including development of a final report. In addition, the Panel will develop a provisional paper including BMP structure and type, draft BMP definition(s), and initial elements of the BMP such as associated components and conservation practices, and USDA-NRCS associated conservation practice codes. Initially identified literature citations will be included to provide a range of 4

potential effectiveness values that the panel will consider and supplement with further evaluation. The panel will present their provisional BMP paper to the AgWG, WTWG, and WQGIT for informational purposes, and for initial Partnership comments on the proposed direction of the panel's evaluation. Provisional panel recommendations will be used only for initial Phase 6 model development and calibration, and not for future implementation progress reporting by the jurisdictions.

Timeline and Deliverables

The Expert Panel project timeline for the development of the panel recommendations is based on the Phase 6.0 model development schedule. This timeline includes the development of a provisional recommendation for this BMP prior to the finalization of a fully documented recommendation report with effectiveness values. Provisional panel recommendations will be used only for initial Phase 6 model development and calibration, and not for future implementation progress reporting by the jurisdictions. The Panel coordinator will work with the Panel to develop a detailed project timeline based on the deadlines below.

Summer 2015 – Panel stakeholder kickoff meeting
September/October 2015 – The Panel will present a provisional report to the AgWG, WTWG, and WQGIT for informational purposes, and for initial Partnership comments on the proposed direction of the Panel's evaluation. The paper will not represent a full recommendation report, and the Partnership will not be asked for formal approval at this time.

February 2016 – Target date for Panel to release draft report to the Partnership.

April 11, 2016 – Target date for full Partnership approval of the panel report.

Phase 6.0 BMP Verification Recommendations:

The panel will use the Partnership approved ***Agricultural BMP Verification Guidance***[3], as the basis for developing BMP verification guidance recommendations that are specific to the BMP(s) being evaluated. The panel's verification guidance will provide relevant supplemental details and specific examples to provide the Partnership with recommended potential options for how jurisdictions and partners can verify cover crops practices in accordance with the Partnership's approved guidance.

3 http://www.chesapeakebay.net/documents/Appendix%20B%20-Ag%20BMP%20Verification%20Guidance%20Final.pdf

Appendix D: Approved Cover Crops Expert Panel Meeting Minutes

8/19/2015

Welcome and Introductions

- Mark Dubin and Ken Staver discussed the charge to this expert panel.
- The Phase 5 Panel has developed efficiencies for a number of species that were not model specific. This Panel may be able to use some of this existing work in making their Phase 6 recommendations.
- This Panel has been charged with looking at commodity cover crops
- Mark reviewed the timeline and deliverables for the Panel, which are included in the Panel charge.
- The provisional paper is meant to be initial information to the Partnership as the Panel begins developing their recommendations. It will not be going through review and approval, it is just meant to be communication.
- Jack asked if this Panel would continue past April 2016 to make modifications based on any changes in the model.
    - Expect the Panel to be finished with their responsibilities once the recommendations are implemented in the model in early 2016.

Previous literature search and summary of the work done by Phase 5 panel

- Jack Meisinger gave an overview of recent work done by the Phase 5 panel
- There is opportunity for this Panel to re-visit the Phase 5 Panel's work if there is additional data or reason to do so.
- Annual legume + grass was previously an average of the two species individually. There may be reason to revisit this category.
- Modeling Team Q: Will there be progress on soil residual N and P in CC efficiencies in Phase 6?
- Jack reviewed some suggestions for the Phase 6 panel from the Phase 5 panel, including use of growth regions rather hydrogeomorphic regions.
- Need for this Panel to coordinate with the Conservation Tillage Panel and with the Nutrient Management Panel on the commodity cover crop piece.

Open session with panel members and interested stakeholders

- Panel members introduced themselves
- Ken briefly explained the work the Panel will be involved in
- Stakeholder questions
- Is the panel considering other species of cover crops that may not be intended for nutrient reductions but may still have some effect?
    - There is a strict legume species that was added in 2014.

Panel discussion/brainstorming (panel only session)

- Mark recommended bringing the three panels together for a joint meeting during the Nutrient Management Panel's face-to-face meeting to address the commodity cover crops.
    - Concerns with timing of reported commodity cover crop and winter cereals for production, within an annual model.
    - Ken and Wade will propose an approach to the Nutrient Management Panel
    - Conservation Tillage panel will take the sediment piece if decision is to break up the components of commodity cover crops.
- There may be some tweaks to the Phase 5 information but the Panel will likely keep most of the Phase 5 information as it exists now.
    - Fall manure dairy situation – important enough to be credited in some way.
- Ken has some contacts for the heat units.
- Assignments:
    - David Wood will provide the Panel some answers to their modeling specific questions.
    - Ken and Wade will discuss the approach to commodity cover crops

Participants

Ken Staver	UMD Panel Chair
Mark Dubin	UMD
Charlie White	PSU
Jason Keppler	MDA WTWG rep
Lindsey Gordon	CRC
Emma Giese	CRC
David Wood	CRC Modeling Team rep
Jack Meisinger	USDA-ARS
Don Meals	TetraTech
Wade Thomason	VT

12/21/2015

Actions & Decisions:

ACTION: Wade and Charlie will work on collecting and summarizing research data on efficiencies of mixtures, and cover crop options to use in summer fallow period. Results will incorporate a heat unit distribution, and be presented in a late January meeting**.**

ACTION: Ken Staver will look for options for developing a framework for dealing with the variation in heat unit accumulation throughout the watershed.

ACTION: Panel members should direct any modeling questions and concerns via email to Lindsey Gordon (Gordon.lindsey@epa.gov) and David Wood (woodm.david@epa.gov), to be addressed by the modeling team in a January meeting.

ACTION: Charlie White will coordinate with Paul Salon to see if NRCS has data from the northern part of the watershed or anywhere else to contribute to Action 1.

ACTION: Panel members should contact Mark Dubin, AgWG Coordinator (mdubin@chesapeakebay.net), and Lindsey Gordon (Gordon.lindsey@epa.gov) if they would like access to the preliminary results from the first beta run of the model, due out by January 8th, 2016.

Meeting notes:

- Ken Staver reviewed the Cover Crops Panel charge and scope of work.

- Staver briefed the workgroup on the resolution of the commodity cover crops issue: the CCP will tackle the issue of commodity cover crops, but the NMP will handle fall manure.
- Staver noted that his preference is that the panel will not reopen the traditional cover crop reduction efficiencies from the Phase 5.3.2 model unless panel members have supporting data to justify changes.
    - Charlie White agreed, and suggested writing a brief report of data sets that they have published or accumulated that are focused on efficiencies of mixtures (grass-legume mixtures, specifically).
    - Jack Meisinger explained that the Phase 5.3.2 did an average because of limited data availability. He suggested the panel go back in and revise/update the 5.3.2 tables. He also reminded the panel to be very careful with mixtures, in how much residual N is left in the fall. The model does not currently estimate residual N, so the panel will be limited in their scope of that area.
    - Staver noted that he didn't see that as a problem – all the panel is focused on is N reduction efficiency.
    - Wade Thomason offered to provide Charlie with more information on species further south.
    - Staver asked for heat units to be contextualized in the data Charlie will provide.
    - White: We have a lot of different crops in our dataset, not just over-wintering crops. We have a lot of the late summer data as well, which I can summarize.
    - Staver: So, Charlie, you're talking about updating mixture efficiencies in the 5.3.2 table, and also providing more insight into the late-summer window.
    - Meisinger suggested the panel define a late-summer time period, and the species that will be planted during that time frame in order to capture vegetable crops and silage. Once Charlie and Wade have presented their data, then the panel can review this issue more fully.
        - Ken Staver suggested the panel look at data on heat units after harvest in response to the summer cover crop issue.
        - Dubin suggested overlaying both options (traditional frost date and heat units).
        - Meisinger asked how the guideline would work for developing a heat unit database form existing meteorological information.
        - Ken Staver offered to take the lead on working on a better representation of heat units.
        - Dubin suggested Wade and Charlie describe their research data in the context of heat units.
- Meisinger suggested making changes in the Phase 5.3.2 efficiency table in the 6.0 version of the panel report. That way, the 5.3.2 effort will be closed out, but updated with a 6.0 auxillary/supplemental table.
    - Staver cautioned that the review effort for phase 6.0 shouldn't become a review of the 5.3.2 effort as well.
    - Dubin noted that during the WQGIT December face-to-face meeting, a decision was made so that there will be a two-year milestone period for incorporating new data into the model, and that panel recommendations will only be incorporated into the model

when a two-year milestone window opens. He suggested focusing on the Phase 6.0 recommendations.

