UNCERTAINTY RELATED TO NUTRIENT OFFSETS AND TRADING IN THE CHESAPEAKE BAY WATERSHED—SUMMARY OF TERMINOLOGY AND DEFINITIONS IN POLICIES AND REGULATIONS

INTRODUCTION

The purpose of this document is to catalogue the terms and definitions of the multiple types of safeguard mechanisms that are used in nutrient trading policies, regulations, and programs of jurisdictions, agencies, and non-governmental organizations within the Chesapeake Bay watershed. Although generally similar in content, these terms and definitions vary across jurisdictions with potential consequences for the implementation of nutrient trading programs.

Safeguards generally take the form of ratios that are applied to credits. These ratios specify how many units of emissions of one type or location may be exchanged for units of another type or location. Generally, the various types of ratios may be categorized by the purpose of the ratio. There are four major purposes for such ratios:

1. **Attenuation**—accounts for spatial differences between the credit generator and buyer
2. **Pollutant—**accounts for various exchanges between forms of nitrogen and phosphorus or between nitrogen and phosphorus
3. **Water quality improvement**—sets aside a portion of credits for improving water quality
4. **Uncertainty**—accounts for variability or the unknown in credit generation

The first section of this document lists the types of ratios that serve each of these purposes. The second section lists the various safeguards in each jurisdiction's trading program and the purpose of the safeguard, where the state has indicated the intention of the safeguard.

TYPES OF RATIOS OR SAFEGUARDS

The terms and definitions discussed herein are taken from existing policies, guidelines, and other documents published by federal and state agencies and non-governmental organizations. Terms and definitions are provided verbatim from existing documents. They are generally presented in the sequence of federal agencies, non-governmental organizations, and state agencies. Table 1 provides a summary of the ratios and sources of the terms.

Table 1: Ratios names, purposes, and references

Purpose of Ratio	Name of ratio	Reference
Attenuation	Location ratio	EPA Toolkit Glossary, 2009
	Delivery ratio	EPA Toolkit, 2009; CBP Trading Fundamentals and Guidelines, 2001; WRI, 2011; WV Nutrient Credit Program; PA Trading Policy and Guidelines, December 2006; MD Trading Policy, 2008
	In-stream delivery factor	Maryland Nutrient Cap Management Phase II-A, April 2008
	Trading ratio (MD, WV)	MD Trading Policy, 2008; West Virginia Nutrient Trading Program
	Edge-of-stream ratio	WRI, 2011; PA Trading Policy and Guidelines, December 2006; Maryland Nutrient Cap Management Phase II-A; 2008
	Equivalency ratio	EPA Toolkit Glossary, 2009
Pollutant	Retirement ratio	EPA Toolkit Glossary, 2009; CBP Trading Fundamentals and Guidelines, 2001; WRI, 2011; Maryland Trading Policy, 2008
Water quality improvement	Special needs (concerns) ratio	CBP Trading Fundamentals and Guidelines, 2001; West Virginia Nutrient Trading Program
	Water quality ratio	CBP Trading Fundamentals and Guidelines, 2001
	Trading ratio (MD and WV)	MD Trading Policy, 2008; West Virginia Nutrient Trading Program
	Reserve ratio	WRI, 2011; PA Trading Policy and Guidelines, December 2006; West Virginia Nutrient Trading Program
Uncertainty	Trading ratio	CBP Trading Fundamentals and Guidelines, 2001; Maryland Trading Policy, 2008; Virginia Trading Guidance; West Virginia Nutrient Credit Program
	Uncertainty ratio	EPA Toolkit Glossary, 2009; CBP Trading Fundamentals and Guidelines, 2001; WRI, 2011; Maryland Trading Policy, 2008; West Virginia Nutrient Credit Program

ATTENUATION RATIOS

Some ratios are used to adjust the load between the buyer and the seller based on the relative position of each. Landscape features and in-stream processes vary throughout the Chesapeake Bay Watershed. Models provide factors that make adjustments to loads based on these factors. The various types of attenuation adjustment ratios

are: location ratio, delivery ratio, in-stream delivery factor, trading ratio (as defined by Maryland and West Virginia), and edge-of-stream ratio. Each is discussed below except the trading ratio, which is defined in the Uncertainty section of this document.

