Agricultural Modeling Team (AMT)
Meeting Minutes

December 8th, 2023
09:00 AM – 11:00 AM
Meeting Materials

Summary of Actions and Decisions

Decision: The AMT approved the November 2023 minutes.

Action: Tom Butler will work with the CBPO & CAST team to address the following requests made from the group:

- Presentation on how manure acres are calculated in CAST
- A "primer" on land use loading rates/ratios, including topics such as:
  - Why loading rates exist
  - How loading rates and ratios interact within CAST
  - How we determine values for loading rates
  - Additional examination and discussion of the existing loading rate/ratio report
- Provide relevant resources to the topic of BMP "excess" (formerly known as "cutoff") for interested parties.
- Continue providing updates on Crop Yields, including the results of the poll sent to AMT members.

Meeting Minutes

Statement of purpose:

To evaluate the crop yield and land uses in CAST and discuss potential alternatives for Phase 7.

Introduction: 09:00-09:05 [5 min (Zach Easton, Virginia Tech)]

Announcements:

- December 11 Water Quality GIT meeting to hear updates on the latest Beyond 2025 Steering Committee activities.
- **Decision:** The AMT approved the November 2023 minutes.

Crop Yield trends 09:05- 09:40 [35 min (15 min presentation 20 min discussion) (Joseph Delesantro, ORISE, and Tom Butler, EPA)]

Tom recapped the importance of Crop Yield data in CAST and discussed progress being made to improve long term crop yields, including multiple potential approaches for estimating yields from the Five-Year Census of Agriculture using correlations to crops with existing annual yield data.

Discussion

Chris Brosch: Is the survey data from us going to be used for a discussion for how to eventually deal with these marginal crops?
Tom Butler: Yes, we'll come back to the group and make sure we're all in agreement on how to use it.
Ken Staver: Do we have an idea of the percentage of crops we don't have data for compared to crops we do have data for?
Joseph Delesantro: The crops we have data for are 95% of estimated applied cropland. Most crops we don't have data for are tenths of a percentage or hundredths of a percentage. Collectively the crops we don't have data for make up about 5%. Sweet corn is around 0.6%, but most are way smaller than that.

Land Uses in CAST 09:40-10:50 [70 min (15 min presentation 55 min discussion) (Tom Butler, EPA)]

Tom presented on Land Use classifications within the existing structure of Phase 6 CAST. Following the presentation, the group discussed potential ways to improve the classification for Phase 7, including the following questions:

- What load sources do we need for BMP reporting in Phase 7?
    - More specific than the existing 14?
- What level of detail can the ag sector track?
    - Can we get data that is more detailed?
    - Is there a benefit to reporting at a finer scale?
- What can the data reporters report?
    - In the future will there be increased detail about different crops?

Discussion

Ken Staver: Important to remember that the 100 crops you note here feels like a huge number. In reality, there are around 10 land uses that have 10 crops, and then 3 or 4 land uses that have 90 crops. It will make a small difference if we start to simplify those things.
Gary Shenk: Yes, it could be a small deal, but there are some counties that it will make a difference in. We number for everything, regardless.
Alisha Mulkey (in chat): Agree with Ken.
Hunter Landis (in chat): Are all of the land class and land use listed somewhere?
Olivia Devereux (in chat): Land uses and crops can be downloaded in excel from this site: https://cast.chesapeakebay.net/Home/SourceData
Jessica Rigelman (in chat):

Land Use	Number of Crops
Ag Open Space	1
Full Season Soybeans	1
Grain with Manure	2
Pasture	2
Silage with Manure	2
Leguminous Hay	6
Other Agronomic Crops	8
Small Grains and Grains	8
Other Hay	10
Specialty Crop Low	14
Specialty Crop High	47

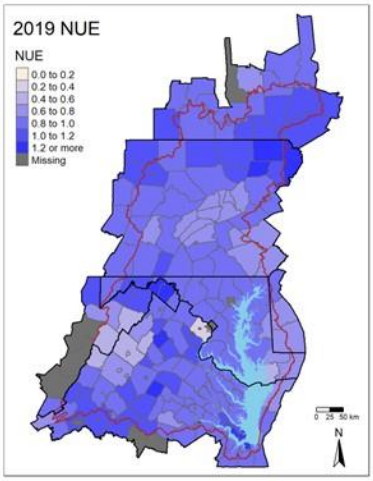
Chris Brosch: Does the report explain how they came to these decisions?

