12 Applications

12.1 Management Scenarios

Management scenarios provide an estimate of the average annual nutrient and sediment loads from each load source in each land-river segment given a particular set of human and animal populations, land use, agricultural practices, management actions, point source loads, and other factors. The average annual loads are based on the expected loads given the hydrology of 1991-2000, which was judged to be a period representing long-term hydrologic conditions (Section 6.1.1 in USEPA 2010c). The time-averaged simulation, also known as the Chesapeake Assessment Scenario Tool (CAST) is used to calculate the results of management scenarios. CAST scenarios may be run by stakeholders and the general public through a web interface at http://cast.chesapeakebay.net/.

The dynamic simulation model is used for calibration as described in Section 10, but also must be used to provide daily inputs to the estuarine Water Quality and Sediment Transport Model (WQSTM) for the subset of scenarios requiring a run of the WQSTM for management purposes. The dynamic simulation model is forced to match the output of CAST for each load source and land-river segment at the edge-of-river scale for each scenario. A Hydrologic Simulation Program – FORTRAN (HSPF) simulation of large rivers is used to deliver daily loads of flow, temperature, nutrients, and sediment to the WQSTM.

Several key scenarios were used to assess the reductions necessary to meet the Chesapeake water quality standards for dissolved oxygen, chlorophyll, and clarity (EPA 2003a; EPA 2003b), to assign reductions to each jurisdiction, and to track progress toward achievement of the reductions. Fundamental scenarios include the 2010 No-Action Scenario and the Everyone, Everything, Everywhere (E3) Scenario, which together formed the basis for the 2010 TMDL Allocation. No Action indicates that there are no best management practices (BMPs) in the scenario. E3 includes BMPs implemented to the theoretical maximum practicable with no physical or financial limitations. Other key scenarios represent important Chesapeake Bay Program years like the 1985 Scenario, corresponding to a period of highest nutrient and sediment loads to the Bay, and the annual Progress Scenarios representing conditions in each year. The lowest loads to the Bay were simulated by the All Forest Scenario which estimated the nutrient and sediment loads under an all forested condition in the watershed.

12.1.1 Scenario Operations in the Time-Averaged Model (CAST)

12.1.1.1 *Calculation of Scenario Loads*

The calculation of scenario loads for a unique combination of land-river segment, load source, and agency follows the calculation shown in Figure 12-1. Values for inputs, land use acres, BMPs, and direct loads vary for each scenario. Values for average load, sensitivity, land to water, and river delivery are constant across scenarios except in special cases. Stream delivery changes in response to other scenario inputs as described in Section 7 and below.

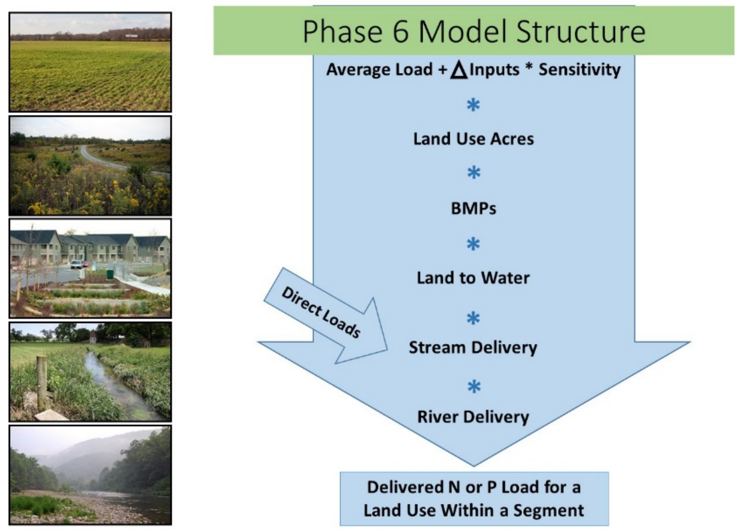

Figure 12-1: Phase 6 Model Structure

The average load is constant across all land segments for a given load source. The load in a scenario is calculated by multiplying the sensitivities described in Section 4 by the local anomaly in inputs. Inputs are load predictors such as fertilizer, manure, and soil phosphorus described in Section 3. The local anomaly in inputs for a given scenario is calculated by subtracting the 1985-2013 area-weighted average inputs across all land segments for that load source from the scenario inputs for each land segment. Equation 12-1 shows the theoretical calculation of scenario loading rates.

Equation 12-1: Scenario loading rates

$$SL_{i,j} = AverageLoad_i + \sum_{n=1}^{N} \left(Sensitivity_{i,n} * \left(Input_{i,j,n} - AveInput_{i,n}\right)\right)$$

Where:
$SL_{i,j}$ = Scenario load for load source *i* and land segment *j* (lbs/acre)
$AverageLoad_i$ = Average Load for a load source *I* (lbs/acre)
$Sensitivity_{i,n}$ = sensitivity for load source *i*, and input *n* (lbs/lb)
$Input_{i,j,n}$ = Scenario input amount for load source *i*, land segment *j*, and input *n* (lbs/acre)
$AverageInput_{i,n}$ = Area-weighted average input for 1985-2014 across all land segments for load source *i*, and input *n*

In the CAST software, a base loading rate is calculated for each load source and land segment that represents the loading rate for the years 1985-2014. Scenario loading rates are then calculated using the change in inputs between the scenario and the base hydrologic years.

Equation 12-2: Base loading rates

$$BL_{i,j} = AverageLoad_i + \sum_{n=1}^{N} (Sensitivity_{i,n} * (BaseInput_{i,j,n} - AveInput_{i,n}))$$

Where:
$BL_{i,j}$ = Base load for load source *i* and land segment *j* (lbs/acre)
$BaseInput_{i,j,n}$ = 1985-2014 inputs for load source *i*, land segment *j*, and input *n* (lbs/acre)

Equation 12-3: Calculation of Scenario loading rates from base loading rates

$$SL_{i,j} = BL_{i,j} + \sum_{n=1}^{N} (Sensitivity_{i,n} * (Input_{i,j,n} - BaseInput_{i,j,n}))$$

Note that combining Equation 12-2 and Equation 12-3 returns Equation 12-1. Equation 12-3 is evaluated for individual species of nutrients. If a calculation results in a negative number for a particular nutrient species in a load source and land segment, the value is set to zero and other species of that nutrient are reduced for the load source and land segment such that the overall mass balance is maintained.

After the calculation of the scenario loading rates and prior to the application of BMPs or delivery factors, an additional step is taken to reset any land use with a nitrogen or phosphorus loading rate less than forest loading rate within the same land segment to the forest load. As such, forest is always the lowest loading land use in each land segment.

At this point, scenario loads are specific to load source and land segment. Land use acres and BMPs are classified by agency in addition to load source and land segment and so scenario loads to streams are specific to load source, land segment, and agency.

The final scenario loads are found by multiplying the scenario loading rates by the acres of land use, the effect of BMPs, and the delivery factors of land to water, stream to river, and river to Bay. Direct loads, including those for water, septic, wastewater, riparian pasture deposition and rapid infiltration basins, are multiplied only by the stream to river and river to Bay factors as land to water factors are not applicable. Shoreline loads do not include any delivery factors. Delivery factors are discussed below in Section 12.1.3.

Nutrient and sediment stream bed and bank loads are further adjusted by the ratio of the edge-of-stream load calculated from the non-stream load sources in the scenario to the average load from the calibration. The entire calibration period is used for stream bed and bank rather than the shorter hydrologic period. Using this longer period for stream load estimates is consistent with the land to water factors that center around one for the entire calibration period. Sediment stream bed and bank loads also are adjusted by adding 4/3rds of the impervious load as described in Section 9.3.2. It follows that where the EOS scenario load is greater for a particular scenario than for the average load from the calibration, then the stream loads will be higher as well.

12.1.1.2 *Projections of Input Data for Scenarios*

The 2012 base conditions are the last year that all data are available to calculate animal manure, land use, and other inputs.

The data used to project future scenarios include the items below. The projection methods for these data are determined by the Chesapeake Bay Program Partnerships source sector workgroups.