- Staver discussed the initially proposed timeline for the panel, and how that timeline will have to shift as the panel continues its work.
    - Mark Dubin suggested modifying the panel's timeline: submitting recommendations in April, and finalizing data in the 3rd beta model run in.
- Jack Meisinger reviewed a spreadsheet of the current cover crop N reduction efficiencies and the calculated ratio of commodity reduction efficiencies to traditional reduction efficiencies.
    - Dubin cautioned against putting too much stock into the current values, and stated that the panel essentially has a blank slate in terms of determining reduction efficiencies.
    - Meisinger asked if anyone had information on a commodity system that's not fall-fertilized vs. a traditional fall-fertilized system in order to compare leaching losses.
    - Staver asked what the commodity cover crop reduction efficiency actually means. He asked if the panel was still tying this back to the previous crop, or if it's relative to production wheat grown with no BMP. Essentially whether the baseline is going to change?
    - White: So are we asking what happens to leaching losses when you go from a winter small grain that's fertilized to a winter small grain that's got reduced fertilizer application? As opposed to going from winter fallow to winter cover?
    - Staver noted that the panel needs to aware of the relationship between the efficiency and the baseline.
    - Jason Keppler suggested the panel also needs to be cognizant of the timeframe for efficiencies. The model operates under a 12-month year, but crops and efficiencies all operate under different timeframes.
    - Staver: Currently, the planting of fall winter cereals isn't represented as a land use. So maybe commodities can be handled as a fall attribute to the land uses where winter cereals are typically planted in the fall.
    - Dubin noted that cover crops are meant to be applied to specific crop categories as a specific BMP, and that the panel also needs to look how Phase 6 is managing the nutrients on those crops. The panel might want to consider what Phase 6 will be using in terms of Nutrient Management recommendations?
    - Meisinger stated that he believed the commodity cover crop issue should be handled under the Nutrient Management Panel.
    - Staver said that the group needs to be careful about defining what the reduction efficiencies actually represent, and ensure that regular Nutrient Management isn't already giving credit for a commodity cover crop as defined by the panel.
    - Keppler: I think we should consider the crop's ability to take up residual N from a previous crop too.
    - Staver: We have the possibility of nutrient application and tillage in the fall. And then also the possibility of no-till and nutrient scavenging so that it works exactly like a traditional cover crop. There is a full range of fall impacts here, and it seems to me that those three months at the end of the year are being ignored.
    - Dubin: As a BMP right now, traditional cover crop's efficiency is applied across the entire 12-month time period. If we're going back to commodity cover crops, and only applying

nutrients in the spring, I don't know if a 12-month BMP crediting will work very well. That's why I wonder if we can manage to turn off the nutrient flow in Scenario Builder, telling the model not to turn on reductions in the fall on commodity cover crop acres.

- Keppler: I'm still not quite following that. It may be beneficial if one of the modelers could give us a briefing of how this is sequenced at our next call.
- Staver: Where is the fall management of winter cereals? The tillage, and nutrient applications, and possible nutrient scavenging, increasing in crop residue cover- how is that being handled in version 6?
- Meisinger: We need to get some clearer understanding of what the Phase 6 model is doing. I think they're assuming a certain condition for that land use – a given set of fall conditions. And that assumption would be modified by a BMP. So we don't need another land use, but if we understand what assumptions were made, we can still add a BMP to that assumption. So we first need to figure out how to get the fall management piece credited.
- Staver: So we really need a presentation from the modeling group in how winter cereal production schedule is represented in Phase 6?
- David Wood will relay the panel's concerns to the modeling team.
- Meisinger identified spreading out the credit over 12 months, and how that is not appropriate for cover crops. If the panel is focusing on a fall timeline, then they need to get the model timeline on a more realistic schedule because the reduction value will not be as long as a calendar year.

- The group brought up the possibility of including other species (besides wheat, barley, rye) in commodity cover crops, but Ken noted that they have very small acreage values.
- Dubin suggested the group develop a list of commodity cover crop species.
- Question for the modeling team: How are they modeling acres/P6 land uses (cropping vs. double cropping)?
- Questions/concerns for the modeling team:

  - Overall, how are winter cereals grown for harvest (both standard/baseline and commodity cover crop version) simulated in Phase 6?
  - Given that in the Phase 6 ag land uses currently proposed the fall planting of winter cereals is not represented, what are the plans for representing the tillage, nutrient applications, possible nutrient scavenging and changes in residue cover associated with this part of the production cycle? Changes over time 1985-2015 in production practices?
  - Can the data sets in scenario builder be used to identify the availability of crop settings where different cover crop options can be used, especially the summer fallow settings that have not yet been addressed?
  - How will the nutrient reduction credit for traditional and commodity cover crops be applied, and specifically, how will the fall nutrient scavenging of a commodity cover crop be represented?
  - In the new inorganic fertilizer sales approach, how are nutrients allocated to winter cereal production and how are they divided between fall and spring since the applications occur in two separate years.

Participants:

Jason Keppler	MDA Watershed Technical Workgroup representative
Mark Dubin	UMD AgWG Coordinator
Ken Staver	UMD Panel Chair
Don Meals	Tetra Tech
David Wood	CRC Watershed Technical Workgroup Representative
Wade Thomason	VT
Charlie White	Penn State
Jack Meisinger	USDA ARS
Lindsey Gordon	CRC Staff

2/29/2016

Actions & Decisions:

ACTION: David Wood and Mark Dubin will work to get a model run for the baseline conditions in 1985.

ACTION: By the next panel meeting, panel members will search for data to characterize:

1. Yield: Ken Staver using NASS data
2. Total N applied: Charlie White, referencing agronomy guides and university recommendations
3. Timing of N application: Jack Meisinger will collaborate with Doug Beegle
4. Tillage: Wade Thomason using data from CTIC, Charlie White will collaborate with Sjoerd Duiker

ACTION: Charlie White will look at mixed cover crops before the next panel meeting.

Meeting notes:

- Ken reviewed the general direction that the panel is heading, and the work that has been done since their last conference call.
- Panel discussed the 'bucket' approach to fertilizer, and other alternative options.
    - Dubin: The Nutrient Management Panel has come to the recommendation that the approach to fertilizer needs to change.
    - Meisinger: And this bucket approach is being driven be fertilizer sales data that are being estimated at the county level. The NMP is recommending an actual N and P BMPs related to N-rates and P-rates, and placement and timing as well. There will be a virtual complete double counting if the bucket approach on the Beta 1 is adopted. Somewhere along the line, one group will have to yield, so our discussion on N-application adjustments may have to be put on hold until that's resolved.
- Staver: Fall establishment of winter cereals is not represented in Phase 6 land uses. We'll have to work with some other panels on that one.
- Meisinger: Could we include that as a BMP following corn or soybeans? It would be an add-on to the baseline of corn grain without anything in the fall.
    - Dubin: We're addressing it as a BMP versus as a cropping land use, and I think the divide here is that it's pretty clean with a traditional cover crop. With the commodity cover crops, I think that's the tricky point. We may have to look at this as a BMP after corn to