Tom Butler: Yes, it does.
Chris Brosch: From folks on this call that were part of that effort - were there any pain points that you specifically remember that we might be able to help with by looking at this again?
Mark Dubin: This was pre-BMP before 1985 regarding the baseline. We worked within the framework of SPARROW relationships.
Ken Staver: There were a lot of pain points. Requests went out to the entire watershed for help doing this. There is not a lot of availability when it comes to long-term full year data on loading rates. We found a lot more data on the big categories, like corn and soybeans. I'm not sure that we can do better now, I wouldn't say the datasets now are much better than they were then. If you had all the information there was to have, it would be something like this.
Chris Brosch: That's useful. The thing that stands out to me is there are a lot of significant digits for something that doesn't seem very precise.
Ken Staver: We had over 100,000 samples to produce these numbers so they are a lot more precise than other CBP modeling estimates.
Chris Brosch: I'll look back at the report then. As a non-participant, I think it would be difficult to explain.
Ken Staver: If you round these to go back a tenth, that would be fine. It doesn't change the overall impact of the table. The origin of this effort goes back to MD when we were targeting cover crops and we were trying to get the biggest bang out of our cover crop dollars so we looked at targeting for effectiveness. That was the origin of this effort and this approach. Now folks are starting to encourage targeting again.
Olivia Devereux: I agree with Ken. This was the 3rd effort to come up with these loading rates and ratios for the P6 model. The first effort, Tetra Tech did a literature review and it was not approved. Second effort was by water stewardship and was not approved. This was the third effort that was finally approved, so there was a lot that went into this. I agree that there is probably not more literature available now that we haven't already investigated.
Alex Soroka: In developing these numbers, you noted you relied on the SPARROW model. We are developing a new timestep model comparing 2011 to 2021, and if there is anyway that we could orient it to make it more useful here we would like to do that.
Mark Dubin: The group needed to work within the confines of the ratios being used within SPARROW so that they would be compatible. The previous two efforts that Olivia mentioned looked at data sources outside of the CBW, which is part of the reason that they were rejected by the AgWG.
Alisha Mulkey (in chat): For clarity - Is this WG tasked only with deciding # land uses in P7? Or will we also develop loading rate and ratios?
Tom Butler: If we were to change the number of land uses, we would probably have to do an adjustment for the loading rates and ratios as well.
Robert D. Sabo (in chat): what does the loading rate ratio interact with? Is it loading rate ratio * (manure + fertilizer rates)?
Olivia Devereux (in chat): @Robert D. Sabo, EPA/ORD the land use average loading rate interacts with nutrient inputs and model sensitivities for loads.
Hunter Landis (in chat): Ken, is there a quick explanation of why there is a difference for the same crop w/ or w/o manure?
Robert D. Sabo (in chat): Hunter I am assuming we don't explicitly account for agricultural surplus
Olivia Devereux (in chat): @Hunter Landis the w/ and w/o manure is to address the nutrient source. From a technical-data processing perspective, it does not need to be separate since