1. Animal populations
2. Animal per animal Unit and manure produced per animal daily
3. Biosolids and agricultural spray irrigation
4. Nitrogen and phosphorus amount to meet crop need
5. Crop acres
6. Crop yield, e.g. bushels per acre
7. Inorganic fertilizer available in the watershed
8. Land Use
9. Nutrient concentration per animal manure type and county
10. Septic systems
11. Soil phosphorus
12. CSO connections
13. Septic systems, RIB, and urban spray irrigation
14. Wastewater data
15. Atmospheric deposition, which is always the allocation average in CAST scenarios

12.1.2 Scenario Operations in the Dynamic Model

As described in Section 10, the calibration operation is a continuous run over the entire simulation period from 1984 to 2013 and was used to calibrate the Phase 6 Watershed Model to observed flow and water quality data over that entire period. Land use, cropping systems, soil phosphorus, fertilizer, manure, atmospheric deposition, BMPs, and other inputs are varied annually over the three-decade simulation period. The data are provided as described in Sections 3, 5, and 6. Point source loads are input on a monthly basis over the three-decade time-series.

In comparison, the scenario operation mode of the Phase 6 dynamic simulation model is run for a ten-year hydrology simulation period from 1991 to 2000 and uses a constant representational input dataset for each scenario. For example, for the 1985 annual progress scenario, the 1985 point source flows, BMPs, animal populations, atmospheric deposition and all other aspects of the simulation would be used with the 10-year average hydrology. This provides a representation of the loads of nutrients and sediment resulting from 1985 management conditions over a ten-year hydrology from 1991 to 2000. The scenario outputs are not compared with observed data as in the case of calibration operations. Scenario outputs are summarized on a ten-year annual average basis. Scenario outputs are compared against other scenarios to evaluate different management options and conditions in the watershed and to load the estuarine model to evaluate the response of tidal waters to management scenarios.

12.1.3 Point Source Load Projections for Scenarios

The design flow is defined as the capacity of the wastewater treatment facility as designed and is used as the facility flow in some scenarios. Because design flow is usually greater than actual flow, and since the NPDES permit limits on nutrients are constant, the point source loads in scenarios using point source design flows are higher than those using actual, as measured flows. The No Action and E3 scenarios use design flows to estimate point source loads across the watershed.

The existing or current flow is the measured discharge in current years. Annual progress run scenarios and current flow-based scenarios, such as the 1985 and 2009 Scenarios, use current flows to calculate point source inputs.

12.1.4 Principle of Relative Change

From time-to-time, new data sources arise that may be judged to be more accurate than data already used in the Phase 6 Watershed Model. The partnership has agreed that changes can be incorporated into the watershed model each two-year milestone period. The initial Phase 6 CAST model is known as CAST-2017, the next is known as CAST-2019, etc. However, caution must be used to maintain consistency with the TMDL. The TMDL critical period was established as 1993-1995 (USEPA 2010c). The estuarine model is used to estimate the change in loading that would result in water quality standards being met in the three-year period 1993-1995. Therefore, the watershed model is best understood in the context of the TMDL as a tool to estimate changes in load from 1995 due to change in management actions. Substituting improved data sets could result in an estimated change in loads that is not consistent with changes actually occurring in the watershed. For example, if a new estimate of the history of atmospheric deposition increases the estimate of deposition in each historical year by 20%, it would not be appropriate to substitute this new data set and thereby increase the estimate of loads to the Bay. Running the 1995 scenario under these circumstances would lead to the impossible conclusion that water quality in the critical period had degraded due to model input changes. To be consistent with the TMDL, all versions of the phase 6 CAST must return the same results for the 1995 scenario.

The CBP has historically addressed this issue by not allowing any changes to the data from the calibration period of the model. If new data arise that are for periods after the calibration, trends were used rather than absolute numbers. For example, if the revised atmospheric deposition data set estimated an increase in recent years of 10%, the increase should be applied to the data set used in the calibration. This method can still be used for many data sets. Other data sets cannot be incorporated without changing the model results during the 1993-1995 critical period.

In response to partnership requests and decisions to be more flexible with the incorporation of data, changes to the data during the calibration period are now allowed. To maintain consistency with the TMDL all versions of CAST are constrained to return the same results for the 1995 scenario. When an update occurs, the 1995 scenario is run in both the current model and the updated model and the difference is subtracted at the EOS level for each load source and land-river segment. For example, if the true forest load in a land-river segment in CAST-2017 was 1000 lbs of N for the 1995 scenario and it increased to 1005 lbs for the 1995 scenario in CAST-2019, all CAST-2019 scenarios would have 5 lbs subtracted from true forest in that land-river segment. Loads have a minimum of 0 lbs.

12.2 Specific Example Management Scenarios

12.2.1 The 2010 No-Action Scenario

This scenario estimates nutrient and sediment loads under the conditions of no point source or nonpoint source controls using land use, population, and agricultural data set at 2010 levels. All existing management practices, including nutrient management and conservation tillage, were eliminated in this scenario. Point source load assumptions were of primary treatment with the phosphate detergent ban in place. The No-Action scenario is a “what-if” scenario of watershed loads with minimal or no controls on load sources. It is used with the E3 scenario to define “controllable” loads which are an important component of the calculation of planning targets necessary to achieve the TMDL.

• No-Action Significant municipal wastewater treatment facilities

The flows of significant municipal wastewater treatment facilities were set at design flows with the total nitrogen (TN) effluent concentration at 18 mg/l and the total phosphorus (TP) effluent concentration at 6 mg/l. The biological oxygen demand (BOD), dissolved oxygen (DO), and total suspended solids (TSS) concentrations of 30, 4.5, and 15 mg/l, respectively.

• No-Action Significant industrial dischargers

The flows of significant industrial dischargers were set at design flows with the total nitrogen (TN) and total phosphorus (TP) effluent loads set to the highest load on record or WIP load if greater. The biological oxygen demand (BOD), dissolved oxygen (DO), and total suspended solids (TSS) concentrations of 30, 4.5, and 15 mg/l, respectively.

• No-Action Non-significant municipal wastewater treatment facilities

The flows of non-significant municipal wastewater treatment facilities were set at design flows with the total nitrogen (TN) effluent concentration at 18 mg/l and the total phosphorus (TP) effluent concentration at 6 mg/l. The biological oxygen demand (BOD), dissolved oxygen (DO), and total suspended solids (TSS) concentrations of 30, 4.5, and 15 mg/l, respectively.

• ***No-Action Combined Sewer Overflows (CSOs)***

The CSO flows were set to their 1991-2000 base condition flow with a minor modification on a VA CSO- COVINGTON that was eliminated in 1999. This VA CSO was put back in the database with its 1998 flows for 1999-2000 for the base line and No Action scenario. The same individually designed default total nitrogen (TN) and total phosphorus (TP) concentrations were used for every scenario or progress.

• ***No-Action Septic Practices***

There are no nutrient and sediment control practices and programs in the No-Action scenario throughout the Chesapeake Bay watershed for on-site waste treatment (septic systems).

• ***No-Action Atmospheric Deposition***

The 2025 CMAQ Scenario is used for atmospheric deposition in both the E3 and No-Action scenarios in determining the “controllable” load. This approach allows for the agreed-to TMDL air reductions to be already considered in the nitrogen load reductions needed to achieve the water quality standards, and the remainder of the load reductions to be achieved by the WIPs are alone tracked in the nitrogen allocations to the Bay States.

• ***No-Action Urban Practices***

There are no nutrient and sediment control practices and programs in the No-Action scenario throughout the Chesapeake Bay watershed for the urban sector.

• ***No-Action Agricultural Practices***

There are no nutrient and sediment control practices and programs in the No-Action scenario throughout the Chesapeake Bay watershed for agriculture.

• ***No-Action Natural Practices***

There are no nutrient and sediment control practices and programs in the No-Action scenario throughout the Chesapeake Bay watershed on forest lands, wetlands or streams where there could be environmental impacts from timber harvesting, dirt & gravel roads, stream restoration or wetland restoration.

• ***No-Action Scenario Shoreline Loads***

The shoreline load data set reflects both fastland and nearshore loads and includes management practices that were implemented at that time. These practices need to be removed to arrive at a No-Action scenario. The following assumptions are from Halka and Hopkins 2006.

- Erosion of fastland from unprotected shorelines represents 65 percent of the total load; nearshore erosion represents 35 percent.