LOCATION RATIO

This is a generalized term defined by EPA and is very close to the delivery ratio definition, also found in the EPA Toolkit Glossary, June 2009.

- (EPA Toolkit Glossary, June 2009) Factor applied to pollutant reduction credits when sources are upstream of a waterbody of concern that accounts for the distance and unique watershed features between a pollutant source and the downstream waterbody (e.g., bay, estuary, lake, reservoir) or area of interest (e.g., a hypoxic zone in a waterbody).

DELIVERY RATIO

The delivery ratio accounts for the in-stream processes that attenuate nutrients. The purpose of delivery ratios is to normalize a load based on delivery to one of the 92 tidal segments in the Chesapeake Bay. This is stated in the definitions that follow, each of which is from policies and guidance for Maryland, West Virginia, and Pennsylvania's trading programs.

The value used for the ratio comes from the Chesapeake Bay Program's Watershed Model, and the term used in the Model is "delivery factor". This is defined for the Chesapeake Bay Program's Watershed Model as:

Delivery factors are the fraction of the load input to the locally-simulated river that reaches tidal waters. Transport factors are the total outputs of a given simulated river reach divided by the total inputs to that reach. Delivery factors are calculated by multiplying transport factors for each successive simulated reach from a local segment downstream to tidal waters.[1]

The 2010 Chesapeake Bay TMDL defines the Chesapeake Bay segments as:

Segmentation is the compartmentalization of the estuary into subunits on the basis of selection criteria (USEPA 2008a). Generally, segments reflect certain unique physical, chemical or biological characteristics of a portion of a waterbody (e.g., salinity, influence of pollutant sources, etc.).[2]

In trading, the delivery factors are used to account for the location of the buyer and seller. For example, the delivery factor for a nutrient credit *seller* is 80 percent, meaning that only 80 percent of nutrients discharged reach the Chesapeake Bay segment. Assume that a credit *buyer* is close to the Chesapeake Bay segment and the *buyer's* delivery factor is 100 percent, so all of the nutrients discharged at the *buyer's* location reach the Chesapeake Bay segment. For a trade to be equitable, the delivery factors must be taken into account. This is done by requiring

[1] G. Shenk, US EPA-Chesapeake Bay Program Integrated Analysis Coordinator, Personal communication, 11/5/2012.

[2] http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/FinalBayTMDL/CBayFinalTMDLExecSumSection1through3_final.pdf; December 29, 2010.

that the seller produce the same number of credits that reach the buyer. In this example, the seller must produce 120 credits for the buyer to purchase 100 credits.

- (EPA Toolkit Glossary, June 2009) Factor applied to pollutant reduction credits when sources are directly discharging to a waterbody of concern that accounts for the distance and unique watershed features (e.g., hydrologic conditions) that will affect pollutant fate and transport between trading partners.
- (CBP Trading Fundamentals and Guidelines, March 2001) Delivery ratios apply discount factors to compensate for a pollutant's travel over land or in water (or both) and may be applied to point, as well as, nonpoint sources. Delivery ratios generally account for attenuation (i.e., the rate at which nutrients are reduced through natural processes, such as hydrolysis, oxidation, and biodegradation, on their way through tributaries to the mainstem of the water body). The ratio varies depending on the location of the source from the mainstem. The general idea is that the greater the distance the pollutant has to travel, the greater the pollutant loss will be. This ratio would work to equalize a trade between a source high in the tributary and one near the mainstem. This ratio is also often termed a "location ratio."
- (WRI, May 2011) Percent of a pollutant that is naturally removed in transport from the edge of a Chesapeake Bay Watershed Model (CBWM) segment to its tidal waters.
- (West Virginia Nutrient Credit Program) The factor that compensates for the natural attenuation or loss of nutrients as they travel in water.
- (PA Trading Policy and Guidelines, December 2006) Delivery Ratios apply discount factors to compensate for a pollutant's travel over land or in water (or both) and may be applied to point, as well as, nonpoint sources. Delivery ratios generally account for attenuation (i.e., the rate at which nutrients are reduced through natural processes, such as hydrolysis, oxidation, and biodegradation, on their way through tributaries to the mainstem of the water body). The ratio varies depending on the location of the source from the mainstem. Generally, the greater the distance the pollutant has to travel, the greater the pollutant loss will be. This ratio would work to equalize a trade between a source in the headwaters and one near the mainstem. This ratio is also often termed a "location ratio." Delivery ratios will be based on information from applicable and accepted data sources, such as the Chesapeake Bay Watershed Model.
- (Maryland Trading Policy, April 2008) Delivery Ratios apply discount factors to compensate for a pollutant's travel over land or in water (or both) and may be applied to point, as well as, nonpoint sources. Delivery ratios generally account for attenuation (i.e., the rate at which nutrients are reduced through natural processes, such as hydrolysis, oxidation, and biodegradation, on their way through tributaries to the mainstem of the water body). The ratio varies depending on the location of the source from the mainstem. Generally, the greater the distance the pollutant has to travel, the greater the pollutant loss will be. This ratio would work to equalize a trade between a source in the headwaters and one near the mainstem. This ratio is also often termed as "location ratio." Delivery ratios will be based on information from applicable and accepted data sources, such as the Chesapeake Bay Watershed Model.