nutrient applications are by crop. However, the relative loading rate was determined to be different by the group at the time.
Chris Brosch (in chat): Apologize for being flippant. I'll do some homework on the specificity of the figures, but might be interested in exploring sensitivity to dropping the 100ths place.
Lisa Duriancik (in chat): Ken, what is the Grain for 'Grain w/o manure' as the reference land use? Was it really equivalent to 'pasture' as a reference land use?
Ken Staver: Lisa, it's saying that those are within the pasture land class.
Gary Shenk: Yes, within their land class, 'grain without manure' and 'pasture' have different loading rates and then all other land uses within their land class have loading rates that are relative to them.
Ken Staver: The loading rate is the EOS (edge-of-stream) number in CAST?
Gary Shenk: Yes.
Mark Dubin: Hunter, the group was looking at manure vs non manure management systems as a different loading rate because if you consider a historic manure-based application field, it could have mineralization occurring over time and have residual nutrient loads present.
Robert D. Sabo (in chat): Also, mix manure/fertilizer cropland areas often have much higher agricultural surpluses (Inputs-crop removal) compared to fertilizer dominated fertilizer input areas. Overall if farmers just have to handle fertilizer, they currently achieve much higher NUE targets.
Zachary Easton (in chat): I don't think aggregating/averaging land uses is a good idea as it would preclude targeting high loading land uses, at least within CAST.
Zach Easton: Averaging the loading rates across these land uses would prevent the ability to target high-loading land uses for implementation of BMPs. As we mentioned in the CESR report, targeting is essential. I think Ken mentioned this at a previous meeting.
Lisa Duriancik: Agree with Zach.
Ken Staver: I agree with Zach. Also, these rates were determined before we were doing P-based nutrient management. The only way these might have changed since then would be because we're distributed manure across more acres to meet P requirements. But I don't think we should combine these. Silage corn is really different from grain corn. The manure is a strong signal - if you look at nitrate transport research, the literature confirms that you will likely see higher nitrate subsurface levels in manure systems. I don't think our data availability for messing around and putting this all together is good enough. What is the push to combine these in the first place with some of our highest loading crops? What's the justification?
Joseph Delesantro: Even though we're discussing aggregating the land uses, we're not suggesting aggregating the sensitivities, so that would stay the same. It would still be accounted for somewhere in the model, just not through these loading rates.
Ken Staver: I'd like to see how manure acres are calculated because we don't have clarity on how we determine how many acres within a county are determined as 'grain w manure' and 'grain w/o manure'. We need to see that calculation before we discuss this, as well as how manure transport plays a part in that calculation. The Hillandale situation is a good example of this - they transported manure out of their county and their N loading rate went up. It doesn't make sense.
Olivia Devereux: It is explained in the model documentation.
Jessica Rigelman (in chat): Acres of SWM = Acres of total silage crops X 0.85
Acres of GWM = Acres of total grain crops X [(0.1311) X (Natural Log of)(Total Animal Units/Total Acres Harvested Cropland)] + 0.5196; note any result below 0.18 should equal 0.18, and any result above 0.81 should equal 0.81.
Ken Staver: Can we have a presentation on that?

Gary Shenk: Yeah, I agree a presentation would be good. We can do that. I see the justification for this change as two parts: a) let's say you have a county with no manure at all, and then suddenly you have a bit of manure. Suddenly you jump up 40% in your load. That step change is something we could get rid of and handle through sensitivities. b) Looking at the Ag Loading Rate Land Use subcommittee report, I agree that looking at areas which had been manured for many years, there were higher subsurface readings of groundwater nitrate, but there are other types of evidence from SPARROW models looking at the effect of a lb of manure vs a lb of fertilizer existing in the landscape, and a lot of the SPARROW models say a lb of manure has a reduced capacity to deliver nitrogen than fertilizer. Some other SPARROW models say they are about equal, but none say manure is higher. Perhaps those areas that are historically high manured have high application rates. The idea for using sensitivities is that we can change the value based on our management. We can look at how much manure has gone in over time and maybe track storages like we do for P.
Ken Staver: Those are reasonable points but I think one of the reasons that the manure application calculation is so important is because something is wrong when you have really low manure application rates because someone doesn't transport manure in and then apply it at 10 lbs of N per acre. So you shouldn't get kicked up for that, but that's not actually how manure is applied. That's why that calculation is important because you may be getting more acres into that class than you should. Maybe we're overestimating the number of acres that get manure because of that calculation. Also, the SPARROW model is just a simple regression model.
Lisa Duriancik (in chat): From Kevin King EOF Network in Ohio as an example of recent data: Manures applied at equal rates to inorganic sources tend to slightly increase tile DRP loads. Preliminary findings suggest statistical, but minor (grams/yr) increase in dissolved reactive phosphorus (DRP) from liquid dairy manure compared to commercial fertilizer. Similar small increases in DRP from swine manure. No differences in poultry litter compared to commercial fertilizer.
Lisa Duriancik (in chat): I agree with Ken on rates and numbers of acres receiving manure.
Chris Brosch: This is supposed to simulate a non-BMP simulation. Gary and Ken's conversation focused mostly on application rates, but application rates are very different from loading rates. I can't justify 40% higher N coming from ground that is growing grain with manure versus without manure. The point of this model is to evaluate management effects and not worry about antecedent conditions because we're trying to drive those out of the system and replace those with better conditions. It's the same system with and without manure, so not sure why one loading rate ratio is 40% higher. I think we do a great job getting application rates right based on the inputs. I don't understand why the loading rate ratio would be so different.
Gary Shenk: You make some good points. I'm not sure about the loading rate ratios.
Chris Brosch: I think maybe we've double counted a non-BMP condition by assigning loading rates that are higher for a manure management condition and also assigning a non-NM factor to the application rates.
Ken Staver: We're working on the 4R approach for reducing nutrient losses from ag systems.
Chris Brosch: I agree. But that refers to application, rate, placement, timing, and we capture all of that in the NM BMP by assigning a coefficient that is higher for non-NM. And we're also assigning a higher coefficient for the source loading rate.
Ken Staver: Grain with manure can get the NM BMP. But because we haven't perfected manure, we cannot side-dress corn with manure. We have to apply 2:1 on plant available N for manure. So you're going to apply more total N before planting before uptake occurs. Manure has an inherent less precise uptake than inorganic manure, so there is an inherent higher loss rate.

