COMMUNITY & ENVIRONMENTAL DEFENSE SERVICES

Richard D. Klein
24 Greenshire Lane
Owings Mills, Maryland 21117

410-654-3021
Help@ceds.org
ceds.org

July 5, 2022

Tina & Mark Seago
236 Bear Creek Pike
Columbia, Tennessee 38401

RE: Keeping The Duck River & Columbia Unique Among U.S. Rivers & Cities

Dear Dr. & Mrs. Seago:

As you requested, I have reviewed the Columbia Bluffs project of concern to you and your neighbors. This review was based upon a number of documents and the other sources cited below, including those listed on the Columbia Municipal Planning Commission, May 11 and July 6, 2022 agendas under 22-0078 – *Big Bear Bluffs – Comprehensive Plan Amendment, Annexation and Rezoning With Preliminary PUD Master Plan.*

From conversations with you and your neighbors, it is clear that a large number of Maury County and Columbia residents are troubled by the direction that annexations and upzonings have taken within the City of Columbia growth boundary. Among the aspects of this growth you and others find most troubling is the apparent lack of responsible planning regarding schools and other elements essential to preserving Columbia area quality of life.

The potential effect of the proposed Columbia/Big Bear Bluffs annexation-upzoning on schools was addressed in my July 2nd letter to you.

The focus of this letter is the potential impact to the Duck River should the requested Columbia/Big Bear Bluffs annexation and upzoning be approved.

COLUMBIA/BIG BEAR BLUFFS PROJECT

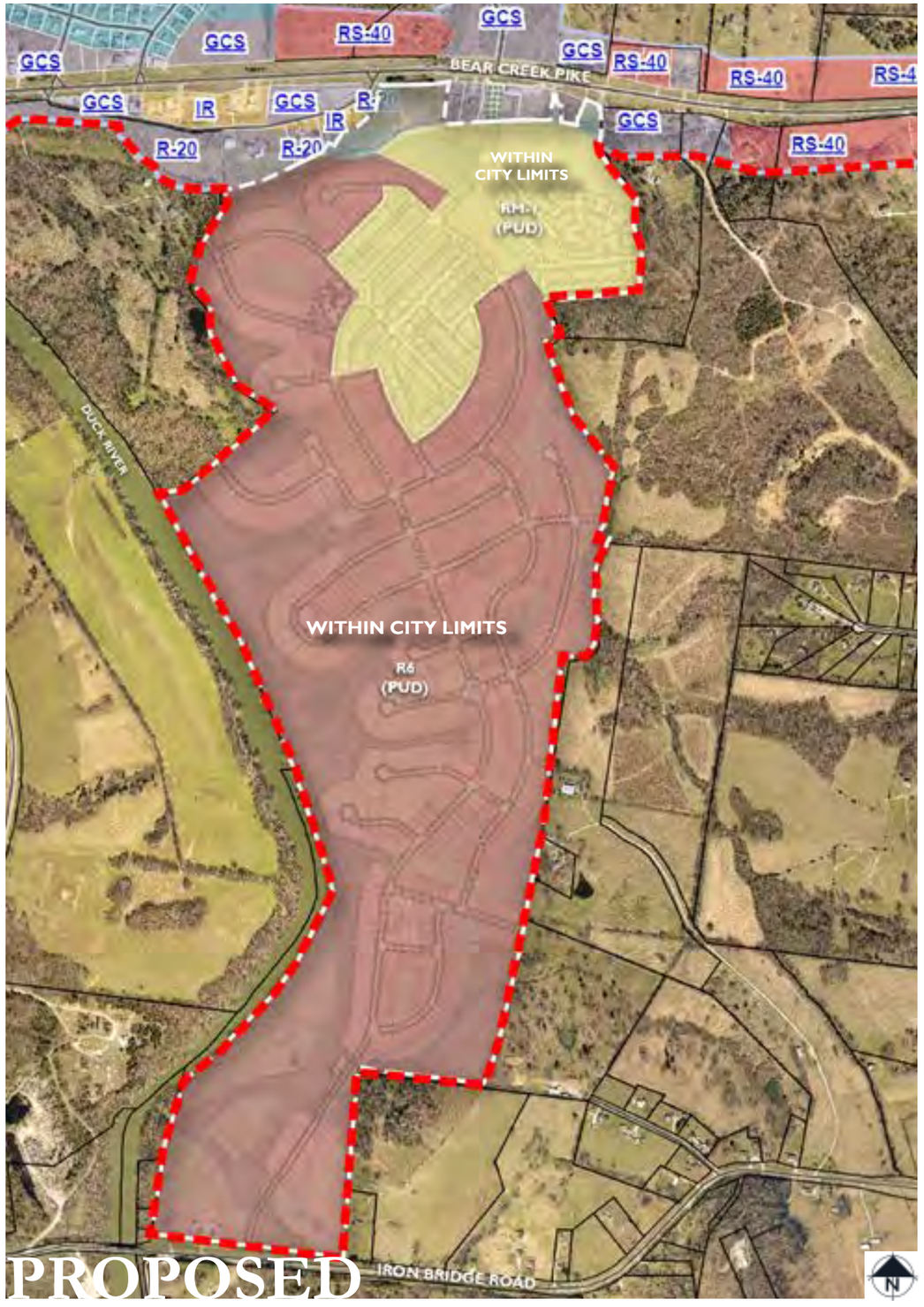
The Columbia/Big Bear Bluffs project is proposed for a 413-acre site adjoining the Duck River.

