Date: September 15, 2020

From: David Wood and Tom Schueler

To: Members, Urban Stormwater Work Group

Re: Cleanup of Removal Rate Crediting for Impervious Cover Disconnection (ICD) and Removal (ICR) BMPs in the Watershed Model

Problem: Over the past 15 years, the urban sector has come up with at least seven different schemes for crediting practices that either remove or disconnect impervious cover in the urban landscape, which has confused states and MS4s, and practically everybody else, as well.

So far, Bay states have not reported many acres of either ICR or ICD in the most recent progress runs for the Chesapeake Bay TMDL. As of 2019, only 824 acres of both kinds of practices were cumulatively reported for credit across the entire Bay watershed (see Table 3 in Appendix A).

A simple, single, unified approach for this class of projects is needed that can be reported and verified by all parties, and which accounts for the hydrologic response of the urban soils that exist after the site is re-developed or otherwise restored.

Summary of Recommendations: Following review of the different practices that credit impervious cover removal and disconnection, this memo recommends:

1. Establishing a new BMP pollutant removal efficiency for ICR to replace the land-use change crediting mechanism.
2. A clear distinction between ICR and ICD practices based on the pollutant load being treated by the practice, as well as guidelines for how and when to report each practice (and other Chesapeake Bay BMPs when appropriate).
3. An update to CAST to ensure ICR and ICD are properly reported.

Background on the Practices: The best way to compare these practices is to describe when and how they occur in the urban land development cycle. Impervious cover can either be physically removed (ICR) or simply disconnected so that some portion of the runoff filters or infiltrates into adjacent pervious soils (ICD). More specifically:

> ***ICR:*** This practice occurs in the land development cycle as: Soil -> Compacted Soil -> Impervious Cover –> Removal -> De-compaction + Amendments => Restored Soil. The degree of runoff reduction achieved depends on the degree to which existing soils are de-compacted or amended to restore their pre-construction hydrologic response. In its most simple formulation, ICR is simply handled as a change in load due to the shift from impervious to pervious land cover.

***ICD*:** This occurs when a given area of impervious cover is disconnected, such that runoff is directed to pervious areas w/ either (a) undisturbed soils, (b) compacted urban soils (c) de-compacted urban soils or (d) de-compacted and amended soils. The disconnection may also require a minimum distance or area over the pervious area which receives the runoff.

However, each of these practices may be categorized as a different Chesapeake Bay Program-approved BMP depending on the design, soil conditions and the position in the landscape. For example, ICD may be reported as a retrofit, performance standard, ICD, or urban filter strip.

Review of Past Efforts to Credit ICD and/or ICR

Phase 1: Category G Practices (2006-2008): The USWG produced general estimates for a wide range of urban BMPs to support local and state planning for the tributary strategies which were a non-regulatory precursor to the Chesapeake Bay TMDL. A category was created for a grab bag of assorted practices for which a BMP removal rate could not be assigned (at the time, circa 2005) due to a lack of research monitoring data. (CBP, 2006). The category included both engineering, site design and land conservation practices[1], as shown below**.**

Category G: Impervious Surface Reduction	Using a BMP to reduce the total area impervious area and therefore encouraging stormwater infiltration.
Natural area conservation	Maintaining areas such as forests, grasslands and meadows that encourage stormwater infiltration.
Disconnection of rooftop runoff	Disconnecting the rooftop drainage pipe and allowing it to infiltrate into the pervious surface thereby reducing the impervious area.
Disconnection of non-rooftop impervious area	Directing sheet flow from impervious surfaces, i.e. driveways and sidewalks, to pervious surfaces instead of stormwater drains.
Rain Barrels	Rain barrels retain a predetermined volume of rooftop runoff (Prince George's LID).
Green Roofs	A multi-layer construction material consisting of a vegetative layer that effectively reduces urban stormwater runoff by reducing the percentage of impervious surfaces in urban areas. (US EPA LID Fact Sheet)

The pollutant reduction credit for Category G practices was simple—site loadings were based on the shift from the higher nutrient loads associated with impervious cover to the lower ones simulated for pervious cover by the CB watershed model used at the time (version 4).