IN-STREAM DELIVERY FACTOR

While this factor has a different name than the delivery ratio, the definition indicates that it is the same as the delivery ratio.

- (Maryland Nutrient Cap Management Phase II-A, April 2008) The In-Stream Delivery Factor is a function of the distance from the edge of the watershed segment and the fall line of the Chesapeake Bay. This represents the pollutant effect of the nutrient reductions between upstream and downstream points. The delivery factor is derived from the Chesapeake Bay Watershed Model.

EDGE-OF-SEGMENT RATIO

The edge-of-segment ratio is a coefficient applied to the nutrients remaining on the land after best management practices (BMPs) reductions are calculated, but before in-stream processes are accounted for. This Watershed Model factor is applied to other models for calculating credits. The edge-of-segment ratio is generally called the edge-of-stream factor in the Chesapeake Bay program's Watershed Model.

- (WRI, May 2011) percent of each pound of pollutant that is naturally removed in transport from the geographic point where it is discharged to the boundary of a CBWM segment.
- (PA Trading Policy and Guidelines, December 2006) A ratio that identifies the amount of a pollutant expected to reach the surface waters at the boundary of a Chesapeake Bay Watershed Model segment through surface runoff and groundwater flows from a pollutant source within a watershed segment.
- (Maryland Nutrient Cap Management Phase II-A, April 2008) Edge of Segment Delivery Factor is the amount of land-applied nutrients expected to reach the surface waters at the boundary of the Chesapeake Bay Watershed Model segment through surface runoff, groundwater flows, and atmospheric deposition. The EOS factor is derived from the Chesapeake Bay Watershed Model.

POLLUTANTS

One source provided a ratio for trading between nitrogen and phosphorus.

EQUIVALENCY RATIO

- (EPA Toolkit Glossary June 2009) Factor applied to pollutant reduction credits to adjust for trading different pollutants or different forms of the same pollutant.

WATER QUALITY IMPROVEMENT

Water quality improvement ratios provide a set-aside of credits to ensure or accelerate water quality improvement. These set-aside credits are not to be used for any reason. They serve as a guarantee that a trade does not simply shift the load between the seller and the buyer, but rather results in an overall decrease in pollutants. It should be noted that in the context of the Chesapeake Bay TMDL, a seller must meet pollution reduction requirements associated with the TMDL allocations to be eligible to trade. These requirements are already ensuring water quality improvements. Therefore, accelerating water quality improvements already is occurring before the trade is fulfilled.

The ratios that specify that the purpose is for water quality improvement include the retirement ratio, special needs or special concerns ratio, water quality ratio, and the trading ratio as defined by Maryland and West Virginia. WRI, EPA, and CBP define a trading ratio, but none of those sources specify the purpose as water quality improvement. Each of the water quality improvement ratio terms and definitions are discussed below except the trading ratio, which is defined in the Uncertainty Section.

RETIREMENT RATIO

- (EPA Toolkit Glossary, June 2009) Factor applied to pollutant reduction credits to accelerate water quality improvement. The ratio indicates the proportion of credits that must be purchased in addition to the

credits needed to meet regulatory obligations. These excess credits are taken out of circulation (retired) to accelerate water quality improvement.