On the next page is an excerpt from the applicant's pattern book.[1] This excerpt shows an aerial of the site as it currently exists and a depiction of the proposed development. The site is presently an equal mix of forest and farmland. Should annexation-upzoning be granted the applicant proposes to develop the site with 800 single-family detached homes, 300 townhomes, 300 multifamily units, and 4.1 acres of commercial development leaving 175-acres of open space of which only 58 acres will be forest.

[1] The Pattern Book is online at: https://www.columbiatn.com/AgendaCenter/ViewFile/Item/896?fileID=7307



EXISTING



PROPOSED

LAND AREA REQUESTED FOR ANNEXATION INTO THE CITY OF COLUMBIA:

ADJACENT TO PARCELS ALONG BEAR CREEK PIKE WHICH ARE ALREADY WITHIN CITY LIMITS.

WITHIN LIMITS OF COLUMBIA'S URBAN GROWTH BOUNDARY

REZONING:

EXISTING ZONING:
MAURY COUNTY - A2 RESIDENTIAL

NEWLY ANNEXED PROPERTIES WILL HAVE AN INITIAL ZONING OF RS-40

REQUESTED ZONING:
PUD-R (RS-6 BASE ZONING)
PUD-C (RM1 BASE ZONING)

ANNEXATION & REZONING

EXCEPTIONAL DUCK RIVER QUALITY MAKES COLUMBIA UNIQUE

The 413-acre Columbia/Big Bear Bluffs site includes 1.25-miles of the Duck River shoreline. The site is located 1.8-miles upriver of the Old Columbia Dam where water is withdrawn by the Columbia Power & Water Systems for consumption by Columbia area residents and others.

The Duck River has been designated *Exceptional Waters* by the Tennessee Department of Environment and Conservation (TDEC).[2] Perhaps the most succinct definition of "Exceptional Waters" is that which appears in the Tennessee General Water Quality Criteria:

"waters with outstanding ecological, or recreational value".[3]

The U.S. Fish & Wildlife Service (USFWS) Information for Planning & Consultation (IPaC)[4] website lists a number of threatened or endangered species for the Duck River system. Of these species, nine are clams (mussels). At first, one might question the importance of species as humble as a mussel. Keeping the Duck River mussel populations healthy also keeps the River clean as a drinking water source for Columbia area residents and suitable for the many aesthetic and recreational benefits the Duck River provides.

Mussels feed by filtering particles from the River and thereby greatly improving water clarity while reducing pollutant concentrations and, as will be seen, at times at the peril of mussel populations. One could argue that the Duck River would not be Exceptional Tennessee Waters were it not for the tremendous mussel populations.

A landmark study was published in 2017, *Historical and Current Examination of Freshwater Mussels (Bivalvia: Margaritiferidae: Unionidae) in the Duck River Basin Tennessee, U.S.A.*[5] The eight researchers who coauthored this164-page study based their conclusions on mussel populations at 112 locations along the Duck River and tributary streams. The researchers also compared current mussel populations with those dating back to 1922.

A basic ecological concept is that the greater the number of species (species richness) the healthier and more stable a population and ecosystem. Table 6, on page 23, of the 2017 study shows 15 mussel species at Columbia Dam in 1922, then 29 by 1965, and 33 in 2002.

The authors attributed this dramatic recovery in Duck River water quality, as indicated by mussel species richness increases, to:

- Wastewater treatment improvements made by Columbia and other Duck River basin cities,
- Improvements in chemical and manufacturing wastewater treatment,

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[2] The portions of the Duck River system designated Exceptional Tennessee Waters are defined in the spreadsheet available online at: https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34304:4364479562473527

[3] See Rule 0400-40-03-.06(4) Antidegradation Statement available online at: https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf

[4] The IPaC website is at: https://ipac.ecosphere.fws.gov/

[5] This study ia available online at: https://lsa.umich.edu/content/dam/ummz-assets/ummz-docs/MR4546/2 Ahlstedt et al Duck River.pdf

- Increases in minimum river flows thanks to TVA's Reservoir Release Improvement program,
- Improved farming practices that reduced erosion and sediment pollution as well as diminishing pesticide releases, and
- Designation of the Duck River as a State scenic river in 2002.