Chris Brosch: Gary explained that it's the opposite. Manure has a lower sensitivity to input than fertilizer. The 4Rs are captured in application rates by the NM BMP, the source is captured by the sensitivity of a lb of manure versus fertilizer, the timing is dealt with in its own way that was previously debated, and the method is also a BMP that is creditable. So the loading rate ratio is redundant to one of these things presumably, so we should eliminate that.
Ken Staver: It's complicated. I think when we use organic sources to meet crop N needs and get the application rate according to the NM plan going for economic optimum production, with everything else being equal, we will universally see higher N loss rates out of the manure acres.
Chris Brosch: Are you using the loading rate ratio to lean on the model to produce the results that produce the scientific understanding we have? because I think the 4Rs are captured elsewhere.
Ken Staver: I think the real difficulty is that when we have monitoring data, we have one data point at the outlet of a mixed use watershed and that's what SPARROW uses. The data point is not isolated to land uses. Trying to figure out where those loads are coming from each of the land uses, which is why I think these specific loading rates are important.
Gary Shenk: Yes, that's what SPARROW uses for calibration, but the way they generate that knowledge is by using multiple points. It's just saying that watersheds that contain a lot of manure are not that different from areas that contain primarily fertilizer in terms of loading rates, and they statistically compare these different areas.
Ken Staver: Are those multiple points all in the Bay watershed?
Gary Shenk: Either one. Same answers within the watershed and outside the watershed.
Alex Soroka (in chat): To clarify, SPARROW uses the export at the stations involved, so for the Bay watershed it would be ~120 stations in the non-tidal network. Our newer model will have ~125 in the CBW.
Alex Soroka (in chat): The plant available nitrogen Ken mentioned was my question. I wanted to know if the value for manure was higher because it is a higher overall N application than fertilizers because not all of the N is available.
Robert Sabo (in chat): Here is the Chesapeake Bay Nutrient Inventory. The NUE (for N and P) maps are in the supplemental word file. https://iopscience.iop.org/article/10.1088/2515-7620/ac5db6.



Lisa Duriancik (in chat): If a producer is following a nutrient management plan, they should not be applying manure on an N basis for that crop, correct? They should be limited by P in terms of their application in much of this region, correct? And then supplement with commercial fertilizer to add N to get to the recommended level for the crop need.