- (CBP Trading Fundamentals and Guidelines, March 2001) A certain percentage of an available credit may be retired (i.e., excluded) from trading in order to increase the potential for a water quality benefit or to provide a margin of environmental safety (similar to an uncertainty ratio) for the overall trading program. Some programs require, for example, that 10% of the available credits for sale be taken off the market before any trades are negotiated. When evaluating the potential use of retirement ratios, it is important to also consider issues of cost, equity, and future economic growth. Options for retirement ratios include the following:
    - Requiring that a portion (e.g., 10%) of all credits traded by both point and nonpoint sources is contributed to the state. This is a fairly equitable approach, and, if the percentage is small, should not impose too onerous a cost on participants.
    - Requiring that BMP credits expire at the end of the rated life of the installation. This is a reasonable requirement; however, difficulties may arise in multiple BMPs installed over an extended period of time and in the case of BMPs functioning efficiently beyond their rated lifespans.
    - Requiring that all credits be retired at the end of 5 years. This is the approach taken in the Michigan program. It establishes a level playing field for all participants. In addition, the duration is sufficiently long enough for planning and assessment purposes.
    - State agencies, citizen groups, or environmental nonprofits may purchase credits with the express purpose of immediately retiring them. Such action may be warranted in locations or periods of worsening water quality. It is, however, a costly option for all concerned and, by removing credits from the market place, may serve to dampen the market for trading and may restrict growth.
    - Entities that cease to operate may be required to retire all or a portion of their credits. This policy may be pursued in areas in which growth is being discouraged for environmental reasons.
    - Credits may be retired as part of penalties imposed on entities that continue to violate their terms of trade for an extended period of time (e.g., over two years).
- (WRI, May 2011) A ratio that discounts each nutrient credit to ensure that a trade results in a net improvement in water quality.
- (Maryland Trading Policy, April 2008) Retirement Ratios are applied to implement policy-driven or programmatic decisions to require that buyers or sellers donate part of all credit purchases or sales to the state or some other entity that will not apply the credits to offset loadings above its cap. The [Maryland] Department will seek a five (5) percent retirement ratio for all point source to point source trades. The percent retirement ratio may be adjusted over time. (Nonpoint source trades have a 10% retirement ratio.)

SPECIAL NEEDS (CONCERNS) RATIO

The special needs or concerns ratio specifies that for specific bodies of water, credits for nutrient trades should be further depreciated because of concerns about the unique environmental issues in those bodies. The definitions of this ratio suggest that in cases where there is concern about a specific waterbody, state regulators have reason to believe that the overall scientific and technical framework for nutrient trades otherwise might not produce sufficient protection of local water quality. This ratio is termed special *needs* in the CBP Trading Guidelines and PA guidelines and special *concerns* in the West Virginia Nutrient Trading Program policy. The two terms refer to the same concept.

- (West Virginia Nutrient Trading Program) Additional ratios applied to credits generated in watersheds of impaired streams (303d-listed) and otherwise as the (West Virginia) Department deems necessary in areas of special water quality concern.
- (PA Trading Policy and Guidelines, December 2006) Special Needs Ratios would account for issues not addressed in other trading ratios; for example, sensitive waters or areas needing additional protection. Special needs ratios will be developed and utilized on an as-needed basis.
- (CBP Trading Fundamentals and Guidelines, March 2001) See "Water Quality Ratios".

WATER QUALITY RATIO

The Chesapeake Bay Program (CBP)'s 2001 trading guidelines define this ratio as protecting against location differences and special concerns related to particularly sensitive areas.

- (CBP Trading Fundamentals and Guidelines, March 2001) Water quality ratios may be included to account for the effect a source has on local water quality, or to relate the relative impact of pollutant reductions in any given watershed segment (e.g., tributary) to mainstem water quality goals, such as indicators of dissolved oxygen and living resources. Water quality ratios would account for situations, including nonattainment areas or sensitive areas such as wetlands, lakes, or wildlife sanctuaries that may require additional water quality considerations. The increase in loads in such areas could have a greater impact than in less sensitive areas. In such cases, sources could have their reductions discounted by a factor (e.g., 10%) to achieve greater water quality protection. The water quality ratio and the delivery ratio are similar in that both involve location, but a delivery ratio addresses attenuation and considers source location relative to the distance from the water body of concern. A water quality ratio addresses location relative to special conditions in the receiving water; if needed, it may exist in addition to delivery ratios.