Table 4, on page 21, of the 2017 study, compared mussel species richness at four low-head dams on the Duck River: Hardison Mill Dam, Lillard Mill Dam, Old Columbia Dam, and Shelbyville Dam. Species richness was highest at the Old Columbia Dam site which is where water for Columbia area residents is withdrawn. This point is 1.8-miles below the Columbia/Big Bear Bluffs site. One might say that the portion of the Duck River along the Columbia/Big Bear Bluffs site and down to the Columbia water intake is the healthiest based on mussel species richness.

So, what does all this means for City and other area residents in the context of the Columbia/Big Bear Bluffs project. Well, with regard to the success of the City, Maury County and Tennessee in restoring the river, the authors wrote on page 100:

"Recovery of mussel resources in the Duck River as reported here is ***unprecedented.****"* [emphasis added]

And on page 97, of the 2017 study, the authors also wrote:

"By all accounts the Duck River has the greatest mussel species richness of any tributary system throughout the United States."

The uniquely high quality of the Duck River is not just a fact recognized by a few scientists. Last February, Nashville Channel 2 station WKRN ran a segment entitled: *The Duck River is the 'most bio-diverse river in North America'*. This segment and the accompanying article can be viewed at: https://www.wkrn.com/special-reports/hidden-tn/the-duck-river-is-the-most-bio-diverse-river-in-north-america/

Visit Columbia Tennessee has devoted a webpage to the Duck River as a way to attract more tourism dollars to the area: https://www.visitcolumbiatn.com/about/duck-river/.

I believe that Columbia may be one of very few cities in the U.S. that has such a high-quality river flowing through its center. Because of its uniquely high quality, the Duck River and its mussel populations enhance Columbia quality of life in many ways, including the provision of a high-quality public water supply and a multitude of tourism and recreational opportunities.

It is for these reasons that it is imperative that growth, such as that proposed for the Big Bear Bluffs site, be managed to preserve and enhance Columbia area quality of life for current (and future) residents in ways that also preserve - perhaps further enhancing – Duck River quality.

POTENTIAL COLUMBIA/BIG BEAR BLUFFS DUCK RIVER IMPACTS

While it is theoretically possible to intensely develop the 413-acre Columbia/Big Bear Bluffs site without damaging the Duck River, this is highly unlikely given site soil constraints and the current state of aquatic resource protections.

In 1979, I published what has been called one of the first studies of the relationship between watershed development and aquatic resource health: *Urbanization & Stream Quality Impairment*.[6] Perhaps one of the best compilations of all the research that followed my 1979 study is *Impacts of Impervious Cover on Aquatic Systems*, by the Center for Watershed Protection.[7]

Transforming the land area draining to a river – the watershed – from farm and forest to homes, buildings, streets, parking lots and other *impervious surfaces* begins degrading highly-sensitive aquatic ecosystems when as little as 2% of a watershed is rendered impervious. Other waters will not exhibit significant, adverse effects until 8% to 10% of a watershed is impervious. Most aquatic life will be eliminated when a fourth (25%) of a watershed is covered with buildings, streets and other impervious surfaces.

The Columbia/Big Bear Bluffs site is presently less than 1% impervious. With the proposed 1400 housing units and 4.1-acres of commercial, the site could become 30% impervious. However, the Duck River watershed has an area of 1,195-square miles by the time it reaches the Tom J. Hitch Parkway bridge just downriver of the site. The 413-acre Columbia/Big Bear Bluffs site occupies a mere 0.05% of that massive watershed. While normally development of the site would have little effect on a waterway with such a massive upriver drainage area, other factors magnify the potential impact of this one annexation-upzoning proposal. These factors are associated with the four categories of aquatic resource impact resulting from development:

- Loss of riparian (riverside) forest,
- Loss of upland forest,
- Construction phase soil erosion and sediment pollution, and
- Post-construction stormwater runoff and loss of groundwater recharge.

Riparian Forest

There is a large body of research documenting the need to maintain forest and other undisturbed native vegetation along stream or river banks. One of the more comprehensive studies documented that to maintain good to excellent aquatic resource quality, forest must be preserved for 100 feet back from each bank and this buffer must exist along a minimum of 70% of the length of a stream or river.[8]

The City of Columbia *Aquatic Buffer Regulations to Protect Streams, Wetlands and Floodplains* call for a minimum 60-foot buffer along streams or rivers designated Exceptional Tennessee Waters,

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[6] This paper is available online at: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1752-1688.1979.tb01074.x

[7] This publication is available online at: https://owl.cwp.org/mdocs-posts/impacts-of-impervious-cover-on-aquatic-systems-2003/

[8] This study, I*KONOS imagery for resource management: Tree cover, impervious surfaces, and riparian buffer analyses in the mid-Atlantic region* is available online at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.95.4037&rep=rep1&type=pdf

such as the portion of the Duck River adjoining the Columbia/Big Bear Bluffs site.[9] The regulations also call for expanding the buffer to include the 100-year floodplain.