Phase 2 The Table B-4 Era: (2008- 2011): The evolution of stormwater crediting is explored in detail of Appendix B of SPS EPR (2012). Starting from around 2008, the CBP (2006) removal rates were superseded by those in "Table B-4," which were derived from an extensive review of performance of runoff reduction practices, that include rooftop disconnection, filter strips, green roofs and rain tanks (see Table 2 below).

Table 2 Excerpts from "Table B-4" Nutrient Removal Rates for Stormwater BMPs			
Practice	**Design Level[1]**	**TN Load Removal[4]**	**TP Load Removal**
Rooftop Disconnect	*1*	*25 to 50*	*25 to 50*
	2	*50*	*50*
Filter Strips	*1*	*25 to 50*	*25 to 50*
	2	*50 to 75*	*50 to 75*
Green Roof	*1*	*45*	*45*
	2	*60*	*60*
Rain Tanks & Cisterns	*1*	*15 to 60*	*15 to 60*
	2	*45 to 90*	*45 to 90*
Notes – See Full Table B-4 in Appendix B of SPS EPR (2012) for the complete footnotes			

The primary technical resource for these revised rates was CWP and CSN (2008), which contained an extensive research review of removal rates for runoff reduction practices that were tied to a two-level BMP design approach featured in numerous Bay state stormwater design manuals proposed and adopted during this period (e.g., VA, WV, DC and DE). Since this stormwater design era preceded the Bay TMDL, however, they were only approved by individual states, and never officially approved by the entire Bay partnership (but were cited in Simpson and Weammert, 2009).

Phase 3: State Stormwater Performance Standards EPR (2012-15): A full-blown expert panel was convened in 2011 to provide consistency for all the stormwater BMPs contained (or proposed) in state stormwater design manuals of this era (SPS EPR, 2012). The report developed a series of adjustor curves to define the unique removal rate for runoff reduction practices, based on the actual runoff volume from the IC treated by stormwater practices at the site (Table 3). The EPR report also explicitly provided for two levels of design for several types of ICD:

- IC disconnection to amended or un-amended soils (using the RR curves)
- Urban filter strips and sheet flow to open space

VA was the only state at the time w/ detailed specs supporting the two-level design approach for these ICD practices, although several other state stormwater manuals subsequently adopted it.

In practice, however, the BMP design spreadsheets of this era tended to treat ICD as a "deduction" from the total site treatment volume, prior to the design of any structural BMPs. Consequently, the credit was seldom reported to the CBP even though it was widely used in many states to sharply reduce the total stormwater

volume requiring treatment by engineered practices at individual new development sites.

Table 3 Classification of Runoff Reduction BMPs in SPS EPR *(adapted from SPS EPR, 2012)*
Accepted Non-Structural Runoff Reduction (RR) Practices
Landscape Restoration/Reforestation
Riparian Buffer Restoration
Rooftop Disconnection (aka Simple Disconnection to Amended Soils, to a Conservation Area, to a Pervious Area, Non-Rooftop Disconnection)
Sheetflow to Filter/Open Space* (aka Sheetflow to Conservation Area, Vegetated Filter Strip)
Non-Structural BMPs, PA 2006 BMP Manual, Chapter 5

Phase 4: ICD and Urban Filter Strips EPRs (~2015 -> ?): For reasons lost to bureaucratic time, a new expert panel was formed in 2014 to specifically credit a range of impervious cover disconnection practices (ICD EPR, 2016), shortly after another very similar one was approved by the CBP for urban filter strips (UFS EP, 2014).

The impervious cover disconnection EPR was facilitated by CWP and VA Tech and contained an extensive literature review on the available scientific research. The EPR built on the prior work of the state stormwater performance standards panel (SPS EPR, 2012) and applied their runoff reduction curves to credit disconnections to HSG C and D amended soils.

The EPR concurred w/ the rates for disconnections to A and B amended soil that the UFS (2014) had recommended. In addition, MDE insisted on a special curve number protocol for disconnections that would apply only to MD sites (see Appendix G of ICD EPR, 2016).

Despite all the work put into these panels, however, Bay states have rarely calculated or reported any credits for the various ICD methods proposed by these two expert panels in the last 5 years.