represent that aspect of it, and then we may have to treat it differently when it gets to the next year and there is the application of nutrients.
    - Staver: I would use the term 'attribute' as opposed to BMP. There's got to be something in those land uses that can be used as an attribute for the winter cereals.
    - Dubin: If the group is saying commodity crops are a mirror of traditional crops, then could we go back to those same traditional values, with a shorter list, and look at the work that's already been done and use that to inform the commodity cover crops values?
    - Staver: I don't really see that there's that much we can use. You're talking about describing commodity cover crops as a land use, but that's separate from describing it as a baseline relative to winter cereals for production.
    - Dubin: Traditional cover crops will be represented as a BMP moving forward, and I'm suggesting we use the same approach for commodities, and just reduce the value because of that early spring nutrient application.
    - Staver: But that's why we want to know how the model is representing loads from wheat as a crop.
    - Meisinger: I don't want to let the model lead us. We should go back to the best data we have and work up some research base if we can.
    - Dubin: But the former panel created that 1985 baseline, and I think we could use that same approach for Phase 6.
    - Staver: The bottom line is the modeling group doesn't just need help with identifying the benefits of a commodity cover crop, they need major help with just modeling winter cereal production. We, just by taking on this issue, have to open the whole can of worms.
    - Staver: We have to disconnect from the modeling effort and try to frame this topic the best we can.
    - Meisinger: The 5.3.2 Nutrient Management Panel developed an efficiency for the FSNT. So we have some information we can use to inform our professional judgement.
- Charlie White updated the group on the mixtures data – he is still working on looking through the data and hopes to have something to report back by the next panel call.
- Mark and Ken discussed the availability of additional resources to assist in completing panel work. The panel will need to identify what type of work they would like to use these resources for, as well as a person the panel identifies who would be able and willing to do this work.
    - Staver: I'm least worried about Charlie and Wade's task of looking at the mixtures data. We need to figure out what issues are our top priority that we can assign to some outside help.
    - Meisinger: Are we going to be using the same approach of looking at total N uptake of the mixtures compared to rye or the pure stands?
        - White: Yes – in the datasets I have, we can do those same comparisons.
        - Thomason: We would have the uptake data in our dataset.
        - Meisinger: Good – I think that makes Charlie and Wade's job much more manageable.
    - Dubin: We could also look at the work from the Phase 5 cover crops panel.

  - Staver: The bottom line is that this work was never really done in the previous panel. Is that correct?
  - Staver: Our panel has some major issues: 1) Trying to get the mixtures in. 2) Sediment and P issue (erosion issue) with traditional and commodities.
    - Meisinger: I think we'll have to sideline the commodity cover crops issue.
    - Staver: Is it reasonable to try and get some bay-wide representation of what people's sense is? What's the sense of what wheat production looks like from '85-'15?
- Panel discussion on how others have collected data.
- Keppler: Wondering what the purpose of the baseline from '85 is as it relates to the CCP work. It sounds like there's some blending between the AMS work, and the tillage panel. Under the time constraint we have, we might be biting off more than we can chew.
  - Staver: Commodities kick us into a wheat-production cycle that goes back to 1985.
  - Keppler: I'm concerned we're trying to help the modelers out in modeling wheat production in this, but we're really just looking at the environmental benefit of commodities grown in the fall, regardless of how it will be managed in the spring.
  - Staver: The baseline is not winter fallow; it's winter wheat and how it was grown.
  - Keppler: So my baseline would be winter fallow.
  - Dubin: There's 2 potential approaches: 1) we modify the small grain production that we're representing for the rest of the year on the front end. 2) We model it similarly to the traditional cover crop. We would be putting something in during the fall, and not fertilizing until spring, and sequestering until March. After that, it becomes commodity production when you put on the fertilizer. I think the panel should consider the two approaches based on available information, time for developing a recommendation, etc.
  - Staver: We could put some mechanistic clarity on this whole topic.
  - Meisinger: So you're proposing a homework assignment on going back and describing qualitatively (and somewhat quantitatively) what was happening in 1985 in terms of tillage, N and P fertilization of winter cereals.
  - Dubin: Could we circle back to the work done by the ag land use loading ratios subcommittee on this?
  - Meisinger: If we each do our homework on pulling out the recommendations, it could benefit several panels. I think it's a good exercise.
  - Dubin: I worry about spending too much time on this and running out of time for developing our recommendations.
  - Staver: Yield, Total N applied, timing of application, tillage. Could we make some statement on how those 4 things change over time?
  - Meisinger: Can we clarify that you would need information within 2 weeks?
  - Charlie will ask Sjoerd Duiker where he acquires his data on tillage.
    - White: We could also look at our agronomy guides to check on university recommendations, and that would cover the N recommendations.
  - Wade will pull data from CTIC on tillage.
  - Jack will attempt to gather data on N timing, and will coordinate with Doug Beegle.
  - Dubin suggested pulling a 1985 Scenario Builder baseline run, which would include all of this information.

- Ken discussed the issue of modeling erosion losses.
    - Dubin: The Ag land use loading ratios subcommittee looked at some of this information.
    - Staver: I'm leaning towards avoiding the P piece. We could certainly look at erosion, but I don't think we should be considering P right now.
    - Meisinger: The 5.3.2 panel tied P and sediment loss together into the erosion piece.
- Meisinger: We discussed if should have an early planted window (August – October) for cover crops. We never followed that up with populating it with species. We can put this off to the next panel, but it would be useful to consider if that would be appropriate for the next panel.
    - Staver: Let me do a heat unit graph on that for the next call, just to see where it would shake out.

Participants:

Mark Dubin	UMD
David Wood	CRC
Lindsey Gordon	CRC
Jason Keppler	MDA
Ken Staver	UMD
Don Meals	Tetra Tech
Jack Meisinger	USDA ARS
Wade Thomason	Virginia Tech
Charlie White	Penn State

3/17/2016

Actions & Decisions:

ACTION: During their next call, the panel will look at Phase 5.3.2 Cover Crop Panel's values, and the panel will determine if they need to make some adjustments to those numbers. Jack will update the panel on what the 5.3.2 panel did in their final version. Jack will also distribute information on what was done in the 5.3.2 panel, and Charlie and Wade will present some approaches to looking at the data.

Meeting notes:

- Charlie White presented summary data of mixture Nitrogen uptake. Data included seeding rate in mixtures relative to monoculture rates, and non-legume N uptake in mixtures relative to monocultures.
    - Paul Salon: If you're planting legumes in your mix, and they're adding N, would that reduce the efficiency of the mix? Even though you're only measuring the content of the grasses, because you're assuming the grasses are taking up all the legume had produced.
        - White: There might be some small amount of transfer while the cover crop is growing. My sense is that level of transfer is pretty minimal in the scheme of things. We can't really sort that out with this dataset, but my assumption is the grasses are getting 100% of N from the residual soil N, as opposed to transfer from the legumes.
    - Salon: I've been doing some growing degree day calculations in the Ithaca area, and my numbers are a lot different than yours. So I might want to coordinate with you on this.

        - White: The lines are for one planting date that was after corn silage, but for other ones that were planted in August, we're hitting a lot higher growing degree days in the fall.
    - Staver: You were dealing with fairly low-N status in most of the soils in these studies, right?
        - White: It varies, really. Some had very high N-status, others have a lower N-status.
    - Meisinger: Do some of these have radish-rye mixtures?
        - White: The Berks County site had that mixture, and others had a combination of radish or rye.
    - Ken Staver suggested the group looks back at the 5.3.2 mixture efficiencies.
        - Staver: We don't have a direct measure of leaching losses.
    - White: Some studies had anion exchange resin bags buried at 30 cms. I don't know if that's the gold standard for leaching, but if we wanted to correlate that data with the N-uptake, we could. My informal opinion is that it's consistent with the 90% efficiency level relative to rye. The mixes all had low anion exchange Nitrate-capture, but it wasn't quite as low as the rye monocultures, typically.
    - Staver: The suggestion is the simple approach from 5.3.2 (half cereal and half legume = cut efficiency in half)…
        - Meisinger: We took the average of the radish (forage radish or legume) and the generic grass mixture. We averaged around 0.65. We didn't have any mixture data, but we wanted to air on the conservative side.
- Matt Johnston discussed how winter grains data is being simulated in Phase 6.
    - Staver: These acres show up in the annual NASS data. The difference between planted and harvested for wheat, for example, is a pretty big gap.
    - Staver: I thought there were 2 winter cereal land uses: 1) winter grains into double cropped soybeans and 2) winter grains into forages.
        - Johnston: Forages is fine, but no – we have small grains, just by themselves. And then the double cropped acres where we think they were harvested in the same year as another cropped. They can be combined mainly with soybeans, but also corn depending on how the data worked out.
        - Dubin: The double cropped acres are a subset of the total domain of acres.
    - Meisinger: There might have been a miscommunication on that, because Ken's explanation of the winter wheat that goes into a forage system – no one leaves their land fallow from June – December. But basically, most of the dairy farmers establishes their long term forage system – that's when they do it. There's no crop harvested, but the land is covered, and so the model is really based quite a bit on that one.
        - Johnston: That was the presentation Olivia gave to the AMS, and that's how we approved how to set up these land uses. I agree from the get-go; I've been confused about the double crops, so we should bring this back to the AMS. We can leave the mechanism in the model, but we should figure this out.
    - Staver: Your small grains land use is some winter cereal harvested in summer, and staying fallow. So it's a single harvest in that year of a winter cereal. Or the other place it

could crop up is in situations where it's harvested and then you plant another crop like soybeans after the harvest.