Chris Brosch (in chat): I'm not convinced that this isn't an amalgamation of all the other methods to managed nutrients. I think we need to spend time on the report and the mechanisms of application, BMPs and sensitivities to timing and nutrient source. I think this was useful at time those items weren't explicit, but I'm afraid it is a vestige that duplicates those other model items.
Lisa Duriancik: First - looking at source alone, if you take rate out of the equation and apply on equal rates and look at differences in losses, there are very minor differences between manure and fertilizer. There was no diff in poultry litter and small diff in liquid manure for dairy or swine. If the other 4Rs are dealt with separately, I think Chris's point about "double counting" and the impact of source on a loss is probably worth consideration. Second - regarding the example of applying manure on a N basis on a corn crop, if a farmer is following NM plan, then they are probably not applying manure on a N basis for a corn crop. Struggling with what we are really capturing if that was the case.
Mark Dubin: The NM BMPs are not prescribed for fertilizer vs manure. Some of your management options may change though like Ken was saying. When we're talking about core N or P, it doesn't have to be one source or another, it could be different.
Lisa Duriancik: It seems like these loading rate ratios are based on data where there were N applications on a long-term basis.
Olivia Devereux (in chat): These loading rates are all on a pre-BMP basis. That is, before NM and any other BMP.
Seth Mullins (in chat): In VA, many NMPs would allow manure to be applied at N rates, but very few actually show the full N need supplied by manure. Most don't have enough manure to do that, and look at P and K needs to distribute manure. Probably more likely in NM plans where litter is imported to hay or pasture.
Ruth Cassilly (in chat): @Ken- CAST Manure QA document -Transport and Treatment for your reference: https://cast-content.chesapeakebay.net/documents/CASTManureQA_20200521.pdf
Mark Dubin: it becomes more difficult every year to represent a preexisting condition across a 40+ year time period.
Gary Shenk: The way the TMDL is structured is that we're modeling the water quality change in 1993 through 1995. Interesting that the literature on this is from that time period. I hear a lot of people saying that we no longer do things that way. We definitely need to have some way to represent that change, but not sure the best way to do so right now.
Ken Staver: This doesn't change the loads you have to deal with. It just means the base load is higher. The model is calibrated to monitoring data. It doesn't help that you have a lower load to deal with. If they aren't higher than everything else has to be higher. It all goes back to targeting.
Robert D. Sabo (in chat): One way to deal with this is to track the surplus and NUE trajectories, but this will require a potentially major overhaul. Which I don't necessarily recommend.
Gary Shenk (in chat): We are tracking all aspects of the NUE, but NUE assumes that all sensitivities are the same. 1 lb of fertilizer = 1 lb of manure = 1 lb of deposition = 1 lb of fixation = -1 lb of uptake.
Chris Brosch: I'm concerned that all the justification for the LU with manure to have a higher loading rate than one that does are BMPs or other items that are mechanistically programmed into this model somewhere else. I think it's redundant. I'd like to request an audit of the mechanisms where we've captured these management items and what is left unaccounted for that this loading rate ratio accomplishes. The thing that concerns me is that when we choose a loading rate for a land it is irrespective of how the model is assigning nutrients to that land use.

Ken Staver: These specific values for different land uses give states the opportunity to report your BMPs on a land use with a higher loading rate to get a bigger reduction, which is how it works in the real world.
Olivia Devereux: These loading rate ratios are not including the BMPs implemented. This is a pre-BMP condition. Any discussion of nutrient management BMP is not relevant to these values.
Tom Butler: If everything was the same loading rate ratio then essentially you would only have the cropland and pasture land class and those would be different.
Chris Brosch: I think that's overly simplistic. Even in a pre BMP condition, I can't understand how the grain with manure land use is 40% leakier than grain without manure land use in a baseline scenario.
Ken Staver: There should be no acres in grain with manure that don't get manure.
Chris Brosch: But it happens.
Ken Staver: That's a separate problem.
Olivia Devereux: It's because there are no animals in that area so there is no manure to be had.
Alisha Mulkey: From a state perspective, the only tool I have is where the BMP gets applied. The farther away that BMP is from the sequence of land use rates and the delivery factors, etc. the harder it is to mitigate. I'm confused on where to go with the value of this chart in particular. Maybe there are some CAST scenarios that describe this change to help us understand it.
Robert D. Sabo (in chat): For Ken and Chris- The key that the lit/meta-analysis review that Ken and his team used to generate loading rates highlighted acres receiving manure/fertilizer vs. nearly all fertilizer rates had higher leaching rates. The mechanism at play that we see in CAST (in the Nutrient Inventory paper) and other independent mass balance datasets is that more manure input driven areas have very low NUE and high surplus, which translates to high loading rates. There may or may not be differing sensitivities to manure and fertilizer ,but the key is the gross nutrient imbalance.
Robert Sabo: Could be helpful at a next meeting to see how the sensitivities are captured rather than the set loading rates for grains with manure.
Tom Butler: For folks who report BMPs - is it helpful to maintain detail in land uses when reporting?
Alisha Mulkey (in chat): Almost never helpful because of BMP cutoff.
Cassie Davis: Agreed.
Dave Montali: Yeah, I think there's another issue of not knowing details sometimes.
Alisha Mulkey: Agree, Dave.
Ken Staver: Seems like excess/cutoff is a big issue. Can we have a conversation about excess/cutoff in the future?
Olivia Devereux (in chat): Some of that excess is due to crop rotations that are reflected as individual crops in CAST.
Jess Rigelman: There are real reasons why you would report at the larger scale of cropland land class. For example, crops change from year to year, so for a lot of the cumulative BMPs that have big reductions, it would make sense that you would report it on a cumulative land use like cropland instead of getting into the specifics.
Dave Montali: It would be helpful to have more of a primer of why we have different land use loading rates within ag and then compared to other things might be a good way to kick off this discussion. I thought we needed relative loading rates across land use classes and sectors for calibration purposes.
Tom Butler: Sure, I can work on that.
Cassie Davis: Just so everyone is aware, the WTWG determined that "cutoff" should now be referred to as excess.