Phase 5: Enhancing BMP Performance w/ Soil Media (2016-2018): The USWG sponsored a research synthesis to see if the performance of urban soils or LID media could be improved by adding amendments such as biochar, alum, iron and water treatment residuals. Hirschman (2016) conducted a thorough research review on how nutrient removal can be enhanced for soil amendments and bioretention media. The final memo outlined an approach for revising the RR and ST adjustor curves to reflect the higher nutrient removal associated with these “PEDs”.

To this point, the PED recommendations have yet to be incorporated into any Bay-wide or state credits, but could easily be integrated into the existing crediting framework for ICR and ICD projects that use soil amendments as part of a treatment train.

Phase 6: ICR Punted to LUWG (~2010 to present): ICR was acknowledged to be a theoretical retrofit application during this era, especially for ultra-urban areas, but was considered to be too expensive and uncommon to have wide-spread application across the Bay watershed. The USWG adroitly punted it over to the Land Use Work Group, where it was subsequently forgotten.

The un-written agreement with the modelers was that ICR should be credited as a simple land use change --- from impervious to pervious cover. This approach to crediting ICR has persisted over the last decade, although the unit area loading rates from both impervious and pervious cover has changed significantly with each subsequent edition of the CB watershed model (e.g., Phase 4 to Phase 6).

Phase 7: ICR Based on Measured Changes in Watershed Land Cover (2018 to present): One of the key enhancements of the Phase 6 watershed model was a vast improvement in the precision and resolution of land cover data used in the Phase 6 watershed model. The new 2013/14 land cover data was mapped at the 1-meter resolution for the entire Bay watershed (Chesapeake Conservancy, 2019).

These high-resolution data will be updated for the 2017/18 and 2021/22 periods. The LUWG raised the prospect that the improved multi-year IC data could be used to measure changes in ICR, and possibly even remotely verify individual practices. This approach will be evaluated in 2020 and 2021 by the Land Use Workgroup. In addition, the Phase 6 model also produced updated loading rates for both pervious and impervious cover that vary regionally (CBP, 2018).

The improved resolution in pervious cover was not helpful, however, in measuring the effect of ICD, as both the current model and land cover data cannot infer the degree of soil compaction for urban pervious areas, and the associated hydrological response.

Recommendations for going forward:

Establish a single ICR efficiency BMP that is clearly differentiated from ICD for tracking and reporting purposes. This section is intended to clarify the differences between ICR and other existing BMPs. Guidance on qualifying conditions, pollutant removal efficiencies, and tracking and reporting requirements for existing practices can be found in their respective Expert Panel Reports and approval memos.

Clarifying the Difference Between ICR and ICD:

The best way to think about the difference between the ICR and ICD BMPs is that ICD treats runoff received from an adjacent impervious area. It is credited based on the acres or runoff volume treated. In contrast, ICR reduces the pollutant loading rate generated on an area of land. It is credited based on the actual area that is converted.

Definitions:

Impervious Cover Removal: Replacing impervious surfaces with pervious surfaces that have been de-compacted and amended to promote infiltration.

Impervious Cover Disconnection: Disconnecting existing impervious area runoff from stormwater drainage systems, such as directing rooftops and/or on-lot impervious surfaces to pervious areas.

Qualifying Conditions for ICR[1]

ICR:

1. New pervious surface should be de-compacted and amended over a minimum depth of 3 inches[2] to promote infiltration and reduce runoff.
2. New pervious surface should be maintained in a turfgrass or meadow condition[3]. The area should not be fertilized and should generally not be converted into a high traffic area prone to compaction, such as an athletic field.
3. Area should be under 0.5 acre in size. Larger areas will be picked up by CBPO high resolution land use imagery, scheduled to be updated every 5 years.

When and How to Report ICR and ICD:

Impervious Cover Removal: Should be reported when an area of impervious cover is physically removed and the site is converted to de-compacted turfgrass cover or meadow (that otherwise does not qualify for the Conservation Landscaping BMP). If runoff from an adjacent impervious area is redirected to the ICR project, ICD and ICR can be additive.