- Johnston: Because of the way the math works out, you'll have both land uses even as you go south. This conversation has proven that Jack and I need to take a close look at the acres in these two land uses and come up with different math for the AMS.

- Staver: If the simulation year starts Jan 1, the N applied for the winter cereal was applied in the previous year, so in the simulation you have to put it on a different land use.
  - Johnston: The simulation treats all of these months as during that year. So you'll see the applications for barley in DE in September and in Dec. of 1985. You'll also see applications for soybeans during the earlier months of that year. So if you have a double cropped land use, the model will grow two crops on that land use in one year.
  - Staver: But it doesn't make sense to put N on the field in the fall if you've got a double cropped soybean on the field.
  - Johnston: What we're saying is the experts on the AMS didn't have all of the benefits of what you're discussing. So why not let Jack and I take a look at the acres and re-define the land uses, and asks the states to re-define what that means in terms of applications. We would work hard to make sure it reflects how double cropping would be managed. That way we can give the states specific instructions of what to apply in those months.
  - Staver: We were thinking of an October to July cycle, right?
  - Dubin: Think of this as January – December. We're capturing the back-end of the previous year, and the front-end of the small grains in the next year.
  - Meisinger: It'll be tough though, because small grains follows the corn crop, which is a different land use – so you're changing land uses between seasons.
- Staver: Our biggest issue to resolve on this panel is commodity cover crops.
- Johnston: Should commodity cover crops have a BMP efficiency, or should they simply be simulated in the model? These are the things that the AMS can discuss.

- Jack gave a presentation on winter wheat data from lysimeter studies.
  - Staver: We're interested in the difference between commodity cover crop management approach and standard practice. I don't think the no-fertilizer N option fits into that calculation.
  - Meisinger: We should decide how we'll use these data to get a reduction efficiency. What I like about this is we've got, instead of a standard rye cover crop, a wheat cover crop as our standard. But the model already has a wheat cover crop in it, so we can plug directly into the wheat data in the 5.3.2 versions, and now add a commodity. We don't have to go through a rye cover crop.
  - Staver: Traditional cover crop isn't a land use – it's a BMP. But in this case, this is a land use, and it has a load. Then we would change the management to a commodity mode, which would reduce the loss. To me, you're reducing the load from standard practice to a commodity load.

- Meisinger: I was thinking we wanted to go towards a % reduction, because it has a broader application range.
- Staver: Phase 6 will generate a kg/ha loss for wheat production. But if we convert to the commodity mode, we'll reduce that loss by some %. So if we're going to apply it as a BMP efficiency, it's got to be applied to the small grains somehow.
- Meisinger: This just gives you an idea that it'll be something less than 50%, and we may end up setting it at 10, 15, etc. We need more data, and this is the best I've got.
- Salon: If you've leached the soil column so much, and the cover crop was so deficient in N, more so than what is typical, I would think that if there was a little more residual N in the column, that 5.2 number would be greater and the % would go down maybe closer to that 15%.
- Meisinger: Those are the kind of things when we go to interpret data, where the professional judgement would come in.
- Charlie: This data is a nutrient management BMP on a cash crop, and it would fall under the nutrient management panel, the way we've got it calculated here. I know we ended up with the commodity cover crop, but looking at it from a cover crop perspective, it seems like we'd want to have some other kind of control than the wheat cover crop. I'd like to see another column that's either no cover crop, or a control like a rye.
- Staver: I was thinking we wouldn't expect any reduction based on this current set up of commodities. You can put the same rate on (and that's another question of rate adjustment), but you wouldn't expect any reduction of the commodity after the grain application. At that point, you're scavenging the N from the previous crop. I think maybe a way to do this is to say that we think the reduction efficiency is related to the fall application, and we'll put that as a BMP efficiency against the previous crop (corn or soybeans). And that's where the commodity cover crop efficiency is applied. So, maybe since it won't help on the 2nd half of the production cycle (we'd put on more N at the end than at the beginning). I don't really know what real practice is. I was told that for soybeans, they cut out the fall application, but the total rate is lower.

- Jack presented information on the Maryland Land Grant Wheat N Recommendations.
  - Meisinger: Getting a baseline out of these recommendations is going to be really hard.
  - Dubin: Some of that range is probably based on a history of whether you had manure applications.
  - Johnston: If the objective is for an efficiency, then does it matter what the recommendation, or the what the model says how much went on winter wheat, if your study suggests you cut out that application and it saves 10% of N, can that 10% apply to any year, with any yield, and any N application?
    - Meisinger: That's the way the model would probably do it. We typically give a % reduction and use that over the years.
- Ken briefed the panel on the history of MD eastern shore winter cereal production.
- Mark notified the panel that all AgWG panels are requested to develop a one-page 'white paper' that outlines the definition of the BMP, applicable land uses, and preliminary structure of the BMP in the Phase 6 model that can be presented to the AgWG and approved.

Participants:

Charlie White	Penn State

Don Meals	Tetra Tech
Jason Keppler	MDA
Ken Staver	UMD
Paul Salon	USDA NRCS
Mark Dubin	UMD
Wade Thomason	VT
Lindsey Gordon	CRC
David Wood	CRC
Jack Meisinger	USDA ARS

5/26/2016

Actions & Decisions:

ACTION: Panel will consider how best to deal with seeding rate recommendations, and Charlie White will look at data in order to pull information on Nitrate leaching and uptake.
ACTION: Jack will distribute .pdfs with information on seeding rates to the panel.
DECISION: The panel tentatively agreed to revise the traditional cover crops ruleset with an additional N application in the fall, with default values if it's not known whether manure was fall applied, and an efficiency is manure is fall applied. (Fall manure applications compared against fall harvest method.)
DECISION: Panel will add triticale to winter cereals commodity crops, with no fall nutrients applied.
ACTION: Jason Keppler will look for data on what percentage of corn acres get a fall manure application, and how much is fallowed in the winter versus planted with a cover crop.
DECISION: Panel will apply an across-the-board reduction on efficiency to the 5.3.2 table.
ACTION: Panel will discuss with modeling team to see if they can consider land uses that are not currently eligible for cover crops.
DECISION: There will be a sub-practice for traditional cover crops, with the potential for a 5th qualifier in the table for fall manure assuming it is applied if there is no information otherwise.
ACTION: Ken will work on revising the panel's preliminary report to be posted in advance of the AgWG meeting in June.
ACTION: Panel will work with Modeling Team to address areas of crediting and fall manure applications – whether there can be expansion of eligibility for fall manure applications.

Meeting notes:

- Mark Dubin provided a summary of the AgWG meeting on May 19th.
    - Mark presented the panel's preliminary report to the AgWG on Ken's behalf. The workgroup felt that the panel's suggested approach was reasonable and appropriate.
- Ken briefed the panel on their 3 main tasks moving forward: modifying efficiencies for mixtures based on new data from PSU and VT, modifying their table to apply to cropland where manure is applied in the fall, and modifying their table to apply to winter cereal production fields (commodity) with no fall nutrients applied.
    - Jack asked what the timeline for the panel's work will be.
    - Mark replied that the panel should have the final version of their preliminary report posted by June 3rd in order for the AgWG to approve it on June 16th.
- Charlie White: I created a spreadsheet for grass and legume values with our dataset using the same approach that we used in the previous panel, and we just made an average across all the studies. I don't see why we couldn't do it that same way again.