- No sediment is delivered to the Bay from fastland protected by structures. However, the nearshore in regions protected by structures erodes at the same rate as nearby unprotected reaches.

- Virginia has 4,060,000 meters of shoreline, of which 3,276,000 are unprotected (81 percent).

- Maryland has 2,912,000 meters of shoreline, of which 1,993,000 are unprotected (68 percent).

Combining the above assumptions, it can be calculated that the aggregate amount of load with BMPs, or pass-through, for a state is the unprotected shoreline fraction * 100 percent plus the protected shoreline * 35 percent.

The pass-through efficiency for Virginia is 0.8744 and 0.7949 for Maryland. The base loads by land-river segment to be used in the No-Action scenario can be found by dividing the current loads by the pass-through efficiency for the appropriate state.

12.2.2 The 2010 Everyone, Everything, Everywhere (E3) Scenario

The 2010 E3 Scenario is an estimate loads given the application of management actions to the fullest possible extent with land use, population, and agricultural data set at 2010 levels. There are no cost and few physical limitations to implementing BMPs for point and nonpoint sources in the E3 Scenario. Generally, E3 implementation levels and their associated reductions in nutrients and sediment could not be achieved for many practices, programs and control technologies when considering physical limitations and participation levels. The E3 Scenario includes most technologies, practices, and programs that have been reported by jurisdictions as part of annual model assessments, Watershed Implementation Plans (WIPs), and annual milestone tracking of implementation. Definitions were provided in the TMDL documentation (USEPA 2010c) appendix J and in some cases are modified by partnership decisions for phase 6.

For most non-point source BMPs, it was assumed that the load from every available acre of the relevant land area was being controlled by a suite of existing or innovative practices. In addition, management programs converted land uses from those with high yielding nutrient and sediment loads to those with lower. E3 does not include the entire suite of practices due to the goal of achieving maximum load reductions. The BMPs that are fully implemented have been estimated to produce greater reductions than alternative practices that could be applied to the same land base.

The current definition of E3 includes a greater number of types of practices than historic E3 scenarios developed in the 2003 and 2010 CBP assessments as well as in E3-like limit-of-technology scenarios developed in even earlier phases of the Watershed Model. This is due to wider development and application of new management technologies over recent years which have increased the scope of options of nutrient and sediment management practices. In the future, E3 load reductions are expected to expand through greater effectiveness of practices and greater efforts on operation and maintenance. For point sources, nutrient control technologies are assumed to apply to all dischargers.

The difference between the 2010 No-Action and 2010 E3 loads defines the "Controllable" loads which are a component of the methodology to allocate target loads needed to meet water quality standards to different regions of the Chesapeake Bay watershed under the TMDL. Each state-basin is expected to meet target loads calculated as a percentage reduction of the controllable loads. The percent reduction in controllable loads is greater in areas which have a stronger effect on dissolved oxygen in deep water of the mainstem Bay and Potomac estuary based on both estuarine circulation and nutrient retention in the watershed. Due to the dependence of state-level TMDL planning targets on the E3 scenario, the partnership spends considerable time coming to consensus on the levels of BMP implementation in the E3 scenario. The WQGIT agreed on the definitions of the E3 scenario during the August 14 and August 28 meetings in 2017.

12.2.2.1 *E3 Wastewater and Other Direct Loads*

- Significant municipal wastewater treatment facilities
  - Flow = WIP flow with most at design flow
  - Nitrogen effluent concentration = 3 mg/l TN
  - Phosphorus effluent concentration = 0.1 mg/l TP
  - BOD = 3 mg/l, DO = 6 mg/l and TSS = 5 mg/l
- Significant industrial dischargers
  - Flow = WIP flow with most at design flow
  - Nitrogen effluent concentration = 3 mg/l TN or WIP concentration if less
  - Phosphorus effluent concentration = 0.1 mg/l TP or WIP concentration if less
  - BOD = 3 mg/l, DO = 6 mg/l and TSS = 5 mg/l
- Non-significant municipal wastewater treatment facilities
  - Flow = Design or 2006 flow if design is not available
  - Nitrogen effluent concentration = 8 mg/l TN or WIP concentration if less
  - Phosphorus effluent concentration = 2 mg/l TP or WIP concentration if less
  - BOD = 5 mg/l, DO = 5 mg/l and TSS = 8 mg/l
- Nonsignificant industrial wastewater treatment facilities
  - Applies the percentage of equivalent reduction from No Action (18 mg/l TN, 3mg/l TP) to E3 (3 mg/l TN, 0.1 mg/l TP) to the 2010 load estimates.

- Combined Sewer Overflows
  - 100% overflow reduction through storage and treatment, separation or other practices. Storage and treatment is assumed in current model scenarios.
- Septic system
  - 10% of septic systems retired and connected to wastewater treatment facilities.
  - Remaining septic systems after connections employ denitrification technologies and are maintained through regular pumping to achieve a 55% TN load reduction at the edge-of-septic-field.

12.2.2.2 *E3 Atmospheric Deposition*

The 2025 CMAQ Scenario is used for atmospheric deposition in both the E3 and No-Action scenarios in determining the "controllable" load. This approach allows for the agreed-to TMDL air reductions to be already considered in the nitrogen load reductions needed to achieve the water quality standards, and the remainder of the load reductions to be achieved by the WIPs are alone tracked in the nitrogen allocations to the Bay States.

12.2.2.3 *E3 Developed Land Practices*

- Stormwater Management
  - 100% of new development has runoff reduction sized for 2.0 inches on impervious area
  - 75% of existing area has runoff reduction sized to treat 1.5 inches for each urban land use type
- Erosion & sediment controls
  - 100% of construction sites are treated to ESC Level 3 and have high-risk Urban Nutrient Management plans
- Urban nutrient management
  - 100% eligible Pervious Cover has Urban Nutrient Management Plan implementation which is split 20% High Risk and 80% Low Risk
- Urban tree canopy
  - *10% gain (2,400 additional acres) of canopy from now (2013) by 2025*
- Street cleaning
  - 100% of Transport Impervious Cover swept using SCP-1
- Storm drain cleanout and advanced grey infrastructure nutrient discovery program
  - 5% of Urban N and P load removed due to both credits
- Urban stream restoration
  - *15% of urban stream miles are restored @ twice the default Stream Restoration value.*

- *Stream miles from Chesapeake Conservancy synthetic data layer at lower order than National Hydrography Dataset (NHD).*

12.2.2.4 *E3 Agricultural Practices*

- Tillage management –
    - High residue on all row crops other than corn silage and soybeans and all low input specialty crops
    - Conservation tillage on row crops corn silage and soybeans and all high input specialty crops except as noted below for low residue
    - Low residue on potatoes, peanuts, and tobacco
- Manure incorporation and injection.
    - All manure is applied as incorporated or injected. Liquid manure is injected while dry manure is incorporated. Dairy and swine produce liquid manure while all others produce dry manure. The split between acres with injection versus incorporation is the proportion of liquid-to-dry manure nutrients applied to crops.
    - Injection is combined with high residue tillage management
    - Incorporation is combined with conservation tillage and low residue tillage management
- Cover crops
    - Implemented on all row crop and high input specialty crops except for mushroom, greenhouse, and container nursery
    - DE, MD, VA, WV, and southern PA
        - Aerial traditional - Soybeans receive early broadcast seeded rye
        - Drilled traditional – corn, sorghum, etc. receive early directed seeded rye
        - Commodity – wheat, barley, rye, etc. receive seeded commodity small grain
    - NY and northern PA
        - Aerial traditional – Corn, soybeans, etc. receive early broadcast seeded rye
        - Commodity – wheat, barley, rye, etc. receive seeded commodity small grain
- Nutrient management
    - 100% of all available agricultural land uses are under
        - core N and core P nutrient management
        - NM supplemental
        - N and P placement
        - N and P rate
        - N and P timing
- Alternative Crops
    - 1% of row crops
- Soil conservation and water quality plans