Impervious Cover Removal to Tree Canopy: Removal of impervious cover to create a new land use condition that meets the qualifying conditions of another CBPO-approved BMP should be reported as the other qualifying BMP. For

[1] Qualifying conditions, reduction efficiencies, and tracking and reporting requirements for ICD are available in the ICD EPR (2016): https://www.chesapeakebay.net/documents/Impervious_Disconnection_Expert_Panel_Report_WQGIT_approved_December_2016.pdf

[2] Consistent with the qualifying conditions for runoff reduction from the ICD expert panel report (2016).

[3] Tree plantings within the ICR area is also allowable, but the area covered by tree canopy should be reported as the Urban Tree Canopy Expansion BMP.

example, replacing impervious cover with tree canopy should be reported as urban tree canopy expansion, or urban forest planting.

Impervious Cover Disconnection: Exists as a BMP in CAST, but is a default efficiency reduction. Should only be used for planning purposes or be reported when runoff from an impervious surface is re-directed to a pervious surface with amended soils, but the treatment volume is unknown.

Urban Filter Strips: Should be reported when runoff from an impervious surface is re-directed to a pervious surface with existing Hydrologic Group A or B soils that do not require amendment because they already have moderate to high infiltration rates. Hydrologic Group C and D soils that are amended per the qualifying conditions of the ICD Expert Panel Report should be reported as a Stormwater Performance Standard.

ICD as a Stormwater Performance Standard: Impervious surface disconnection can be part of a "treatment-train" of other practices, or stand-alone. If it is a stand-alone practice where runoff from impervious cover is re-directed to an amended soil, and the runoff treatment volume is known, the practice should be reported as a Runoff Reduction (RR) practice using the Stormwater Performance Standards BMP Expert Panel Report. If the practice is part of a treatment train of other BMPs, the dominant practice should be reported along with the volume treated, total impervious acres treated, and total site acres, per the Stormwater Performance Standards BMP Expert Panel report.

Proposed Nutrient and Sediment Reductions for ICR

There is an existing ICR BMP in CAST that currently is calculated as a land-use change from impervious cover to turf grass. The land use change method complicates ICR reporting and isn't the most accurate way to simulate the pollutant removal benefits of the practice. To address the issue, the CAST team analyzed multiple ICR scenarios to propose a new, efficiency-based pollutant removal rate. The proposed reduction efficiencies are described in Table 4 and more information on the analysis methods can be found in Appendix B.

Table 4. Nutrient and Sediment Reductions for ICR[1]

	TN	TP	TSS
ICR	36%	0%	61%

[1]See Appendix B for detailed methodology.

Proposed ICR Technical Reporting Requirements:

- *Practice Name*: Impervious Cover Removal
- *Measurement Name:* Impervious Acres (Acres)

- *Location of the BMP:* Qualifying NEIEN Geographies, including Lat/Long, or County, or Hydrologic Unit Code (HUC12, HUC 10, HUC8, HUC6, HUC4), or State
- *Date of implementation:* Year practice was installed
- *Previous Land Uses*: Roads; Buildings and Other Impervious
- *Credit Duration*: 10 years

CAST Update to Fix ICD Reporting

Finally, during this review it was discovered that there is currently an error in CAST with regard to the ICD reporting requirements. While ICD should be reported as impervious cover area treated, CAST currently allows ICD to be reported on both pervious and impervious land uses. Making this fix will both improve the accuracy of the pollutant reductions reported, but will also help reduce the chance of accidental "double-counting" with ICR.

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UFS EP (Urban Filter Strip Expert Panel). 2014. Recommendations of the Expert Panel to Define Removal rates for Urban Filter Strips and Stream Buffer Upgrade Practices. Approved by Chesapeake Bay Partnership. Annapolis, MD.

Appendix A. Impervious Surface Reduction BMP Analysis Memo

memo

To:	David Wood
From:	Olivia Devereux and Jess Rigelman
CC:	Jeff Sweeney
Date:	7/9/2020
Re:	Impervious Surface Reduction BMP

Purpose

The purpose of this memo is to determine an alternative credit for the Impervious Surface Reduction BMP (ISR) and differentiate it from the Impervious Disconnection to Amended Soils BMP (ISD). The difference between the ISR and ISD is not clear to many CAST users. The definition and characteristics of the two BMPs is below. The BMP name is the same in NEIEN and CAST. There are no other NEIEN BMP names that map to either of these two CAST BMPs. Both are considered cumulative BMPs, which means the previous years' implementation amount is summed over time.