- Panel asked whether they needed to include placeholder efficiency values in their preliminary report.
- Meisinger: I want us to all be aware of units when thinking about multipliers. I would suggest we use a multiplier. If we keep the old values, our multiplier would be 1.
- Staver: If we define the mixtures as having at least half the planting rate, that's standard.
    - Meisinger: I think that's good. The grasses are doing most of the work, but you might want to think about if you have a mixture of grasses.
- Staver: As a group, do we feel like we should specify the mixtures as at least in some combination half of the non-legume planting rate?
    - White: My recommendations for developing seeding rates for CC mixtures with non-legumes is to cut seeding rate to about a quarter of the monoculture seeding rate. When you cut it in half, those non-legumes have such compensatory growth, that even at a half seeding rate you don't get any legumes in the stand. I would say the rate should be about 25% of the monoculture rate. So if you're saying a mixture will only count when it's 50% but we recommend not to plant that high, we're sending mixed messages there.
    - Keppler: I pulled up the NRCS standards, and they have similar figures – 35-45%.
    - Staver: I'm worried about relying on proxy data of above-ground biomass. I'm comfortable getting down to a half rate, but when we get down to a quarter rate, only using above-ground biomass, makes me a little concerned.
    - White: And I'm hearing a lot of farmers saying that our recommendations for seeding are too high.
    - Meisinger: Back in the day, one bushel per acre was pretty standard. I think what you may be dealing with is that we've got a lot of varieties of seed, and I think some of the bump in seeding rates is compensating for poor seeding quality. Could we say it has to be no less than 25% of the pure stand rate?
    - Panel agreed that resolving the issue of seeding rates will take more discussion.
    - Mark reminded panel members that this item is not top priority, and that the panel certainly needs to resolve issues with manure applications on cover crops and commodies.
    - Ken suggested setting a floor on the non-legume planting rate.
    - Action: Jack will distribute .pdfs with information on seeding rates to the panel.
- Ken reviewed and discussed fall manure applications on traditional cover crops.
    - Keppler: And this is for traditional cover crops only, correct?
        - Staver: Correct.
    - Meisinger: NASS does count small grains harvested in the spring, and that piece will be part of the land use (small grains + forage seeding land use).
    - Dubin: I discussed that the other day, and Matt will be taking a look at that. We're going to double check they could be going in the wrong land uses.
    - Decision: The panel tentatively agreed to revise the traditional cover crops ruleset with an additional N application in the fall, with default values if it's not known whether manure was fall applied, and an efficiency is manure is fall applied. (Fall manure applications compared against fall harvest method.)

- Mark reminded the panel that they need to consider when these practices will be credited in the model.
- Mark asked the panel if they should assign manure application to the following year on manure eligible cover crops?
    - Keppler suggested something as simple as a multiplier that reduces traditional cover crop efficiency as a way of representing fall N in the model, and keeping to the panel's timeline.
    - Ken agreed that was a good idea.
    - Action: Jason Keppler will look for data on what percentage of corn acres get a fall manure application, and how much is fallowed in the winter versus planted with a cover crop.
- Ken reviewed the proposed modifications and structure of winter cereals commodity crops, with no fall nutrients applied.
    - Decision: Panel will add triticale to winter cereals commodity crops, with no fall nutrients applied.
    - Jason Keppler suggested commodities are treated exactly the same as traditionals, up until a specified date at which point it would be treated differently.
    - Ken Staver asked about how the panel would establish a baseline for when cover crops would be simulated, and when N would be applied.
    - Keppler: But at that point, the benefits have been achieved by March 1st.
    - Jack Meisinger suggested leaving the structure as is, where it will get half the credit. Half of the losses will occur from fall and half from the spring applications. He noted that there is not sufficient data/literature currently available.
- Panel's next steps:
    - Action: Panel will consider how best to deal with seeding rate recommendations, and Charlie White will look at data in order to pull information on Nitrate leaching and uptake.
        - Jason Keppler suggested adding a line in the table where the grass rate would be specified.
        - Action: Jack will pull data on this topic as well.
    - When you increase fall N rate, how does that reduce cover crops efficiency?
        - Decision: Panel will apply an across-the-board reduction on efficiency to the 5.3.2 table.
        - Action: Panel will discuss with modeling team to see if they can consider land uses that are not currently eligible for cover crops.
        - Decision: There will be a sub-practice for traditional cover crops, with the potential for a 5th qualifier in the table for fall manure assuming it is applied if there is no information otherwise.
    - Regarding winter cereal commodity crops with no fall nutrients applied: Panel considering across-the-board reduction to the 5.3.2 table to look at fall scavenging ability and eliminating fall N application.
- Action: Ken will work on revising the panel's preliminary report to be posted in advance of the AgWG meeting in June.

- Action: Panel will work with Modeling Team to address areas of crediting and fall manure applications – whether there can be expansion of eligibility for fall manure applications.

Participants:

Jason Keppler	MDA
Don Meals	Tetra Tech
Mark Dubin	UMD
Charlie White	PSU
Lindsey Gordon	CRC
David Wood	CRC
Ken Staver	UMD
Jack Meisinger	USDA

9/12/2016

Actions & Decisions:

DECISION: The panel agreed to expand the definition of the 2nd category of grass/legume mixtures to include a grass monoculture with the same efficiency value.

ACTION: The panel will search for additional literature sources to substantiate crediting traditional cover crops with fall manure applications for N reductions at 70% of the table values currently used for traditional cover crops planted where no manure is applied in the fall.

ACTION: Ken Staver will gather additional information from Mark Dubin on commodity cover crops values. Wade Thomason will search for literature sources to help substantiate the recommendations on these numbers.

ACTION: Ken Staver will contact Quirine Ketterings for information on values for Nitrogen applications to fall cereal grains.

- Ken Staver reviewed the work of the panel thus far, and the summary of final report that he drafted. The panel charge included providing recommendations on traditional cover crop efficiencies, and the panel agreed to leave the Phase 5.3.2 efficiencies largely unchanged with the exception of legume-grass mixtures. Wade and Charlie looked into these values, and determined that the efficiency value was calculated by averaging the grass and legume rates.
    - Charlie White: In many cases, we are recommending mixtures with closer to a 25% seeding rate of the non-legumes.
- Staver: The second topic we covered was to expand the traditional Cover Crop BMP to include cropland where manure is applied in the fall following the harvest of the summer crop. Previously, if manure was applied in the fall, you were essentially ineligible for cover crops. It looks like that for every dairy cow in a standard operation, about an acre of land would receive fall manure. This is a real land use, and the nutrient losses associated with fall manure applications are known to be high, and it's known that winter cereals are effective at reducing that loss, so it seems like this is an important practice that should receive credit.
- Staver: The third consideration was to review the commodity cover crop BMP, which wasn't addressed in the Phase 5.3.2 Cover Crops Panel. Currently, there is a winter cereals land use in the Phase 6 model, but the problem is that the calendar year runs from Jan – Dec., so in the model, the year starts with the winter cereal already existing, and the establishment phase is not explicitly identified in the land use. So it's unclear how to handle this, because the winter

cereal spring application will be a nutrient application within the winter cereal land use. That was going to be handled as a model simulation, and the panel was going to address just the fall aspect, where no fall N would be applied compared to the standard practice of at least some N application during this time.

- Ken noted that he was unsure if the model explicitly modeled the fall nutrient application, and as a result the panel would leave commodity cover crops as they are currently represented. Over-wintering crops are captured in the model to the extent that they are reported in the agricultural census. Ken noted concerns that the model does not represent the establishment phase of over-wintering crops, and this may inaccurately represent when nutrients are applied to these crops.