UNCERTAINTY

Three ratios — reserve ratios, trading ratios, and uncertainty ratios — are used to compensate for uncertainty. This uncertainty can be related, in part, to scientific issues such as lack of information or variability in scientific literature, abnormal weather, or geographic variability.

Additionally, uncertainty around the number of credits that should be created from any given practice is an important consideration. While this uncertainty partly is taken into account in the establishment of the BMP effectiveness values, the uncertainty ratios also provide a buffer against this uncertainty. The uncertainty ratios generally are to be applied to credits sold by nonpoint sources. There is no explicit information of the reliability of the pollution reduction resulting from a nonpoint source. This is because monitoring does not occur for every nonpoint source and modeling provides information on relative differences in loads rather than actual loads.

These ratios also can provide insurance against failed credit generation. In this case, the credits above what buyers need are placed into a credit pool that may be accessed instances of failed credit generation. An example of failed credit generation is when a practice such as cover crops is used to reduce nutrient and sediment loads, but the cover crop fails to get established due to lack of rain. In this example, the credits were not actually produced, even where they may be under contract.

RESERVE RATIO

Reserve ratios are credits set-aside for uncertainty related to credit production failure, among other purposes.

- (WRI, May 2011) Percent of each nutrient credit allocated into a credit insurance pool.
- (PA Trading Policy and Guidelines, December 2006) A 10% ratio that is applied to the pollutant reductions generated, which establishes the credits to be set aside for the Department's credit reserve.
- (West Virginia Nutrient Credit Program) The proportion of the credits generated by a nutrient reduction set aside in the credit reserve for the purposes of insurance against risk of nutrient reduction project failure for natural or unexpected causes.

TRADING RATIOS

Trading ratios are credits set-aside for multiple types of uncertainty.

- (CBP Trading Fundamentals and Guidelines, March 2001) To account for the uncertainty regarding the effectiveness and monitoring of nonpoint source controls, trading ratios are applied in the cases in which nonpoint sources are involved. For example, a trading ratio of 2:1 means that for every pound increase in pollutant traded by a point source, there must be a corresponding two-pound trade from a nonpoint source.
- (Maryland Trading Policy, April 2008) Discount factors applied to pollutant reductions to account for uncertainty, water quality, delivery or special need concerns.
- (Virginia Trading Guidance) Two pounds of nonpoint load reductions, of either total nitrogen or total phosphorus, to be acquired by a point source, to offset one pound to be discharged.
- (West Virginia Nutrient Credit Program) Discount factors applied to nutrient reductions, to account for uncertainty, delivery, credit reserve or special need concerns.

UNCERTAINTY RATIOS

Uncertainty ratios are named to specify the purpose as uncertainty. The types of uncertainty addressed are broadly defined in the definitions below.

- (EPA Toolkit Glossary, June 2009) Factor applied to pollutant reduction credits generated by nonpoint sources that accounts for lack of information and risk associated with BMP measurement, implementation and performance.
- (CBP Trading Fundamentals and Guidelines, March 2001) Point source nutrient discharges are relatively constant and easily quantified. By contrast, nonpoint source nutrient discharges are more uncertain and are readily influenced by storm events, seasonal variations, and site-specific physical and chemical characteristics. In addition, the BMPs applied to nonpoint sources generally provide a reduction potential that is an estimate rather than a measured value … To accommodate for this range of potential efficiencies, most trading programs attempt to address nonpoint reduction uncertainties by assigning a rate greater than 1:1 (i.e., requiring that more than one nonpoint credit be traded for one point source credit).
- (WRI, May 2011) Trading ratios that account for the variability in nutrient removal efficiencies for agricultural BMPs. May be based on scientific uncertainty or random weather fluctuations.

- (Maryland Trading Policy, April 2008) Uncertainty Ratios are intended to account for variation in the expected reliability and efficiency of the source or type of reduction being applied toward credit for another. They are calibrated to create a margin of safety or otherwise attempt to ensure that the credited practice provides a minimum level or reductions, even if actual reduction efficiencies and units removed are on the low end of an expected range. In some instances uncertainty ratios will not be employed because they are already accounted for in quantification methods. Trades involving nonpoint sources may use uncertainty ratios of greater than 1:1.
- (West Virginia Nutrient Credit Program) Ratio applied to point-to-nonpoint trades to account for uncertainty in modeling and BMP performance.

