# Managing Watershed Environment Recovery
(Implementing Act 167 Using CMP)

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## Introduction

Managing watershed environment recovery is the logical extension of original concepts presented in an earlier paper "Environment Recovery Via Enhanced BMP." Enhanced BMP (Best Management Practice) implements the CMP (Capitalist Management Plan) where dollar values are assigned to items of the water budget. The long term value of the water budget is compared with the design, construction, and maintenance costs to achieve a responsible outcome. Environment recovery, primarily increased local cooling, is necessary due to the years of lost evapotranspiration cooling since the country was settled. The value of environment recovery is emphasized to establish the return on investment.

The CMP concept puts price tags on managed items so that specific requirements can be generated for particular areas in a watershed and evaluated. Solar insolation, incoming radiation, on Pennsylvania is about 150 watts per square meter and is worth $266,000. per acre year. Elements of the water budget: 1. evapotranspiration is worth $3,500. per acre inch; 2. recharge is worth $167. per acre inch at Audubon Water Co. prices, while Aqua America (formerly Philadelphia Suburban Water) water is worth $110. per acre inch; 3. runoff has negative worth since it is a lost opportunity, at most minus $3,500 per acre inch. These are value received dollars. Value of not needing to cool, value of cooling received, and value of stored water represent a net return in a fully implemented CMP.

Act 167 of 1978 is the Stormwater Management guideline for Pennsylvania. It calls for Stormwater Management Plans on a watershed basis. Historically, counties have not had sufficient engineering capacity, capital funds, or priority to implement Act 167. One result has been the implementation of Stormwater Management BMPs via Township Codes that did not address effects on or from adjacent townships in a watershed. Indeed, Township Codes did not address effects of developing a site adjacent to sites in their township.

The CMP analysis of a watershed addresses projected growth and estimates the value of the growth. Values for a nominal 1 % growth projection of the watershed are presented to provide a basis for determining what to approve and for developing requirements for projects to mitigate watershed problems. Implementation costs would get developed during the design phase.

Examples of the dollar value of the elements of watershed environment are presented to help assess the deficiencies of past and current practices and point the way to recovery. In particular, a 10% reduction of albedo or evapotranspiration (ET) cooling is the negative dollar amount of a 10% increase. The emphasis is on why there should be real concern over how the Schuylkill River Watershed should be managed and the specifics of what needs to be implemented.

## Ten Percent From 1% Is **$126.3** Million Per Year From Implementation Forward

Values associated with watershed environment recovery, achieved by requiring development to implement increased albedo (bold) and evapotranspiration (bold), are presented in Table 1. The Schuylkill River Watershed above the Fairmount dam gage is 1.21 million acres. For ease of scaling the results, the calculations assume 1% of the watershed, 12,115 acres, is developed each year.

Increasing evapotranspiration 10 % contributes $116.6 million per year. This amount is gained by the CMP stormwater management requirement, KET = 1.1, on the 1% assumed new development sites. It is the added 10 % of the value of the nominal evapotranspiration cooling from the new development site. This is the added value of managing the watershed stormwater for environmental gain. The albedo management requirement, KALB = 1.1, on new development sites contributes $9.66 million per year by not warming the area. Total savings would be $126.3 million per year from that area.

The bright side of a possible future is depicted in the lower right corner of Table 1. These numbers are the values of what could be built. The 1% rate is for ease of scaling an individual assessment of the problem.