    - 100% of all available agricultural land uses
- Manure Transport
    - Transport excess manure
- Animal Waste Management Systems
    - 100% of all livestock and poultry production areas
- Mortality composting
    - 100% of all livestock and poultry mortality
- Animal Feed Operations
    - Barnyard runoff control on 100% of all large animal livestock facilities
    - Loafing lot management on 100% of all large animal livestock facilities
- Dairy precision feeding
    - 100% of dairy at 24% reduction in TN and 28% reduction in TP
- Biofilters and lagoon covers
    - 100% of dairy and swine, excludes manure storage for dry or stackable manure
- Land change BMPs
    - Riparian forest buffers on agriculture
        - Unbuffered pasture within 30m of all streams and rivers with the exception of tax ditches in Maryland and Delaware
    - Wetland restoration
        - 1% of available agricultural acres in crops and pasture for each modeled hydrologic segment in the Chesapeake Bay watershed.
    - Tree Planting
        - 1% of available agricultural acres in crops and pasture for each modeled hydrologic segment in the Chesapeake Bay watershed.
    - land retirement
        - 7% of available agricultural acres in crops and pasture for each modeled hydrologic segment in the Chesapeake Bay watershed.
    - Total not to exceed 15% by land-river segment
- Stream restoration
    - 15% of agriculture stream miles are restored at twice the default stream restoration value. Stream miles are from the Chesapeake Conservancy
- Pasture Management
    - 100% of all available livestock pasture is under
        - off-stream watering without fencing
        - Prescribed grazing
        - Pasture management composite

12.2.2.5 *E3 Natural and other Practices*

- E3 Forest harvesting practices
    - 100% of harvested forest area
- No net loss of true forest
- Diploid oysters = 112,000,000 oysters in MD, 280,000,000 oysters in VA

12.2.3 Annual Progress Scenarios

Progress scenarios use the estimated land uses, animal numbers, BMPs, point source loads, and other specifications form the year indicated in the scenario name. The only exception is atmospheric deposition, which is taken 'off the top' of the TMDL calculations. Progress scenarios use 'allocation air', which is the atmospheric deposition expected in 2025 with expected controls in place. Progress scenarios that are run with atmospheric deposition for that actual year are known as 'real air' or 'RA' progress scenarios. Progress scenarios track implementation progress in the watershed since the creation of the Chesapeake Bay Program.

12.2.4 The All Forest Scenario

This scenario uses an all forest land use and estimated pristine atmospheric deposition loads for the 1991 – 2000 period and represents a challenge scoping scenario to the Watershed Model with the loads simulated in the watershed at the lowest conceivable level. The input atmospheric deposition loads were reduced by about an order of magnitude.

12.2.5 Base Calibration Scenario

The Base Calibration Scenario is used in data correction procedures and represents the calibration of the time series of land uses, loads and hydrology over the ten-year simulation period of 1991 – 2000 used for TMDL scenarios.

12.3 Scenario Output by Input Type

Typically, output from the watershed model is expressed in terms of load from each land-river segment, agency, and load source, where load source refers to a land use, point source, or other direct source to surface or ground water such as septic systems. Chesapeake Bay Program partners occasionally request load in terms of input type, such as fertilizer, manure, or atmospheric deposition. Since loads from fertilizers, for example, are also loads from watershed model agricultural and developed load sources, the two types of sources cannot be represented in the same analysis. Figure 12-2 shows conceptually how loads move through a watershed from input to load source, and through the filters of management and watershed delivery. Loads can be totaled from inputs or load source, but inputs and load sources cannot be mixed. Note, however, that certain loads such as wastewater and septic are both inputs and load sources and would appear in both an accounting based on load sources and an accounting based on inputs. This is not the only way to represent the system, but it has been found useful for the Chesapeake Bay Program partners. Other researchers have looked a mass balance approach around a watershed. For example, the "net anthropogenic nitrogen inputs" (e.g. Howarth et al. 2011) method is commonly used. At the time of this writing, an analysis of loads by input type is not available to external users of CAST. It is only available through a request to the Chesapeake Bay Program Office.

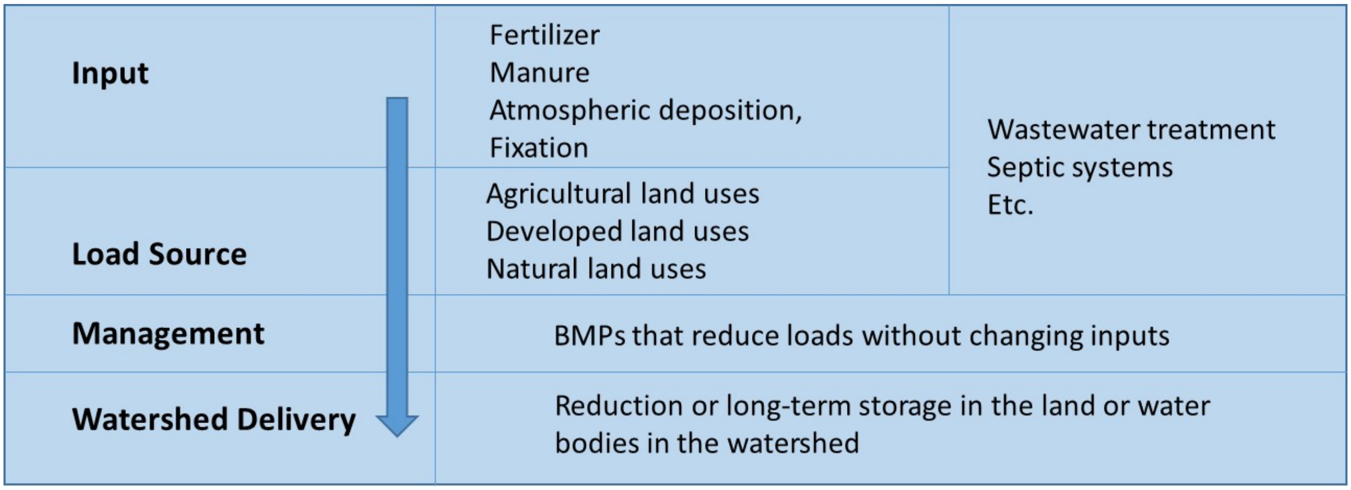

Figure 12-2: Representation of inputs and load sources in the Phase 6 Watershed Model

12.3.1 Nitrogen input calculation

Load sources are divided into those that have inputs and those that do not. Wastewater, septic, stream bed and bank, and shoreline load sources do not have load inputs and are included in the calculation as their own inputs. All other sources have at least one input. Table 12-1 shows the inputs that correspond to each load source. To determine the amount of load from the load source attributable to each input type, the total input is multiplied by the sensitivity for the combination of input and load source described in Section 4 to get the estimated effect of each input source. To maintain mass balance, the estimated effect for each input type are reduced or increased proportionally such that the sum of the effects matches the total load for the load source. Equation 12-4 shows the calculation of load effects for each input type.

Equation 12-4: Calculation of load effect for each input type

$$IL_{i,j,k} = Input_{i,j,k} * S_{i,j} * \left(\frac{TL_{j,k}}{\sum_I \left(Input_{i,j,k} * S_{i,j}\right)}\right)$$

Where:
IL = Load from a load source and land segment attributable to a particular input (lbs/acre/year)
Input = amount of a particular input to a load source and land segment (lbs/acre/year)
S = Sensitivity (lbs out / lb input) for a load source and input type
TL = Total load for a load source and land segment
i = index for input type

j = index for load source
k = index for land segment

In the case where there is only one input type, Equation 12-4 is still used with the result that the entire load from the load source is attributed to a single input source. Several loading sources have only either atmospheric deposition or manure inputs as shown in Table 12-1.