UNCERTAINTY PROVISIONS BY JURISDICTION

All jurisdictional nutrient credit trading programs in the Chesapeake Bay watershed include a mechanism to address spatial differences between the buyer and the seller. The jurisdictions with trading programs are all using the Chesapeake Bay Program's Watershed Model delivery factors and/or edge-of-segment factor to account for attenuation. In this section, the focus is on the methods each jurisdiction uses to address water quality improvement and uncertainty (Table 2). Safeguards take the form of a trading ratio (Virginia), reserve ratio (Pennsylvania and West Virginia), retirement ratio (Maryland), and an uncertainty ratio applied to specific BMPs (Maryland and West Virginia). Virginia also has a fund of credits that appear to serve as water quality improvement.

The purpose of the uncertainty ratio is in part to address the variability in effectiveness of BMPs. The nutrient reductions for BMPs are applied with little variation in effectiveness values. That means that differences in soils, distance to a waterbody, or slope are not explicitly taken into account in the effectiveness value. There are some BMPs that vary according to the landscape, such as cover crops and a few other BMPs. These vary only according to land use and hydrogeomorphic regions (HGMRs).

The Chesapeake Bay Program Phase 5.3.0 Watershed Model documentation iterates the reasons that the BMP effectiveness values include uncertainty.

Uncertainty in estimates of bmp effectiveness is due to factors including (1) variability in precipitation, hydrology, soils, and geology; (2) variable performance of land management practices; (3) lag time between implementing a practice and full performance and observed water quality benefits; and (4) the effects of cover, slope, and other intrinsic factors on pollutant load delivery to receiving waters. To more realistically estimate operational pollutant removals from BMPs, one must examine the factors and then use them to adjust efficiencies estimated from research plots accordingly.[3]

The BMP effectiveness values are widely accepted in the Chesapeake Bay watershed and have a long history of use in the Chesapeake Bay Program's Watershed Model. The uncertainty ratio is applied for some BMPs for which no fixed reduction has been approved by the Chesapeake Bay Program.

[3] Chesapeake Bay Phase 5.3 Community Watershed Model, Section 6-1. *Best Management Practices for Nutrients and Sediment*, p.6-4. ftp://ftp.chesapeakebay.net/Modeling/P5Documentation/SECTION_6.pdf, last accessed 11/4/2012.

Table 2: Safeguards in use in existing state trading programs. The numerical value is specified for nonpoint sources where it was in the policy. If it was solely defined, it is indicated by an "X".

State Program	Reserve Ratio	Retirement Ratio	Trading Ratio	Uncertainty Ratio (for specified practices only)	Reserve Fund
Maryland		10%	X	≥20% (for specified practices only)	
Pennsylvania	10%				
West Virginia	20%		X	≥20% (for specified practices only)	
Virginia			2:1	X	Water Quality Improvement Fund

MARYLAND

Maryland's program includes a retirement ratio of five percent for point sources and 10 percent for nonpoint sources. This means that for a farmer, or other nonpoint source, to sell 100 credits, they must produce 110 credits. The program also includes an additional factor to guarantee water quality improvement for those credits generated by BMPs not yet approved by the Chesapeake Bay Program. For unapproved BMPs, credits are discounted by at least 20 percent.

PENNSYLVANIA

Pennsylvania established a reserve ratio that sets aside 10 percent of all credits. Additional safeguards are built into the reduction credit calculations by taking a conservative approach to the factors used in the calculations. Pennsylvania also places a cap on the number of credits that may be sold overall. This cap is termed the "tradable load."

WEST VIRGINIA

West Virginia established a reserve ratio of 10 percent for point and nonpoint sources including municipal separate storm sewer systems (MS4s) and septic hookups. Like Maryland, the program includes an uncertainty ratio for credits generated by BMPs not approved by the Chesapeake Bay Program. The uncertainty ratio for those BMPs is at least 20 percent.

VIRGINIA

Virginia's program includes an uncertainty factor of a 2:1 ratio for nonpoint source generated credits. This means that to sell 100 credits, 200 must be created. In addition, some permittees may be required to pay into a Water Quality Improvement Fund. Credits from this fund may be used as a safeguard for point sources that are unable to acquire credits elsewhere.

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