- Ken also noted that according to the literature, a lower seeding rate coupled with a later planting date has the potential to increasing leaching rates. This could potentially lead to a request for the panel to develop a sliding scale of efficiencies based on changes to these variables, but that the Phase 6 panel does not have the time to delve into this question. Previous panels have developed efficiencies based on timing, and to some degree the seeding rate (regarding mixtures), but not on a finer scale.
    - Paul Salon: If you're planting early, and you plant half the seeding rate, should there be some thought as to what the effect of the seeding rate is going to be on an early planting crop? This would be a monoculture crop.
    - Staver: The uptake credit in mixtures comes from the grass. So I don't know what it would be for a monoculture, and the panel is under the gun to produce a report in a short time frame. The idea of creating a category that cuts the monoculture rate for reduced credit might be a significant piece of work, and I don't recall any specific studies.
    - Salon: NRCS in NY might make that part of our study.
    - Charlie White: I think farmers do want to reduce their rate, but a lot of it comes back to how data is being collected to go into the model. My impression is if farmers are getting cost-share, then they do their practices to the specifications of the cost-share, which has the full rate specified. Farmers who do this on their own would likely do half the rate. But I'm not sure if only farmers who are getting cost-shared are being credited in the model.
    - Staver: For unspecified cover crops, my understanding is that you get the lowest credit in that general category. But planting rate – there are no planting rate categories; there's just one.
    - Jason Keppler: You're right that we rely on NRCS to establish the standards. We've had issues with germination, and we've gone out and done the 'rate cost' – taking out a square meter ring and counting the # of plants within that area to determine an average cover. That's been acceptable, and that might be something for others to consider. It's not just a bushel/acre rate.
    - Staver: When this panel was formed, no one requested that we consider lower planting rate options. It would be a numerical calculation that we could fold into the mixtures.
    - Keppler: Speaking as a jurisdictional representative, if jurisdictions relying upon NRCS or technical recommendations for the inflation of BMPs, and if the NRCS offices

recommend a certain seeding rate for a certain time, then the states should use that recommendation, and I think that's defensible to the Bay Program.
    - Staver: The problem I have is that the efficiency table went back to research studies that almost all used an equivalent of the 2 bushel/acre rate. Commodity rates are even higher than that. It would strictly have to be a calculation, and I can't say that we have research underpinning numbers that would be determined for this; it would be a lot of BPJ. I could see getting some pushback pretty hard if NRCS recommends lower planting rates than what was used to establish the cover crops efficiencies.
    - Paul Salon: In NY, we're about to allow for a lower seeding rate. So we have scenarios for instances that aren't necessarily mixtures, but function as mixtures. Perhaps we could incorporate that?
    - Staver: I would say that for monocultures, we shouldn't go below half-rate. In MD, I think that for anything that's not incorporated into the soil received an increased 10% in planting rate.
- Staver: We're really on the hot seat to get this report written and distributed for review. And at the moment, I don't have any specific nitrate leaching data to back this up.
    - White: I could send you % biomass and cover.
    - Staver: This mixtures thing has come out of a push for diverse crops and quality, and an interest in accommodating this larger scale effort that's not just about reducing nitrate leaching, but the other benefits as well. But the idea of opening up across the board the seeding rate still seems a bit out of reach for this panel. That said, if NRCS is backing this, then that lends some weight to the argument for including this. And this would be something where we take a very simplistic approach.
- Regarding mixtures, Ken proposed that the Phase 5.3.2 reduction credits would be modified to be at least 25% of the recommended planting rate of grass cover. A second grass/legume category would be added for mixtures documented to contain at least 50% of the full grass planting rate. The group discussed whether to specify these practices as ineligible for fall manure.
    - Charlie White noted that efficiency values were not specific for the two categories.
    - Staver: The category that's already defined in the Phase 5.3.2 work is the average of the legume and the monoculture grass. Since the full legume credit is very small, the efficiency is a tiny bit higher than the grass rate.
    - Staver: For 25-50% of the seeding rate, you receive half the efficiency rate of the Phase 5.3.2 grass efficiency. If you plant it at above 50%, then you would receive 70% of the full grass efficiency. One way to do this would be to leave the second category at either a half-rate or above for just a pure stand. It would just change the definition of the column to broaden it to include mixtures with no legumes, but the efficiency would remain the same.
    - Wade Thomason: Radical changes often get radical responses – I think this moves us in the right direction, and I'm happy with what's going on.
    - Keppler: Agreed. I think if we start adding more columns and opening it up for further discussion would just delay us more. If we tweak this language to be more accommodating, that's the simplest route.

- Wade Thomason: Is there support in the literature for the 70% effectiveness for cover crops on fall manure applied cropland against cover crops on cropland where no fall manure is applied?
    - Staver: The studies don't have very specific data on this.
- Ken proposed that the panel defer considering commodity cover crops, and instead leave the reduction efficiency to roughly half of the traditional cover crops.
    - Wade Thomason: I see where and why you're proposing this, but I'm uncomfortable with it because no expert group has derived these numbers in the first place. So it makes me nervous to continue using these values when these numbers may not have any strong basis.
    - Staver: I feel the same way, and I think the panel can state that the numbers may not be right, but that the panel did not have the means to consider these cover crops at this time. So by default, the existing values will remain.
    - Thomason: Isn't there some soil data available on this? The Poffenberger paper?
- Jason Keppler: In the final report, are you planning on drafting a summary table of all the options? Just for consolidation purposes, it might be beneficial to have a master table of all the efficiency values.

Participants:

Lindsey Gordon	CRC
Ken Staver	UMD
Wade Thomason	VT
Charlie White	Penn State University
Paul Salon	USDA NRCS
Don Meals	Tetra Tech
Jason Keppler	MDA

Appendix E: Consolidated Response to Comments:

PA SCC & DEP: Page 8 – Please provide further explanation regarding the statement made in the report, as quoted below:

"The Panel considered options for revising cover crop P reduction credits but at this time recommends effectiveness estimates only for nitrogen (N) for two principal reasons. **First, cover crops primarily function to trap or sequester N, with only minor reductions for phosphorus (P) and sediment.** Second, as of publication of this report, sufficient data are not available on the effect of cover crops on P and sediment. The Panel recommends that consideration of P and sediment reductions for the new cover crop BMPs be undertaken at a later time and that placeholder efficiency values of zero be maintained for P and sediment until reasonable estimates can be derived from best available data or an independent agricultural model such as APEX."

We respectfully request an explanation as to how the conclusion was made that there are only minor reductions in P and sediment, when soil erosion is one of the primary considerations in the NRCS cover crop standard. On page 7, the report states the following, "This practice will only be credited where local USDA-NRCS review considers the planting adequate to provide the level of soil cover needed to prevent soil erosion." This makes sense, as USDA-NRCS Cover Crop Standard (340) includes reduction of soil erosion from wind and water as one of the purposes. Pennsylvania USDA-NRCS1 states, "Cover crops reduce runoff, build soil organic matter, retain nutrients, fix atmospheric nitrogen, reduce and alleviate compaction, provide weed control, and improve soil health." The best description of the benefits of cover crop that we found is from the New York USDA-NRCS2 website:

"The protective canopy formed by a cover crop reduces the impact of rain drops on the soil surface thereby decreasing the breakdown of soils aggregates. This greatly reduces soil erosion and runoff, and increases infiltration. Decreased soil loss and runoff translates to reduced transport of valuable nutrients, pesticides, herbicides, and harmful pathogens associated with manure from farmland that degrade the quality of streams, rivers and water bodies and pose a threat to human health. A cover crop slows the velocity of runoff from rainfall and snowmelt, reducing soil loss due to sheet and rill erosion. Over time, a cover crop regimen will increase soil organic matter, leading to improvements in soil structure, stability, and increased moisture and nutrient holding capacity for plant growth. These properties will reduce runoff through improved infiltration (movement of water through the soil surface) and percolation (movement of water through the soil profile)."

In the tables, there are many 0 and NA values associated with the phosphorus and sediment efficiency estimates. As stated in the report, the Panel suggested placeholders (0) for P and sediment. Would all of the NA values be provided that placeholder value (0) as well?

We also request an explanation regarding the statement of insufficient data to provide updates on the phosphorus and sediment efficiency values. We would surmise that there is research to support the claims made by USDA-NRCS, Land Grant Universities, and others on the benefits of cover

crop, including the reduction of phosphorus and sediment.