Table 12-1: Inputs by load source

Sector	Load Source	Manure	Fertilizer	AtDep	Fixation	No Input
Agriculture	Ag Open Space			X		
Agriculture	Double Cropped Land	X	X	X	X	
Agriculture	Full Season Soybeans	X	X	X	X	
Agriculture	Grain with Manure	X	X	X		
Agriculture	Grain without Manure		X	X		
Agriculture	Legume Hay	X	X	X	X	
Agriculture	Non-Permitted Feeding Space	X				
Agriculture	Other Agronomic Crops	X	X	X	X	
Agriculture	Other Hay	X	X	X	X	
Agriculture	Pasture	X	X	X	X	
Agriculture	Permitted Feeding Space	X				
Agriculture	Riparian Pasture Deposition	X				
Agriculture	Silage with Manure	X	X	X		
Agriculture	Silage without Manure		X	X		
Agriculture	Small Grains and Grains	X	X	X		
Agriculture	Specialty Crop High	X	X	X		
Agriculture	Specialty Crop Low	X	X	X	X	
Developed	CSS Buildings and Other			X		
Developed	CSS Construction			X		
Developed	CSS Roads			X		
Developed	CSS Tree Canopy over Impervious			X		
Developed	CSS Tree Canopy over Turf Grass		X	X		
Developed	CSS Turf Grass		X	X		
Developed	MS4 Buildings and Other			X		
Developed	MS4 Roads			X		
Developed	MS4 Tree Canopy over Impervious			X		
Developed	MS4 Tree Canopy over Turf Grass		X	X		
Developed	MS4 Turf Grass		X	X		
Developed	Non-Regulated Buildings and Other			X		

Sector	Load Source	Manure	Fertilizer	AtDep	Fixation	No Input
Developed	Non-Regulated Roads			X		
Developed	Non-Regulated Tree Canopy over Impervious			X		
Developed	Non-Regulated Tree Canopy over Turf Grass		X	X		
Developed	Non-Regulated Turf Grass		X	X		
Developed	Regulated Construction			X		
Natural	CSS Forest			X		
Natural	CSS Mixed Open			X		
Natural	Harvested Forest			X		
Natural	Headwater or Isolated Wetland			X		
Natural	Mixed Open			X		
Natural	Non-tidal Floodplain Wetland			X		
Natural	Shoreline					X
Natural	Stream Bed and Bank					X
Natural	True Forest			X		
Natural	Water			X		
Septic	Rapid Infiltration Basin					X
Septic	Septic					X
Wastewater	Combined Sewer Overflow					X
Wastewater	Industrial Wastewater Treatment Plant					X
Wastewater	Municipal Wastewater Treatment Plant					X

12.3.2 Phosphorus input calculation

Agricultural phosphorus loads are dependent on applied water extractable phosphorus (WEP) and soil phosphorus concentrations and these are in turn dependent on inputs. Phosphorus loads from an agricultural load source are first separated into loads derived from WEP and soil phosphorus using the method of Equation 12-4. Since soil phosphorus is the result of the history of inputs, the soil phosphorus can be attributed to inputs of fertilizer and manure based on the application rates and effects. Inputs of fertilizer and manure affect soil phosphorus differently as described in Section 3. The entire history of inputs form 1985 to the current scenario are considered. Each input is multiplied by the factor in the table contained in the section titled "Prediction of Soil Phosphorus for Scenarios" in a calculation similar to Equation 12-4 to determine the fraction of soil P that is due to each input type.

Loads are modified by more factors than the four input types that are shown in Table 12-1. For example, the nitrogen load in most agricultural land uses is determined in part by the amounts of vegetative crop cover and nutrient uptake. Phosphorus has sensitivities to runoff and washoff in addition to inputs of fertilizer and manure. However, these other factors determining load are not inputs, but properties of the climate, watershed, or agricultural system that determine how readily inputs are converted to outputs. The full table of factors influencing load from load sources is available on the CAST documentation page under the name Inputs by Load Source.

In developed areas, fertilizer can act as a source for turfgrass, however impervious and construction land uses have no assigned sources of phosphorus in the Phase 6 Watershed Model. The phosphorus load from these load sources may arise primarily from decay of organic matter or downstream erosion caused by increased flow intensity. Similarly, natural areas and mixed open do not have applied sources. For the accounting of loads from sources, phosphorus loads from these areas are left in natural or urban categories rather than attributed to specific inputs.

12.4 Technical Documentation of the Planning Target Methodology for the Chesapeake Bay Program's 2017 Midpoint Assessment

This section details the methods and decisions that resulted in the final planning targets for the Chesapeake Bay Program partnership's 2017 Midpoint Assessment. Planning targets are load caps from major basins within states that are consistent with the 2010 TMDL state-basin allocations (USEPA 2010c). Updates of modeling tools require changes in loading estimates necessary to reach similar water quality endpoints. The 2017 planning targets maintain the protection of water quality in the 2010 TMDL but allow the use of updated models. This documentation is meant to be technical and specific such that an analyst would be able to recreate the loading rates based on files available on CBP servers.

12.4.1 Principals' Staff Committee Decisions

The Principals' Staff Committee (PSC) met several times throughout 2017 and 2018 to discuss the 2017 Midpoint Assessment planning targets. The details of the planning targets were worked out in CBP workgroups and teams with the PSC making the final decisions. STAR's Modeling Workgroup oversaw the development of the models used in the midpoint assessment and reviewed the planning target methodology for technical sufficiency. The Water Quality Goal Implementation Team and its workgroups oversaw the development of model input data, the definition of key scenarios, and the expression of equity in calculating the planning targets.

December 19-20, 2017

Decisions recorded in the minutes

- approved the Phase 6 suite of modeling tools
- Set the assimilative capacity at a level above 195 million lbs of N and 13.7 million lbs of P which will still achieve oxygen water quality standards, including a 6% variance for CB4MH Deep Channel

- New York received 1 million lbs N and 0.1 million lbs P in equity pounds
- West Virginia received 2 million lbs N in equity pounds
- Use the clean air act expected reductions to get the maximum assimilative capacity
- Planning target calculations are to be made as if the Conowingo were in the 1990s state with additional reductions required from a separate Conowingo WIP.
- The Conowingo effect is 6.01 million lbs of N and 0.262 million lbs of P in the Susquehanna. This decision was never revisited with updated models and so these numbers stand.

March 2, 2018

Decisions recorded in the minutes

- West Virginia's equity pounds amended to 1.89 million lbs N
- Re-affirmed New York's equity pounds
- Defined Assimilative Capacity as 196.5 million lbs N and 13.75 million lbs P

July 9, 2019

Decisions recorded in the minutes

- The final suite of models was approved
- The planning targets were approved with the following stipulations
    - West Virginia received a return to 2 million equity pounds N
    - New York received an additional 0.25 million equity pounds N
    - In order for these requests to be granted,
        - Maryland's planning target was reduced by 50k pounds N
        - Virginia's planning target was reduced by 16k pounds N
        - New York's planning target was reduced by 24k pounds N
        - West Virginia's planning target was reduced by 24k pounds N

12.4.2 Model Versions

The WQSTM geo runs and scenarios for all analyses December 2017 through July 2018 are based on calibration run 223, as presented at the October 17, 2017 Modeling Workgroup meeting. Draft planning targets from December that were shown to the WQGIT and PSC were based on the October 2017 version of the Phase 6 Watershed Model that had gone through the fatal flaw review process and was approved by the PSC in December 2017. This began the planning target review period.

During the planning target review period, several changes were made to the Phase 6 Watershed Model

- An updated pull of NEIEN data on 5/16/18
- Correction of an error in the processing of data that were submitted by latitude and longitude
- Correction of nitrogen fixation. The previous version of the model had fixation that was 50% too high everywhere
- Allowing stream bed and bank load to be negative due to BMP implementation

It was shown that the Watershed Model was still well-calibrated after these changes, however they necessitated a change in the baseline run used for analysis of WQSTM runs. The baseline is a detrended calibration run. These changes also resulted in a change in the delivery factors which in turn affected the relative effectiveness in the planning target ("hockey stick") chart.

Several changes were also made to the E3 scenario

- Correction of wastewater file used in the calculation of changes in stream bank loads for scenarios. This also affected the No Action scenario
- BMPs were applied to federal land. Previously, federal land had been included in the calculation of land are available for BMPs, but the BMPs were applied to non-federal area only
- BMPs that are not defined as a percent implementation were previously applied to entire counties rather than just the portion within the watershed, although the available acres were calculated just within the watershed. This was corrected.
- Stream restoration feet were correctly applied
- Tax ditches in Maryland and Delaware were removed from land available for forest and grass buffers

The corrections to the model and the small changes in the E3 scenario resulted in revised planning targets, which were further adjusted by decision of the PSC as documented above. The Conowingo analysis was not re-run with the updated model and so the previous model results stand.