The dark side of our past, and current Township Code future, places negative values in those columns. An indication of the warm future is given in column 2, Area Developed since 1999. The concerns are: 1. what percent of evaporative capability was destroyed as the areas were developed; 2. what percent of

Table 1. Schuylkill River Watershed Annual Savings

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Study of Watershed Environment Recovery via CMP | | | | | |
| | | | | | | | | |
| | | | | Schuylkill River Watershed | | | | |
| | | | (Using Brandywine Creek Water Budget as an Estimate) | | | | | |
| Schuylkill River | | | Fairmount Dam Gage | | 1893 | mi^2 | 1211520 | Acres |
| | | | | | | Incremental Gain | | |
| Avg. ALB | 0.3 | | | $79,763.54 | /Acre yr | $7,976.35 | /Acre yr | (*KALB) |
| Avg. ET | 25.862 | 25 | inches | $3,500.00 | /Acre in | $96,250.00 | /Acre yr | (*KET) |
| Avg. RCHG | 14.877 | 14 | " | $167.00 | /Acre in | $2,338.00 | /Acre yr | (*1) |
| Avg. Rain | 45.938 | 45 | " | | | | | |
| | | mi^2 | | | | | | |
| Year | Area Deve | 18.93 | | Development Rate | | **1.0** | %/yr | |
| 2000 | 18.930 | | | | | 12115.2 | Acres/yr | |
| 2001 | 37.860 | | | | | $96.64 | $1,166.09 | Annual Value |
| 2002 | 56.790 | | | | | $9.66 | **$116.61** | **Annual Saving** |
| 2003 | 75.720 | | | Recovery | | Albedo | ET | Total |
| 2004 | 94.650 | | Transition | Area | KALB | 1.1 | 1.1 | Alb + ET |
| 2005 | 113.580 | | Implemen | mi^2 | | (millions/year) | (millionsyear) | (millions/year) |
| 2006 | 132.510 | | Impact | 18.930 | | **$9.66** | **$116.61** | **$126.27** |
| 2007 | 151.440 | | | 37.860 | | **$19.33** | **$233.22** | $252.54 |
| 2008 | 170.370 | | | 56.790 | | **$28.99** | **$349.83** | $378.82 |
| 2009 | 189.300 | | | 75.720 | | **$38.65** | **$466.44** | $505.09 |
| 2010 | 208.230 | | | 94.650 | | **$48.32** | **$583.04** | $631.36 |
| 2011 | 227.160 | | | 113.580 | | **$57.98** | **$699.65** | $757.63 |
| 2012 | 246.090 | | | 132.510 | | **$67.64** | **$816.26** | $883.91 |
| 2013 | 265.020 | | | 151.440 | | **$77.31** | **$932.87** | $1,010.18 |
| 2014 | 283.950 | | | 170.370 | | **$86.97** | **$1,049.48** | $1,136.45 |
| 2015 | 302.880 | | | 189.300 | | **$96.64** | **$1,166.09** | $1,262.72 |
| | | | | | | | | |
| | | | | Col. Totals | | **$531.49** | **$6,413.48** | $6,944.98 |

rain was hustled off site by “Rate” BMPs before it could be processed via the reduced ET capacity? Apply these values to the area being developed in column 2. (Will Pennsylvania’s new “Volume” BMP be an improvement? How much cooling will it add to areas being developed?) An eye opener for the spread sheet literate is to calculate accumulated losses since 1950, at 0.5% development per year and 10% and 20% loss of ET per year. With the 10 year gain of $6.944 billion, will cooling begin to catchup with accumulated warming?

Sprawl Quantified

Otto (2002) analyzed paving and sprawl of major cities. Philadelphia was reported, their Table B., as having an “Avg. Yearly Infiltration Loss” 23.5 to 59.0 billion gallons. The value the infiltration (recharge) loss is $155 to $362 million per year. Water budgets of several Chester County watersheds have up to 3 times as many inches of evapotranspiration as recharge. Assuming equal inches , the value of ET cooling could be $7.24 billion per year. Totaling $7.602 billion plus a smidgen for albedo losses. Fortunately, Philadelphia’s losses are spread among other watersheds. The area they analyzed contained 1504 square miles, 962,436 acres (equivalent to 80% of the Schuylkill watershed), possibly a circle of radius 21.9 miles.