In a very limited literature search, we were able to find some research done by staff at USDA-ARS in the mid-west and other regions of the US that may be useful in determining estimates of sediment reduction efficiencies :

- Dabney, S.M., J.A. Delgado and D.W. Reeves. 2001. Using winter cover crops to improve soil and water quality. Commun Soil Sci. Plant Anal.. 32(7-8): 1221-1250.
- Dabney, S.M., Gumiere, S.J. 2013. Erosion by water: vegetative control. Encyclopedia of Environmental Management. S.E. Jorgensen, ed. Taylor & Francis: New York, II:1036-1043.
- Kaspar, T. Cover Crops for Soil and Water Quality. USDA-ARS, National Laboratory for Agriculture and the Environment. Ames, IA https://www.agry.purdue.edu/cca/2009/CCA%202009/Proceedings/KasparCover%20Crops%20for%20Soil%20and%20Water%20Quality%2010-23-092%20Final%20Version%2011-24.pdf
- Kaspar, T.C., Singer, J.W. 2011. The use of cover crops to manage soil. In: Hatfield, J.L., Sauer, T.J., editors. Soil Management: Building a stable base for agriculture. Madison, WI: American Society of Agronomy and Soil Science Society of America. p. 321-337.
- Langdale, G.W., Blevins, R.L., Karlen, D.L., McCool, D.K., Nearing, M.A., Skidmore, E.L., Thomas, A.W., Tyler, D.D., and Williams, J.R. 1991. Cover crop effects on soil erosion by wind and water. In: Hargrove, W.L. (ed) Cover crops for clean water. Proceedings international conference, April 9-11, 1991, Jackson, TN. Soil and Water Conservation Society of America, Ankeny, IA. https://www.ars.usda.gov/ARSUserFiles/30200525/91-%20Cover%20Crop%20Effects%20on%20Soil%20Erosion.pdf "A principal function of cover crops is to prevent land degradation by wind and water erosion."
- Moore, E.B., Kaspar, T.C., Wiedenhoeft, M.H., Cambardella, C.A. 2014. Rye cover crop effects on soil quality in no-till corn silage-soybean cropping systems. Soil Science Society of America Journal. 78(3):968-976. DOI: 10.2136/sssaj2013.09.0401.
- Nair, A., Kaspar, T.C. 2015. Cover crops in vegetable production systems. Extension Publications. HORT 3026. Iowa State University Extension and Outreach.
- Sharpley, A.N., Smith, S.J. Effects of cover crops on surface water quality. USDA-ARS, National Agricultural Laboratory, Durant, OK. http://www.swcs.org/documents/filelibrary/CCCW3surface_79CEC411D2D30.pdf

The Panel was brought together in August, 2015 and the panel charge and scope (page 25) included addressing cover crop reduction efficiencies for N, P and sediment. At some point, the decision was made to focus solely on N efficiencies. It seems that the limited time frame by which the panel had for development of recommendations may have been the issue, not the lack of sufficient data.

Might the panel recommend using RUSLE2 to provide estimates on relative effect of cover crop on sediment reductions? As stated on the RUSLE2 website3:

"RUSLE2 was developed primarily to guide conservation planning, inventory erosion rates and estimate sediment delivery. Values computed by RUSLE2 are supported by accepted scientific knowledge and technical judgment, are consistent with sound principles of conservation planning, and result in good conservation plans. RUSLE2 is also based on additional analysis and knowledge that were not available when RUSLE1 was developed. RUSLE2 is based on science and judgment that is superior to that of RUSLE1. We learned things from RUSLE1 that are incorporated into

RUSLE2.

RUSLE2 has evolved from a series of previous erosion prediction technologies. The USLE was entirely an empirically based equation and was limited in its application to conditions where experimental data were available for deriving factor values. A major advancement in RUSLE1 was the use of subfactor relationships to compute C factor values from basic features of cover-management systems. While RUSLE1 retained the basic structure of the USLE, process-based relationships were added where empirical data and relationships were inadequate, such as computing the effect of strip cropping for modern conservation tillage systems."

RUSLE2 allows the user to choose different cover crops and seeding options, time of seeding, etc. that will fall in line with the three types that the panel laid out. Estimates can surely be devised using different scenarios in RUSLE2.

There may not be sufficient time for this to occur with the current Phase 6.0 cover crop expert panel report; however, the option described above, or some other acceptable option to estimate cover crop sediment and/or phosphorus reductions, should be taken up within the next year as a means of determining estimates to fill in the recommended placeholder values.

1. USDA-PA
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/pa/soils/health/?cid=nrcseprd1221425
2. USDA-NY
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ny/technical/?cid=nrcs144p2_027252
3. RUSLE2
http://fargo.nserl.purdue.edu/rusle2_dataweb/About_RUSLE2_Technology.htm

Response:
The primary technical comment relates to an error in the text of the draft report on page 7 that states sediment and P reduction credits for cover crops will be 0 for all cases in Phase 6 until further analysis can be conducted. The spreadsheet with the actual reduction credit values accurately depicts the panel's recommendations on sediment and P reduction credits. Reduction credit values were not changed from existing values, but because of changes in the way land uses are identified in Phase 6, and with the development of the Conservation Tillage BMP for Phase 6, the sediment and P reduction credits are applied to subset of land uses, rather than to the High Till land use that existed when previous cover crop reduction credits were developed. In addition to the sediment and P reduction credits specified in this report, cover crops also will play a role in achieving higher sediment and P reduction credits in the Conservation Tillage BMP. The text on page 7 was corrected to accurately represent the table values, and also to describe the rationale for the changes.

PA SCC & DEP: Page 16 – Practice Monitoring and Reporting
Has there been any thought to grouping cover crops together for NEIEN reporting? The Phase 5.3.2 CAST source table currently has roughly 130 choices for reporting "traditional" cover crop, 130 choices for commodity cover crop, and we can assume that more are being proposed through this expert panel report. We recommend that if efficiency values are the same, those individual cover crop practices should be commingled together under one reportable practice and then, in the definition, the individual practices will be identified.

Having many different sub-categories of the same practice to choose from is not only confusing for our practitioners and those who report the practice, but also unnecessary. We do not take away from any jurisdiction that has the need to internally track the many different cover crop practices for cost-share and other purposes, however if there are efficiency values that are the same, then they

should be grouped together for NEIEN reporting for consistency and general ease of use.

Response:
The comment will be addressed in the Appendix A of the Panel Report, which is the responsibility of the CBPO Modeling Team and the Watershed Technical Workgroup as part of the final panel report approval process.

CBF:
A few comments below on the Cover Crop Expert Panel draft report. As always, our sincere appreciation to you and the panel members for their efforts in updating the science and efficiencies. Overall, we thought the report was well-written and organized, but we think the panel is being too conservative in their estimates of the water quality benefits of cover crop mixtures. I have cut and pasted the relevant sections from the draft report below and highlighted a few sentences. In particular, the VA research indicates that the N uptake and biomass production of mixtures was at least as good as pure stands of cereal rye (at 75% cereal rye seeding rates), and as high or higher than single species winter cereal. The PA study indicated only "marginal" reductions in N uptake when rye was reduced to roughly 30%.

These observations, coupled with the fact that mixtures provide soil health benefits and increase soil organic matter that can also have long-term water quality benefits, leads us to the recommendation to change the reduction credits for mixtures *containing at least 50% of the full grass planting rate to receive full N reduction credit*, not 0.7 as proposed. Mixtures should be encouraged. By providing long-term soil health benefits farmers will begin to see the agronomic and economic value, and not view the cover crops as only a water quality program. Encouraging mixtures will help farmers value mixed species cover crops so that if cost share funds for cover crops become less available farmers will continue to utilize them.

Lastly, we note that NRCS cost share pays the highest for a species mix, a reflection of the multiple environmental benefits they provide.