12.4.3 Planning Target Methodology

Referenced files are in (on the CBP C4 system as of 10/2020):

F(gshenk):\TMDL\2017 MidPoint Assessment\Planning Targets\Planning Target Calcs\2018 06 PSC\
And copied to:
G:\Modeling\TMDL\2017 Midpoint Assessment\Planning Target Calculation\

Scenarios

Scenarios were pulled directly from CAST-2017

No action: The 2010 no action scenario found in 'Loads by Geosegment 20180614 June 2018 Calibration.xlsx'
E3: The '2010 E3 with Fed & taxditches4' scenario found in 'Loads by Geosegment 20180620 June 2018 Calibration 1985 E3.xlsx'
2017: The 2017 scenario found in 'Loads by Geosegment 20180614 June 2018 Calibration.xlsx'

12.4.3.1 *Assimilative Capacity for the Planning Targets prior to Equity Pounds*

When the PSC defined the assimilative capacity in December of 2017, the loads they were referencing had an equivalent water quality response as the Phase II WIPs run through the Phase 6 model. That is, the sum of the Phase II WIP loads multiplied by the appropriate estuarine effectiveness factor was calculated to arrive at separate 'total oxygen effect' values for nitrogen and phosphorus. The initial planning targets were calculated by calculating the intercept in the 'hockey stick' allocation curve that would result in the same total oxygen effect using updated no action, E3, relative effectiveness, and estuarine effectiveness values.

The March 2018 assimilative capacity used the same method and models as the December 2017 calculations with the addition of equity pounds for New York and West Virginia. The additional pounds were offset by accounting for expected load reductions from atmospheric deposition from 2025 to 2030 and by increasing the CB4MH nonattainment to 6.49% by decision of the PSC.

The final targets approved by the PSC in July 2018 were based on the above methods with the final modeling system and included some adjustments that occurred during the PSC meeting. The initial targets were calculated in the spreadsheet 'Planning Targets 2018 06 18 N fixation fix.xlsx'. PSC adjustments were made in the file 'Assimilative Capacity with Updated WIP 2018 07 02.xlsx' with the final targets and exchange ratios in 'Final Approved Phase 3 Planning Targets 2018 07 09.xlsx'. Further adjustments were made in response to the Phase III WIPs using the approved exchange ratios and the final results are in '2019 Planning Targets, Exchanges, and WIPs.xlsx'.

12.4.3.2 *Additional Capacity Available for Equity Pounds*

The WQSTM model was run with the updated Watershed Model baseline and the updated WIP2 scenario. Additional scenarios were run adding .5%, 1%, and 2% to the WIP2 loads. After these scenarios were run, it was determined that the decreased load to the coastal ocean should have been considered. An additional scenario was run with the WIP2 plus 2% loading from the watershed, but an adjusted boundary condition. The outcome is in “Target 2018 07 06.xlsx”.

The following calculations are made in the spreadsheet “Assimilative Capacity with Updated WIP 2018 07 09.xls.” After the ocean boundary condition scenario was run, it was determined that the ocean factor used in the model was incorrect. A calculation was made to adjust for the error. This calculation was verified by a later WQSTM run. The calculation is in the sheet ‘ocean boundary condition’. The ocean boundary condition was used to decrease the scenario results for the WIP+1% and WIP+2% runs. Simple extrapolation of the violation rates for these two scenarios found that CB4MH Deep Channel would meet a violation rate of 6.49% at an increase over the WIP II loads of 2.071%. This was used as the new *assimilative capacity*.

The assimilative capacity (WIP II + 2.071%) load for each state basin was multiplied by its estuarine effectiveness to arrive at a total allowable oxygen effect for N and a separate number for P. The same calculation was carried out for the initial targets calculated above. The oxygen effect of the change in atmospheric deposition from 2025 through 2030 was subtracted from the oxygen effect of the initial targets calculated in ‘Planning Targets 2018 06 18 N fixation fix.xlsx’. The result is an additional available load of 745,000 pounds of N load with a deficit of 208,000 pounds of P (sheets ‘Calc PT TN WIP+198’, and ‘Calc PT TP WIP+198’), both in units relevant to Susquehanna loads. Using approved exchange rates left 254,000 pounds of N at the Susquehanna available for distribution to partners. With requests from NY for 250,000 pounds of N and WV for 110,000 pounds, that left a deficit of 91,000 pounds of Susquehanna N. The numbers are not strictly additive since states have different oxygen effects as expressed by the exchange ratios.

12.4.3.3 *Final PSC adjustments*

The PSC noted that MD, VA, and PA had benefited from the latest round of model changes when the difference between 2017 and the proposed planning target was considered. Of those three states, MD had 45% of the benefit, PA had 41% of the benefit, and VA had 14% of the benefit. MD and VA agreed to reduce their planning target by the same percentage of the gap as they had benefit. PA’s portion was split evenly between NY and WV by reducing the pounds that they requested. The initial targets had the following adjustments to arrive at the final targets. Units are pounds of nitrogen. Calculations are in the sheets ‘Calc PT TN MDPAVA’ and ‘Calc PT TP MDPAVA’.

MD - 50,000
VA - 16,000
NY +226,000
WV +86,000

Results are in “Final Approved Phase 3 Planning Targets 2018 07 09.xlsx”

12.4.4 Exchanges

12.4.4.1 *Geographic Isolation Runs*

Using a separate run for each geographic area, use the Phase II WIP scenario as a base and raise nitrogen by 1 million lbs per year. The increase is accomplished by multiplying the 10-year time series by a constant factor for all cells loaded by the geographic area. As in all scenarios, a full 10-year spin-up is performed. The modeled change in the 25th percentile of dissolved oxygen is recorded for each designated use. The process is repeated for phosphorus using 100,000 pounds per year.

As with other purposes related to the TMDL, the volume-weighted average of the standard set of designated uses is used for the calculations. The Deep Water designated uses are CB3MH, CB4MH, CB5MH, and POTMH. The Deep Channel designated uses are CB3MH, CB4MH, and CB5MH. The result is expressed in units of micrograms per liter improvement in dissolved oxygen per million pounds of nutrient reduction at the edge of tide.

Table 12-2: Exchange Ratios for Phase III WIPs

	Effectiveness in Oxygen ug/l change per 1,000,000 lbs N or P		Lbs of N to equal effect of 1 lbs P
GeoBasin	**N**	**P**	**N:P exchange Ratio**
Susquehanna	16.325	38.503	2.36
Western Shore	14.109	35.264	2.50
Patuxent AFL	10.931	27.505	2.52
Patuxent BFL	13.514	35.667	2.64
Potomac AFL	14.045	22.210	1.58
Potomac BFL	13.201	22.165	1.68
Rappahannock AFL	8.065	11.765	1.46
Rappahannock BFL	9.278	15.453	1.67
York AFL	4.630	9.111	1.97
York BFL	5.165	8.681	1.68
James AFL	2.647	7.673	2.90
James BFL	2.351	7.434	3.16
Upper Eastern Shore	10.709	31.840	2.97
Middle Eastern Shore	11.244	43.196	3.84
Lower Eastern Shore	9.782	25.243	2.58

GeoBasin	Effectiveness in Oxygen ug/l change per 1,000,000 lbs N or P N	P	Lbs of N to equal effect of 1 lbs P N:P exchange Ratio
Virginia Eastern Shore	15.214	20.404	1.34
Atmospheric Deposition	15.827		

12.4.4.2 *General Nutrient Exchange Calculations*

Jurisdictions are allowed to make basin-to-basin and nitrogen-to-phosphorus exchanges based on rates that are established through geographic isolation runs of the estuarine model. To determine the exchange ratio between basins or nutrients, the effectiveness value in Table 12-2 for the basin and nutrient that will receive a higher planning target is divided by the effectiveness for the basin and nutrient that will receive a lower planning target.

For example if the nitrogen target in James BFL (below fall line) is to be raised by lowering the nitrogen target in York BFL, the York BFL load will be lowered by 2.351/5.165 = 0.455 pounds for every pound that is raised in the James BFL. It can be helpful in making these calculations to remember that the effectiveness values in Table 12-2 are a measure of the power of nutrients from those areas to effect dissolved oxygen. Susquehanna nitrogen, at 16.325 is much more potent than James BFL nitrogen at 2.351. Therefore, it is reasonable that a pound of Susquehanna nitrogen would be worth 7 pounds (16.325/2.351) from the James, and not reasonable that it would be worth 1/7th (2.351/16.325) of a pound from the James.