Impervious Disconnection to Amended Soils (ISD)

Efficiency (percent reduction): TN: 12.3; TP: 14.6; TSS: 15.6

Inspection frequency to receive model credit: 5 years

Definition: Disconnecting existing impervious area runoff from stormwater drainage systems, such as directing rooftops and/or on-lot impervious surfaces to pervious areas with amended soils. Report disconnect to un-amended soils as Urban Filter Strip. Measured in acres implemented.

Impervious Surface Reduction (ISR)

Land use change: Impervious land uses to pervious land uses

Inspection frequency to receive model credit: 10 years

Definition: Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Measured in acres implemented.

Methods

To propose an efficiency for ISR, we calculated the percent change with the existing land use change ISR BMP under multiple scenarios. We considered the following:

- Presence of other BMPs compared to ISR in isolation
- Different levels of implementation
- Geographic differences, by state

The BMPs in a scenario interact with each other, so we assessed the impact of the presence of BMPs from the most recent progress, which is July 1, 2018 to June 30, 2019, against a scenario with no BMPs, commonly called a No Action scenario. We also assessed the impact of different levels of implementation using varying percent of available impervious acres. Levels of 5%, 10%, 15%, 20%, and 25% of available impervious acres were considered.

All scenarios were run for the entire Chesapeake Bay Watershed using CAST-19. The difference in loads was determined by calculating the percent difference in the load between the scenario with ISR and the scenario without ISR and normalizing to the acres implemented using the formula below. All loads were compared at the edge-of-stream. Areas with combined stormwater and sewers were excluded.

> *((Pervious and Impervious Lbs without ISR) – (Pervious and Impervious Lbs with ISR)) / ISR Acres / Impervious Acre Lbs with ISR*

Results

The results show that an efficiency of 36% reduction for TN and 61% reduction for TSS would approximate the load reduction from ISR as it is currently modeled. There was no reduction for TP and the value is listed as zero. These efficiencies are averaged across the major jurisdictions. The actual amount for each jurisdiction is in the table below. Results vary among jurisdictions because geographical differences can impact the pollutant loads. Geographical differences in load reductions can be accommodated by different efficiencies for the same BMP, as is already done for other BMPs in CAST.

Table 1: Comparison of total nitrogen, phosphorus, and sediment efficiencies for each major jurisdiction.

Geography (CBWS Portion Only)	**TN Efficiency**	**TP Efficiency**	**TSS Efficiency**
Delaware	39%	0%	67%
District of Columbia	23%	0%	37%
Maryland	39%	0%	66%
New York	40%	0%	66%
Pennsylvania	37%	0%	62%
Virginia	37%	0%	65%
West Virginia	37%	0%	64%
Average	*36%*	0%	*61%*

These results were tested for differences between a scenario with and without other BMPs. There was no difference in the effect of ISR between the scenario with other BMPs and where ISR was implemented in isolation from any other BMPs, commonly named a "no action" scenario. These results also were tested for varying levels of implementation. The comparison of amount of implementation among 5%, 10%, 15%, 20%, and 25% show differences less than 1.

The derived efficiency for ISR ranks 16 out of 29 other BMPs that treat impervious area. This BMP is among the top half of efficiency BMPs. Table 2 shows the comparison of the average derived ISR efficiency among the other urban efficiency BMPs. There are other land use change BMPs and load reduction BMPs, like tree planting and dirt and gravel roads.

Table 2: Rank of derived ISR efficiency among other BMPs that treat impervious areas.