"In the case of grass-legume mixtures, the capacity of full rate winter cereal cover crops to take up well in excess of typical fall root zone nitrate pools suggests that cutting the grass planting in rate in half in a mixture will not cut the N reduction efficiency of the mixture practice in half, as was the basic approach used for mixtures by the 5.3.2 Cover Crop Expert Panel. The approach currently in place averages the grass and legume reduction values but because the annual legume N credit is so low (0.06-0.07) the credit for mixtures currently is approximately half of the value of the full rate credit for the grass in the mixture (specifically, the credit is half of the full rate for the grass in the mixture plus 0.03). The most direct support of the proposed change is from recent studies in PA (Poffenbarger et al. 2015) that reported N uptake by rye in mixture only decreasing marginally when the rye planting rate in a mixture was reduced from 2.7 to approximately 1 bu/ac. Rye cover crop total N uptake in these studies exceeded 100 kg/ha in two of the site years considered. In the four siteyears considered, the sharpest drop in N uptake as planting rate decreased occurred when planting was delayed until October 10, supporting the approach taken by the Phase 5.3.2 cover crop panel that mixtures should only be credited in the early and normal planting date categories. In studies in VA under lower N status conditions, Thomason et al. (2015) reported mixture N accumulation to remain little changed when rye planting rates were cut to approximately 75% of the full planting rate in a mixture, and also when planting dates were delayed from mid-September to mid-October. Other studies of cover crop mixtures conducted at multiple sites in VA (Fleming and Thomason 2015) found mixture biomass and N uptake to be as a high or higher than full rate single species winter cereal cover crops although N uptake by the component species in the mixtures was not determined. One management factor supporting mixtures is that legume survival is enhanced by earlier planting dates, which also allows the grass component in the mixture more time to take up root zone nitrate before leaching occurs. A second supporting factor is that the legume N fixation function of

mixtures is likely most desirable to producers who don't have access to manure as grass in mixtures tends to outcompete legumes when soil N status is high (Clark 2007). This means that mixtures usually will be planted on sites with relatively low N status, increasing the likelihood that the grass component of the mixture can take up most of the root zone nitrate pool before leaching occurs. The Panel proposes adding a second category for mixtures that allows down to 25% of the full grass planting rate because these types of mixtures are being promoted as part of the nationwide effort primarily focused on soil quality that promotes diverse cover crop mixtures (Finney and Kaye 2016). These mixtures have been shown to be useful for N uptake in the northern part of the watershed (Ketterings et al. 2011) following winter cereal grain harvest. South of central PA planting of soybeans after winter cereal grain harvest is widespread eliminating the growing window for many potential cover crop species. Again, the studies by Poffenbarger et al. (2015) are the main direct support of this additional category as rye N uptake down to panting rates approximately 25% (0.54 bu/ac) of the full rate were evaluated and never found to reduce rye N uptake to below 50% of that by full rate monoculture rye plantings. The consensus of the Panel is that mixtures containing 25 - 50% of the full grass planting rate should receive the N reduction credit developed for mixtures in the 5.3.2 Cover Crop Expert Panel report that is the average of the credit for the credit of grass component of the mixture and the credit for annual legumes. Mixtures containing at least 50% of the full grass planting rate should receive an N reduction credit of 0.7 of the full grass planting rate as currently specified. Mixtures with less than 25% of the full grass planting rate should not receive a reduction credit beyond those currently specified for annual legumes. Mixtures and reduced planting rate monocultures should not receive credit except in the early and standard planting date categories."

Response:
The panel only dealt with changes in nutrient losses associated with mixtures, and not other benefits such as soil quality, increased pollinator habitat and economic returns to farmers, etc. The decisions on mixtures had to be made based mostly on above ground biomass data, which is a proxy for uptake of soil nitrate, but not a direct measure of changes in nitrate leaching. Mixtures with legumes present a complex situation as in several studies, the total biomass was not broken down into species components so above ground biomass was partly uptake of soil nitrate, and partly N fixation by legumes. Clearly, under favorable fall conditions where leaching is delayed and extensive growth occurs before winter conditions set in, and where soil nitrate levels are moderate, lower grass planting rates in mixtures or alone can take up the same quantity of nitrate as full rate plantings which often become N limited, especially for early planting dates. However, the panel had to rely somewhat on first principles since only proxy data were available to assess mixture effects on N losses. A key first principle is that as planting rates decrease, depletion of soil nitrate will occur more slowly, increasing the risk that nitrate will be leached out of reach of cover crop roots before uptake can occur. While the panel has no argument with the many benefits of mixtures, we maintain that the increase in mixture N reduction credits that we recommended, not be increased any further. It also is important to specify that the panel analyzed the N loss reduction potential of winter cover crops related to scavenging of soluble N forms, and not effects related to changes in fertilizer N applications as a result of N fixation by legume cover crops. Such an analysis would require a systems level, longer term perspective possibly best addressed under Nutrient Management BMPs which deal with rate, timing and placement of N sources.

Appendix F: Conformity with WQGIT BMP Protocol

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT 2014) outlines the expectations for the content of expert panel reports. This appendix references the specific sections within the report where the panel addressed the requested protocol criteria.

1. **Identity and expertise of panel members:** *See Table 1in Section1.*

2. **Practice name or title:**
   - Traditional cover crops
   - Commodity cover crops

3. **Detailed definition of the practice:** *See Section 2 for detailed definitions of cover crop BMPs.*

4. **Recommended N, P and sediment effectiveness estimates:** *See Section 3 and attached tables in P6_CC_effectiveness coefficient summary.xls*

5. **Justification of selected effectiveness estimates:** *See Section 3.1 for justification of effectiveness estimates, based on literature and best judgment of Panel members.*

6. **List of references used:** *See Section 7 for the full list of references.*

7. **Detailed discussion on how each reference was considered:** *See Section 4 for discussion of how literature data and best judgment were considered.*

8. **Land uses to which BMP is applied:** *See Table 2 in Section 5.1 for table of CBW land uses to which the cover crop BMPs apply.*

9. **Load sources that the BMP will address and potential interactions with other practices:** *See Section 3 and attached tables in P6_CC_effectiveness coefficient summary.xls*

10. **Description of pre-BMP and post-BMP circumstances and individual practice baseline:** *See Section 5.*

11. **Conditions under which the BMP works, including conditions where the BMP will not work, or will be less effective:** *See Section 3.2*
    a. **Variations in BMP effectiveness across the watershed due to climate, hydrogeomorphic region, or other measureable factors.** *See attached tables in P6_CC_effectiveness coefficient summary.xls*

12. **Temporal performance of BMP including lag times between establishment and full functioning:** *Cover crop is an annual practice and there is no lag time anticipated between establishment and full function of the BMPs*

13. **Unit of measure:** *Acres or percentage of acres implementing practice.*

14. **Locations in Chesapeake Bay watershed where the practice applies:** *All acres of the applicable land uses in Table 2 (Section 5.1) in the Bay watershed. Note regional difference in proposed reduction efficiency values.*

15. **Useful life of the BMP:** *Cover crop is intended to be represented as an annual practice, so for the purposes of this report the useful life of the practice is 1 year.*

16. **Cumulative or annual practice:** *Annual.*

17. **Description of how BMP will be tracked, reported, and verified:** *See Section 6 for a discussion of how manure injection & incorporation should be tracked and reported to the Bay Program. More details are also available in the Scenario Builder Technical Appendix (Appendix A).*

18. **Ancillary benefits, unintended consequences:** *The Panel did not review cover crop BMPs for external environmental benefits. The Panel did not identify any unintended consequences.*

19. **Timeline for a re-evaluation of the panel recommendations:** *The Panel recommends review in 5 years (or standard timeline) to incorporate results of ongoing research. Information from long-term studies with natural rainfall will be especially desirable.*

20. **Outstanding issues that need to be resolved in the future and list of ongoing studies, if any:** *See Section 4 for discussion of data gaps and research needs.*

21. **Documentation of dissenting opinion(s):** *While no dissenting opinions were expressed or recorded, significant notes related to recommendations were recorded in Appendix D (Approved Cover Crop Expert Panel Meeting Minutes).*

22. **Operation and maintenance requirements and how neglect alters performance:** *The requirements and performance are covered by the state programs, which in their own way document these elements.*