Watershed Environment Recovery Areas (WERA)

A Watershed Environment Recovery Area (WERA) is a site dedicated to cooling and recharge, to recover a portion of our environment. They are divided into two groups, active and passive. Both types may have short term storage facilities that feed the water to the recovery area. Recovery areas employ spray and drip dispersion systems appropriate to the facility, terrain, normal societal functions. Candidate areas include: woods, riparian buffers, playing fields, gardens, roof gardens, parks, trails, State game lands, right of ways (power line, abandoned railroad), farm fields, etc. Implementation costs get developed in the design phase.

Managing An Environment

The previous sections indicated that significant warming was allowed to occur and major cooling was prevented from happening for several decades. Recovery will require more than planting riparian buffers and praying for rain. Increasing watershed albedo (don’t warm it) and increasing evapotranspiration (cool it) can ultimately reverse and recover a semblance of the “old watershed.” Implementation will be an interesting exercise for the citizenry.

The Schuylkill River Watershed counties have Planning Commissions, Water Resources Authorities, etc., staffed with personnel that know their portion of the watershed and are working effectively with the Townships and DEP. Missing items include direction, authority, responsibility, staff, and money. Money for staff, analyses, construction, maintenance, and ongoing operating expense. DEP is the Department of Environmental Protection. A key is that protection is not management, and their directives serve to protect those that follow the directives and allow fines for violations. Township codes assure that progress conforms to policy and directives, come what may.

Organizations in the Schuylkill River Watershed can muster their forces, assess the watershed, delineate problem areas, as they should have been doing, and look at them with a different methodology. Get concerned with watershed cooling, it has monetary value. It is the direction to proceed.

Watershed organizations have access to the best, most comprehensive information base ever available. It is appropriate to systematically plan how to manage watershed cooling. Incorporate cooling concerns into Act 167 Plans during plan generation. Have the consultants that generated the plans provide an addendum on cooling sites, etc.

The process should develop WERA that become important to the individuals that got intimately involved with them. The section on WERA contains a representative dozen. The costs can be onerous.

The Carrot

The costs of change need to be addressed and incorporated into projects early in the cycle so that efforts are not wasted.

A key to developing support is demonstrating the cooling capability of WERA. Implement demonstration WERA in public areas. Include black asphalt, an adjacent section of white asphalt (painted), a water collection system, a drip or spray water distribution system, an automatic monitoring system, and a self guided information-education display.

WERA pipe water to storage facilities. Pipe and facilities cost money initially and for maintenance. Active WERA pump water. Pumping costs are recurring and could conceivably be reduced by tax rebates and "load smoothing" operating schedules. Excelon (PECO) has cooling needs and pumps water from the Delaware River to their Limerick facility. It could be in their financial interest to level "off peak" loads by pumping water for environment cooling.

Selling the financing of environment recovery is key. The return on investment in WERA projects can be high. Marketing them is essential. It is important to develop goals and a baseline plan as the basis for developing the costs analysis that will be needed to get the necessary financing.

WERA Sites

ACTIVE WERA pump their water; graywater and accumulated runoff. Office complexes can capture roof runoff and pump it back up for evaporation from the roof or a roof garden. Impounded runoff is available from dams and retention basins for some time after a rain. Pumping can occur during off-peak rate hours. This approach is potentially useful for power company load smoothing (tax incentives could be a function of pumping power provided to induce participation). (Note: it is cost effective to buy water from Aqua America, a.k.a. Philadelphia Suburban, for $110. an acre inch and evaporate it for $3500 making $3390. profit. The $3500 is environment value received, the $110. is out of pocket.)

PASSIVE WERA use gravity to move their water. Passive WERA receive water during rain events. Passive systems are appropriate for edges of the watershed where there is sufficient drop, gradient, between the water source and the storage facility fill the short term storage tanks. The drip or spray distribution system is gravity fed. Multistory offices can drizzle collected roof water down the sides of the building.