BMP	Avg Nitrogen Efficiency	Avg Phosphorus Efficiency	Avg Sediment Efficiency
Filter Strip Stormwater Treatment	0.00	0.00	22.00
Floating Treatment Wetland 10% Coverage of Pond	0.80	1.60	2.30
Floating Treatment Wetland 20% Coverage of Pond	1.70	3.30	4.70
Floating Treatment Wetland 30% Coverage of Pond	2.50	4.90	7.00
Floating Treatment Wetland 40% Coverage of Pond	3.30	6.50	9.20
Floating Treatment Wetland 50% Coverage of Pond	4.10	8.00	11.50
Dry Detention Ponds and Hydrodynamic Structures	5.00	10.00	10.00
Permeable Pavement w/o Sand, Veg. - C/D soils, underdrain	10.00	20.00	55.00
Vegetated Open Channels - C/D soils, no underdrain	10.00	10.00	50.00
Impervious Disconnection to amended soils	12.30	14.60	15.60
Dry Extended Detention Ponds	20.00	20.00	60.00
Filter Strip Runoff Reduction	20.00	54.00	56.00
Permeable Pavement w/ Sand, Veg. - C/D soils, underdrain	20.00	20.00	55.00
Wet Ponds and Wetlands	20.00	45.00	60.00
Bioretention/raingardens - C/D soils, underdrain	25.00	45.00	55.00
Impervious Surface Reduction	36.00	0.00	61.00
Conservation Landscaping Practices	39.00	25.00	0.00
Filtering Practices	40.00	60.00	80.00
Permeable Pavement w/o Sand, Veg. - A/B soils, underdrain	45.00	50.00	70.00
Vegetated Open Channels - A/B soils, no underdrain	45.00	45.00	70.00
Permeable Pavement w/ Sand, Veg. - A/B soils, underdrain	50.00	50.00	70.00
Bioretention/raingardens - A/B soils, underdrain	70.00	75.00	80.00
Bioswale	70.00	75.00	80.00
Permeable Pavement w/o Sand, Veg. - A/B soils, no underdrain	75.00	80.00	85.00
Bioretention/raingardens - A/B soils, no underdrain	80.00	85.00	90.00
Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain	80.00	85.00	95.00
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain	80.00	80.00	85.00
Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain	85.00	85.00	95.00

Stormwater Performance Standard-RR and ST	calculated from water volume treated	calculated from water volume treated	calculated from water volume treated

The most recently reported implementation by major jurisdictions to the Chesapeake Bay Program office was for the 2019 Progress. Reported acres of ISR and ICD to NEIEN are shown in Table 3. The amount credited is different than what is shown in the table. Amount credited is cumulative over time, requires inspection, and the acres available to which the BMP can be applied.

Table 3: Acres of ISR and ICD reported to NEIEN by the major jurisdictions. Table shows the years where the amount was reported. If the year is not included, then there were no acres reported.

Progress Year	State	Impervious Surface Reduction Acres	Impervious Disconnection Acres
2015	DC	0.066115584	0
2017	DC	0.948230624	0
2018	DC	0.668203578	0
2019	DC	21.86697183	0

Progress Year	State	Impervious Surface Reduction Acres	Impervious Disconnection Acres
1988	MD	0.96	0
1991	MD	0.58	0
1992	MD	3	0
1996	MD	1.56	0
1997	MD	0.4	0
1999	MD	2.64	0
2001	MD	12	0
2004	MD	0.294	0
2005	MD	11.44	0
2006	MD	112.78465	0.17528
2007	MD	44.85277	14.78352
2008	MD	7.19157	0.10125
2009	MD	15.50191	1.9965
2010	MD	6.71621	1.1445
2011	MD	17.54152	0.89389
2012	MD	10.59	1.42273
2013	MD	11.03189	39.18668
2014	MD	3.09371	2.15337
2015	MD	5.46898	7.07758
2016	MD	14.88971	18.31396
2017	MD	10.35863	67.62906

2018	MD	8.22272	0.19
2019	MD	0	0.9

Progress Year	State	Impervious Surface Reduction Acres	Impervious Disconnection Acres
2005	PA	9.6	0
2014	PA	8.7	0
2015	PA	0.15	0

Progress Year	State	Impervious Surface Reduction Acres	Impervious Disconnection Acres
2002	VA	0.2	0
2003	VA	6.7	0
2005	VA	202.54	0
2006	VA	6.423	0
2007	VA	7.75	0
2008	VA	3.89	0
2009	VA	4.27	0
2010	VA	16.551	0
2011	VA	11.94	0
2012	VA	19.47	0
2013	VA	5.09	0
2014	VA	13.531	0
2015	VA	3	0
2016	VA	7.01	0
2017	VA	5.7472	0
2018	VA	4.1362	0
2019	VA	6.5361	0

Progress Year	State	Impervious Surface Reduction Acres	Impervious Disconnection Acres
2011	WV	0.11	0