12.4.4.3 *Nutrient Exchanges in the Phase III WIPs*

Requests for exchanges in the final Phase WIPs were used to create the final exchanged planning targets that are equivalent to the July 2018 planning targets. Calculations are carried out in the file 'Calc Planning Targets with exchanges and sediment 2019 10 03.xlsx'.

12.4.4.3.1 State-basin Exchange Ratios

The geographic isolation runs produced effectiveness values by basin and above/below fall line. Target loads are calculated by state-basin and states generally used a type of average effectiveness value by state-basin in their WIPs. Even though generally expressed as state-basin, the planning targets are in fact calculated by state-basin and above/below fall line. This allows for an effectiveness value to be calculated by state-basin weighted by the planning target for state-basin and fall line as shown in Table 12-3.

Table 12-3: State-basin effectiveness values

State-Basin	N	P
PA Susquehanna	16.325	38.503
PA Potomac	14.045	22.210

State-Basin	N	P
PA Eastern Shore	10.709	31.840
PA Western Shore	14.109	35.264
MD Eastern Shore	10.507	32.744
MD Western Shore	14.109	35.264
MD Potomac	13.732	22.186
MD Patuxent	12.401	32.359
MD Susquehanna	16.325	38.503
VA Potomac	13.697	22.193
VA Rappahannock	8.702	13.237
VA York	4.966	8.845
VA James	2.464	7.572
VA Eastern Shore	15.214	20.404
WV Potomac	14.045	22.210
WV James	2.647	7.673
DE Eastern Shore	9.959	27.634
DC Potomac	13.204	22.165
NY Susquehanna	16.325	38.503

12.4.4.3.2 Maryland Exchanges

Maryland's WIP provided requested exchanges using approximate exchange factors in Appendix F (table F-1 on page F-2, page 199 of the document). For nitrogen, Maryland wanted higher planning targets in the Eastern Shore, Potomac, and Susquehanna basins and lowered The Western Shore planning target appropriately. The calculations suggested by Maryland are carried out with state-basin exchange values in Table 12-4. Maryland did not propose phosphorus exchanges.

Table 12-4: Maryland Exchanges

Basin	2018 planning Target	final WIP3	State Proposed Target	difference	weighted average exchange	Oxygen effect	Exact PT
Eastern Shore	15.21	15.44	15.60	0.39	10.51	4.13	**15.60**
Patuxent	3.21	3.08	3.21	0.00	12.40	0.00	**3.21**
Potomac	15.30	15.64	15.80	0.50	13.73	6.91	**15.80**
Susquehanna	1.18	1.57	1.60	0.42	16.32	6.79	**1.60**
Western Shore	10.89	8.97	9.60	-1.29	14.11		**9.63**

Virginia's WIP contained a set of nine basin-to-basin and nitrogen-to-phosphorus exchanges in table 4 on page 155. Exact calculations were carried out using the 'from' pounds which resulted in some changes to the 'to' pounds. In all cases, however, the WIP III meets the planning target. Calculations are shown in Table 12-5.

Table 12-5: Virginia exchanges

Basin	2018 N planning Target	final WIP3	State Proposed Target	difference	weighted average exchange	Exact N PT
Eastern Shore	1.434	1.548	1.826	0.392	15.214	**1.826**
James	25.925	20.917	21.813	-4.112	2.464	**21.813**
Potomac	15.995	15.380	16.515	0.519	13.697	**16.515**
Rappahannock	6.851	6.432	7.086	0.235	8.702	**7.086**
York	5.520	5.297	5.714	0.194	4.966	**5.714**
State	2018 P planning Target	final WIP3	State Proposed Target	difference	weighted average exchange	**Exact P PT**
Eastern Shore	0.164	0.141	0.152	-0.012	20.404	**0.152**
James	2.731	2.126	2.241	-0.491	7.572	**2.241**
Potomac	1.892	1.674	1.823	-0.069	22.193	**1.823**
Rappahannock	0.849	0.764	0.819	-0.030	13.237	**0.819**
York	0.556	0.524	0.548	-0.009	8.845	**0.548**

West Virginia's WIP called for the CBP to raise the James planning targets and lower the Potomac target. The James loads were set by rounding up the WIP loads to the nearest 10,000 lbs for TN and 1000 lbs for TP, reflecting the significant digits commonly displayed in the tables. The exchange lowered the Potomac target by 1400 lbs TN and 500 lbs TP.

Pennsylvania's WIP met the phosphorus targets for all basins but did not meet the nitrogen target in any basin. Pennsylvania requested that their phosphorus planning targets be moved up to the WIP values and the excess distributed to nitrogen within the same basin as shown in Table 12-6

Table 12-6: Pennsylvania exchanges

Basin	2018 TN planning Target	final WIP3	State Proposed Target	difference	weighted average exchange	Exact PT
Eastern Shore	0.446	0.539	0.456	0.010	10.709	**0.456**
Potomac	6.114	7.344	6.145	0.031	14.045	**6.145**
Susquehanna	66.592	75.381	66.866	0.275	16.325	**66.866**
Western Shore	0.024	0.023	0.025	0.001	14.109	**0.025**
Basin	2018 TP planning Target	final WIP3	State Proposed Target	difference	weighted average exchange	**Exact PT**
Eastern Shore	0.025	0.022	0.022	-0.003	31.840	**0.022**
Potomac	0.357	0.338	0.338	-0.019	22.210	**0.338**
Susquehanna	2.661	2.544	2.544	-0.116	38.503	**2.544**
Western Shore	0.001	0.001	0.001	0.000	35.264	**0.001**

12.4.5 Sediment planning targets

Development of Sediment Planning Targets in the Phase I and II WIPs

In Phases I and II, the Chesapeake Bay Program (CBP) partnership found that a greater level of Best Management Practice (BMP) implementation was needed to meet the nutrient-based WQS, primarily for Deep Water and Deep Channel dissolved oxygen (DO), than was needed to meet the sediment-based water clarity/SAV WQS. In addition, we found that the water clarity/SAV WQS is generally more responsive to nutrient load reductions than it is to reduction of sediment loads. The CBP partnership agreed for the Phase I WIPs, and subsequently at a June 2011 WQGIT meeting for the Phase II WIPs, that the primary emphasis in the WIPs should be on nutrient reduction BMPs, which by their nature of reducing both nutrient and sediment loads in the watershed also achieve the water clarity/SAV WQS. This decision was further supported by research and findings in the Chesapeake (Gurbisz and Kemp, 2014; Lefcheck et al., 2018).

Accordingly, the Phase I WIP sediment targets were calculated using estimated sediment load delivered to the Bay resulting from the BMPs that the jurisdictions planned to implement to meet the TMDL allocations. An additional 10% allowance was added to the calculated sediment target in each major basin-jurisdiction to allow for modifications to the WIP moving forward.

The Phase II WIP target loads were based on the Phase I WIP practices, adjusted to exactly meet the TMDL allocations, run through the updated phase 5.3.2 model and further reduced to meet water quality standards. Again, as with phase I, an additional 10% was added to the expected sediment load to allow for future modifications to the WIPs.

The Phase III WIP sediment targets were set in a process similar to the original 2010 TMDL. Specifically, Phase III WIP sediment targets were calculated based on the jurisdictions' Phase III WIPs by quantifying the estimated sediment load delivered to the Chesapeake Bay using the Phase III WIP BMPs, adjusting for any over or under achievement in nitrogen and phosphorus, and including an additional 10% allowance. To adjust for over or under achievement by state-basin, the phosphorus in both the final planning targets after exchanges and the phase III WIPs was converted to nitrogen using the appropriate exchange ratio. The target total was divided by the WIP total to calculate a ratio of aggregate under or over achievement. The WIP sediment load was then multiplied by this ratio to arrive at a preliminary sediment target. The preliminary target was multiplied by 110% to arrive at the final sediment target.