1. Schuylkill Valley Nature Center, Roxborough, ACTIVE

2. Mine Run, Audubon, Perkiomen tributary receives runoff from Trooper, PASSIVE.
3. Crabby Creek, a Valley Creek watershed tributary receives runoff from Paoli, PASSIVE.
4. Little Valley Creek, RR right of way, ACTIVE.
5. Tulpehocken@ Blue Marsh Dam, ACTIVE (see example, Table 2.)
6. State Game Lands above Blue Marsh Dam, ACTIVE
7. Graterford SCI, PASSIVE
8. Evansburg Park State Game Lands, Skippack Creek, ACTIVE
9. Schuylkill River Trail, PASSIVE
10. Perkiomen Trail, PASSIVE
11. WalMart -Home Depot Malls (Trooper), ACTIVE
12. Rain Barrels, Your Back Yard, PASSIVE

Example: Mine Run, Audubon, Perkiomen tributary receives runoff from Trooper, PASSIVE

A riparian buffered streamlet that empties into the Perkiomen at Audubon Sanctuary. The Trooper main stem is 3 miles long, the Arcola School branch is 1.1 miles, and Woodland school branch is .8 mile. The stream now dries up in the summer. Twenty five years ago suckers spawned in it above Audubon. The creek drops from 336' at Trooper to 110' at Wetherill dam. Culverts move water through the riparian areas to the Creek. The Township has right of way along the creek to minimize possibility of damage to private property.

Gravity fed WERA are appropriate for: the Audubon Sanctuary field below Egypt Road, the woods above Shearwater Drive, the park below Sunnyside Ave., along Linnet Rd., below Shannondell. WERA storage tanks have a potential value of $12.86 per hundred gallons evaporated, an inch of rain from fifty acres has a potential value of $175,000. Shannondell is a 140 acre retirement village with a maximum impervious coverage of 50%.

Example: Tulpehocken Blue Marsh Dam WERA, ACTIVE

Located northwest of Reading, PA, the “Tully” is a fine coldwater fishery. The dam watershed is 175 square miles. Just below the dam is the “Waterworks” where pumps extract water for local use. Stream flow rate is managed, with levels set in response to rain events and other considerations. It is appropriate to consider recovering a portion of high flows to feed WERA evaporation and recharge areas.

Table 2. presents 13 instances, covering 39 days in 2003, that had high flow rates that might be appropriate for pumping water to the WERA. The cost of pumping is difficult to estimate so the cost of commercial water was used to estimate the net profit.

Example: WalMart-Home Depot, ACTIVE (Retrofit)

The typical 50 acre impervious site with flat black roofs and flat black parking spaces. Paint it white, capture roof and parking lot runoff in retention systems, drizzle retained water onto the flat roof and parking lot. Evaporating 30 inches of drizzled water is worth $5.25 million per year. Painting it white, increasing albedo from 10 to 60%, is worth $6.65 million per year.

Table 2. Pumping Opportunities At Blue Marsh Lake (2003)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Tulpehocken at Blue Marsh Dam | | | | |
| | | | | | | | |
| | | Amounts of water "Available" and Value | | | | | |
| | Low | High | Duration | Cubic Feet | Acre In. | ET Value | ET $, Buy |
| 12/17/03 | 980 | 1500 | 1 | 44928000 | 12376.86 | $43,319,008.26 | $41,957,553.72 |
| 12/19/03 | 600 | 980 | 1 | 32832000 | 9044.63 | $31,656,198.35 | $30,661,289.26 |
| 12/29/03 | 390 | 575 | 9 | 143856000 | 39629.75 | $138,704,132.23 | $134,344,859.50 |
| 04/15/03 | 400 | 700 | 2 | 51840000 | 14280.99 | $49,983,471.07 | $48,412,561.98 |
| 06/04/03 | 400 | 700 | 10 | 259200000 | 71404.96 | $249,917,355.37 | $242,062,809.92 |
| 06/24/03 | 400 | 2000 | 3 | 414720000 | 114247.93 | $399,867,768.60 | $387,300,495.87 |
| 07/23/03 | 400 | 1000 | 2 | 103680000 | 28561.98 | $99,966,942.15 | $96,825,123.97 |
| 09/16/03 | 400 | 1000 | 2 | 103680000 | 28561.98 | $99,966,942.15 | $96,825,123.97 |
| 09/25/03 | 400 | 480 | 2 | 13824000 | 3808.26 | $13,328,925.62 | $12,910,016.53 |
| 10/15/03 | 400 | 600 | 1 | 17280000 | 4760.33 | $16,661,157.02 | $16,137,520.66 |
| 10/28/03 | 400 | 800 | 2 | 69120000 | 19041.32 | $66,644,628.10 | $64,550,082.64 |
| 11/20/03 | 400 | 500 | 2 | 17280000 | 4760.33 | $16,661,157.02 | $16,137,520.66 |
| 12/01/03 | 400 | 700 | 2 | 51840000 | 14280.99 | $49,983,471.07 | $48,412,561.98 |
| | | | | | | | |
| | | | 39 | | | $1,276,661,157.02 | $1,236,537,520.66 |
| | | | | | | | |
| | | | | | | | $40,123,636.36 |
| | | | | | | | Water Cost |