Elizabeth Hoffman (in chat): Cutoff, etc, is an important note on the topic of "targeting". We work from the real world back into the model in terms of addressing resource concerns at the field scale and sometimes that's challenging to then "credit" given the groupings
Olivia Devereux (in chat): @dave montali previous versions of the model did not have the specific crops as land uses. There was an aggregate crop land use representing typical rotations.
Robert D. Sabo (in chat): just curious when the next round of fertilizer sales data will be incorporated in CAST?
Olivia Devereux (in chat): @Robert D. Sabo, EPA/ORD CAST-23 is scheduled to be released in the spring. The release after that will be Phase 7.

Action: Tom Butler will work with the CBPO & CAST team to address the following requests made from the group:

- Presentation on how manure acres are calculated in CAST
- A "primer" on land use loading rates/ratios, including topics such as:
    - Why loading rates exist
    - How loading rates and ratios interact within CAST
    - How we determine values for loading rates
    - Additional examination and discussion of the existing loading rate/ratio report
- Provide relevant resources to the topic of BMP "excess" (formerly known as "cutoff") for interested parties.
- Continue providing updates on Crop Yields, including the results of the poll sent to AMT members.

Recap/Closing 10:50-11:00 [10 min (Zach Easton, VT)]

Adjourn – 11:00

Up Next: Friday, January 12th, 2024, from 09:00 - 11:00 am.

Participants

Jackie Pickford, CRC
Tom Butler, EPA-CBPO
Zach Easton, VT
Olivia Devereux, Devereux Consulting
Cassie Davis, NYS DEC
Kristen Bisom, WVCA
Dave Montali, Tetra Tech, WV, MWG
Alisha Mulkey, MD Dept. Ag
Emily Dekar, Upper Susquehanna Coalition
Dylan Burgevin, MDE
Gary Shenk USGS@CBPO
Tad Williams Virginia Tech
George Doumit, DE DNREC
Helen Golimowski, Devereux Consulting, CBPO
Victor Clark - DE - Farm Freezers
Jess Rigelman, J7 Consulting, CBPO contractor
Ruth Cassilly, UMD CBPO
Tamie Veith, USDA-ARS
Scott Heidel, PA DEP
Eric Hughes, EPA-CBPO
Joseph Delesantro, CBPO modeling team
Karl Blankenship, Bay Journal
Curt Dell, USDA-ARA, University Park, PA
Mark Dubin, UME/CBPO
Tyler Trostle PA DEP
Hunter Landis VA DCR
Chris Brosch, DDA
Elizabeth Hoffman, MDA
Ashley Hullinger, PA DEP
Candiss Williams
Jeff Sweeney, EPA
Kate Bresaw, PA DEP

Ken Staver, UMD
Seth Mullins, VA
Tim Larson, VA DCR

Alex Soroka, USGS
Lisa Duriancik, NRCS

**Common Acronyms
AgWG- Agriculture Workgroup
AMT- Agricultural Modeling Team (Phase 7)
BMP- Best Management Practice
CAST- Chesapeake Assessment Scenario Tool (user interface for the CBP Watershed Model)
CBP- Chesapeake Bay Program
CBPO- Chesapeake Bay Program Office (houses EPA, federal partners, and various contractors and grantees working towards CBP goals)
CBW-Chesapeake Bay Watershed
CRC- Chesapeake Research Consortium
EOS - Edge of Stream
EOF - Edge of Field
EPA- [United States] Environmental Protection Agency
K - Potassium
N - Nitrogen
NM - Nutrient Management
NMP - Nutrient Management Plan
NUE - Nitrogen Use Efficiency
P - Phosphorus
PSC – Principals' Advisory Committee (CBP)
STAC- Scientific & Technical Advisory Committee
TMDL- Total Maximum Daily Load
SPARROW - SPAtially Referenced Regression On Watershed attributes [USGS model]
WTWG - Watershed Technical Workgroup
WQGIT- Water Quality Goal Implementation Team