Figure 12-3 gives an example for a hypothetical WIP that did not meet the planning targets. Suppose that the sum of the nitrogen load from the planning target and the phosphorus load from the planning target exchanged for nitrogen is 80% of the same calculation performed on the planning targets. Further suppose that the sediment load from the WIP is 1.25 million pounds. The 1.25 million lbs in the WIP would be multiplied by 80% to arrive at a preliminary target of 1 million lbs. Finally the preliminary target would be multiplied by 110% to arrive at a final sediment target of 1.1 million pounds.

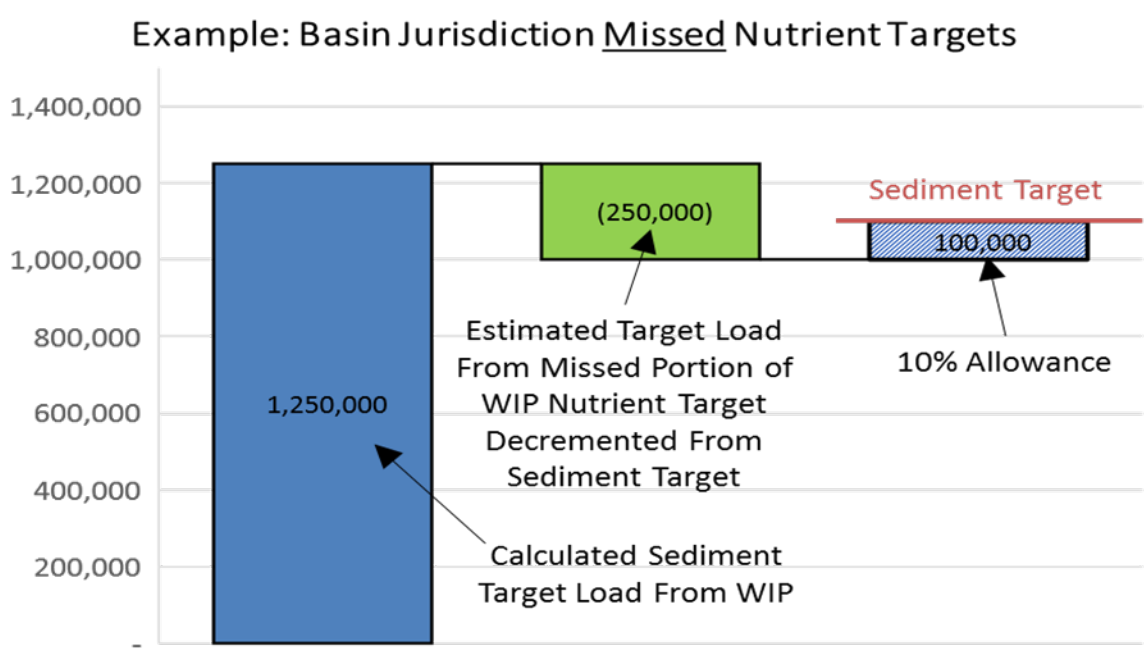

Figure 12-3: Example of sediment target for underachieving WIP

In fifteen out of nineteen state-basins, the combined nutrient loads specified in the WIP were below the planning targets as a buffer against future growth or climate change. In the hypothetical example shown in Figure 12-4, the state-basin has a planning target that is 133% of the WIP for nutrients. A WIP sediment load of 0.75 million pounds is multiplied by 133% to arrive at a 1 million pound preliminary sediment target which is, in turn, multiplied by 110% to arrive at a final sediment target of 1.1 million pounds.

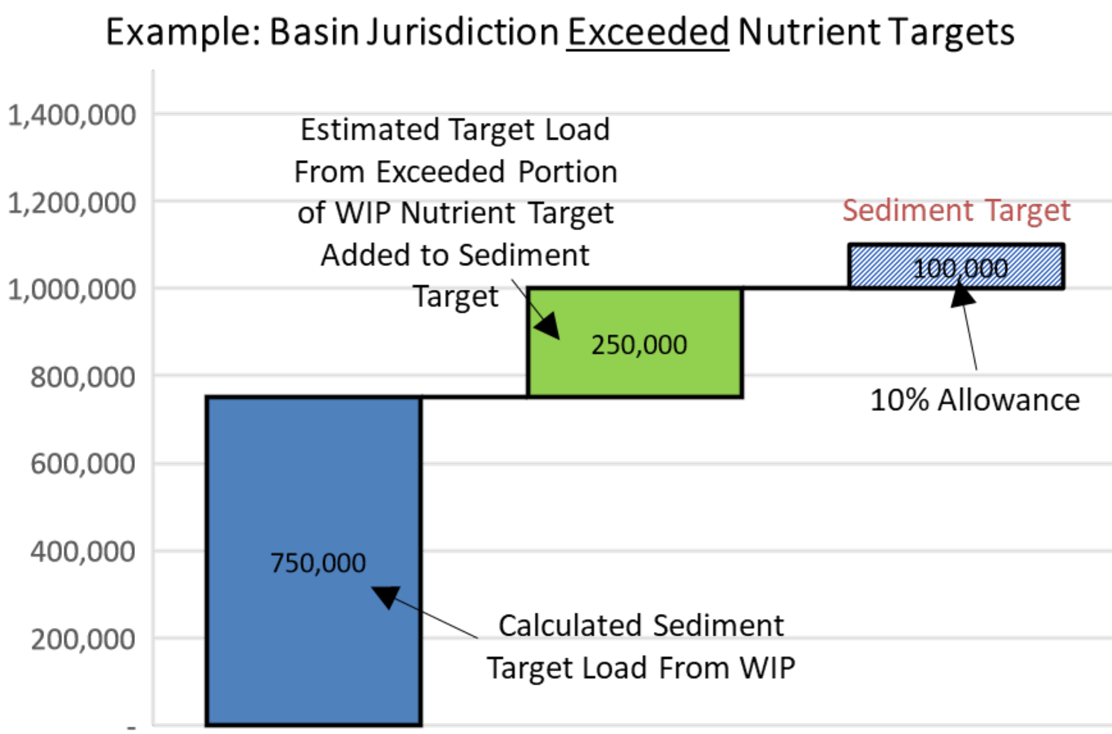

Figure 12-4: Example of sediment target for overachieving WIP

12.4.6 Final Phase III WIP Planning Targets

Final nutrient planning targets with and without exchanges are shown in Table 12-7 along with final sediment planning targets which are only available after exchanges.

Table 12-7: Final planning targets after exchanges and sediment in million pounds per year

Geography			2018 Planning Targets approved by PSC		2019 Planning Targets with Exchanges and Sediment		
Major	State	StateBasin	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Sediment
Potomac	DC	DC Potomac	2.42	0.130	2.42	0.130	41.9
Eastern Shore	DE	DE Eastern Shore	4.55	0.108	4.55	0.108	26.7
Eastern Shore	MD	MD Eastern Shore	15.21	1.286	15.60	1.290	2903.4
Patuxent	MD	MD Patuxent	3.21	0.301	3.21	0.300	437.7
Potomac	MD	MD Potomac	15.30	1.092	15.80	1.090	1928.0
Susquehanna	MD	MD Susquehanna	1.18	0.053	1.60	0.050	113.8
Western Shore	MD	MD Western Shore	10.89	0.948	9.63	0.950	2959.9
Susquehanna	NY	NY Susquehanna	11.53	0.587	11.53	0.587	532.7
Eastern Shore	PA	PA Eastern Shore	0.45	0.025	0.46	0.022	27.4
Potomac	PA	PA Potomac	6.11	0.357	6.14	0.338	295.5
Susquehanna	PA	PA Susquehanna	66.59	2.661	66.87	2.544	1838.2
Western Shore	PA	PA Western Shore	0.02	0.001	0.02	0.001	0.3
Eastern Shore	VA	VA Eastern Shore	1.43	0.164	1.83	0.152	473.3
James	VA	VA James	25.92	2.731	21.81	2.241	2015.2
Potomac	VA	VA Potomac	16.00	1.892	16.51	1.823	1929.7
Rappahannock	VA	VA Rappahannock	6.85	0.849	7.09	0.819	1505.1
York	VA	VA York	5.52	0.556	5.71	0.548	949.1
James	WV	WV James	0.04	0.005	0.05	0.006	13.0
Potomac	WV	WV Potomac	8.18	0.427	8.18	0.427	595.9