Example: Rain Barrels

Chester County Water Resources Authority has promoted rain barrels in their communities. Their value depends on how the water is dispersed. A fifty gallon barrel of water is worth $0.20 as recharge and $6.43 as evaporation. Water budgets indicate that there may from one to three times as much ET as recharge. Assuming twice as much evapotranspiration as recharge, a 50 gallon barrel would be worth $4.35 and a 90 gallon barrel worth $7.84 per filling. An inch of rain on an 8' by 10' area equals 50 gallons. (Sustainable Solutions offers a 90 gallon barrel online, ssolutions@comcast.com).

<u>WERA Joke du Jour</u>

The ocean is rising, the OCEAN is rising! Oh My! Good Grief! Wring you hands and rationalize, “put that stuff back where it came from!”

The earth surface is 71% water. Thus, you could lower the ocean level one inch by moving water onto land until it reaches a depth of 2.448 inches. In the past century sea level at Atlantic City rose 16 inches. Now it must be moved back and kept there. That means putting 40 inches of water on all solid surface, everyone’s back yard. It did come from our backyards but it was once on the polar icecaps, glaciers, and mountaintops and in aquifers. It initially got there naturally as part of the hydrologic cycle as the earth aged. The WERA is the means of putting it back.

Harvey (1999), table 4.4, attributes a major portion of the oceans rise to melting of the ice packs. Thermal expansion of the ocean as it warms is a secondary effect. Thus sending cooler water to the ocean will also contribute towards lowering ocean level.

Every watershed in the world needs to be "WERA'd" and allowed to work for years to cool the environment and to return the water to the desired spot. It will take more than a century to put it back, even if the task is begun today. The later the start, the bigger the task.

Summary

Cooling the watershed involves two simple tasks: 1. don't warm it and 2. cool it. Increase watershed albedo. Increase evapotranspiration.

The wealth the hydrologic cycle provides to the gaged Schuylkill River watershed environment is $116.6 billion per year. The goal of watershed management is to realize as much value as possible. The capital generated, the value realized, gained, from the CMP approach of fundamentally sound development of the watersheds is immense, $116,609,000. per year, table 1. from evapotranspiration and $9,664,000. from albedo improvement on 1% of the watershed. These values contrast with the losses that occur with BMP implementations and blacktopped sprawl. (While I have not addressed these losses, values double the potential gains I present would not surprise me.)

Work to develop an Environment Recovery Plan for the Watershed.

Implement changes that force development to increase site albedo. Develop programs that guide citizenry in the selection of high albedo roofs and driveways.

Advocate managing rain as a valuable commodity rather than trash, have it cool the watershed. Advocate mitigating years of wasteful stormwater management practices through implementing WERA. Work with townships to get environmentally sound handling of the development site water budget, i.e.: get CMP implemented.

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