On the next page are two aerial photos from the Tennessee Property Viewer Site: https://tnmap.tn.gov/assessment/. The aerial on the left (on the next page) shows the 413-acre Big Bear Bluffs site. The middle aerial then shows the portion of the site within a 100-year floodplain. The right-hand image is from the applicant's Pattern Book and shows that a large portion of the 100-year floodplain will be kept in undisturbed forest.[10] Except for a small portion, the Pattern Book excerpt shows that most of the forest buffer will extend at least 100 feet back from the Duck River bank top.

While the applicant is to be commended for proposing to preserve this extensive riparian forest, a buffer alone is not sufficient to counteract the negative impacts from construction phase sediment pollution or post-construction impervious surface runoff. Buffers are only effective in controlling polluted runoff when it travels as a very shallow and slow-moving sheet flow across a forest floor. This sheet flow allows much of the runoff to soak into the soil and for pollution particles to be filtered by leaves, twigs and vegetation.

Both construction and post-construction runoff quickly forms into a deep, rapid channel flow that carries the full pollution load through a buffer to adjoining waters. Because of this, local, state and federal laws require the use of construction phase erosion and sediment control measures and post-construction stormwater management to minimize runoff pollution before it reaches a buffer or waterway.

Loss of Upland Forest

The aerials on pages 2 and 7, of this letter, show that the 413-acre Columbia/Big Bear Bluffs site is presently about half forest. Forest above the floodplain and throughout watershed uplands is of equal and perhaps greater importance to the Duck River ecosystem health when compared to riparian (riverside) forest.

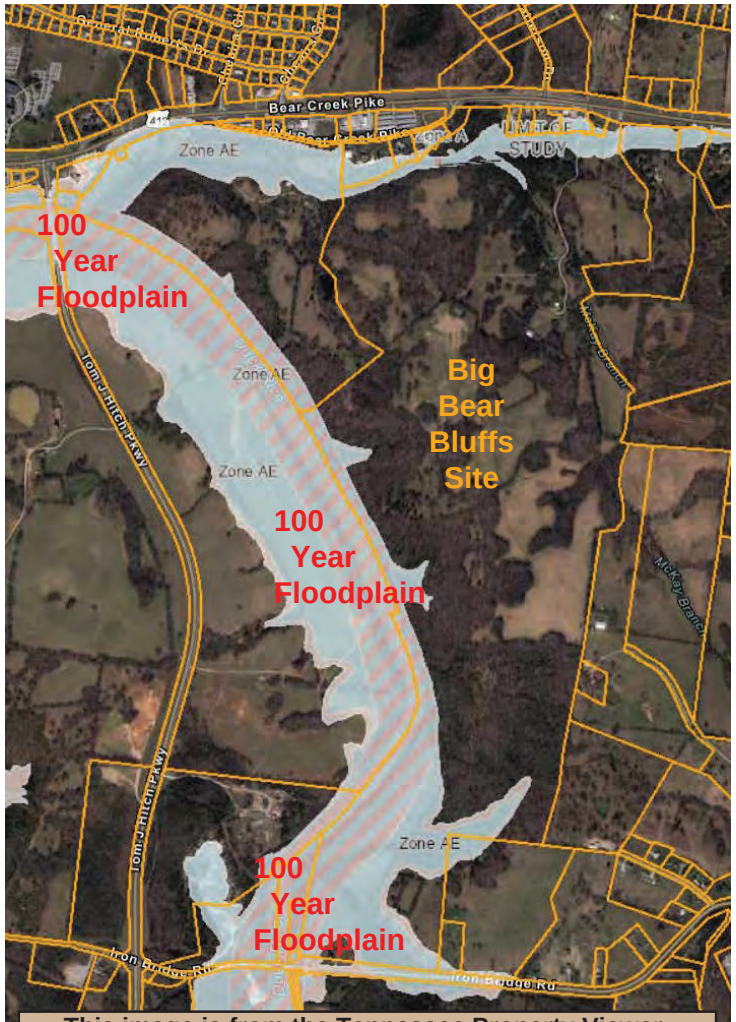
When rain falls upon a forest it is intercepted by leaves, branches, and other tree structures then settles upon a leaf-covered forest floor. This interception greatly increases the amount of rain (or snowmelt) that soaks into the forest soils. As this infiltrating water passes through the soil much of the air pollutants it contained is removed. Over a period of weeks or months the infiltrated water cools as it travels through the soil and underlying geology to enter wetlands or waterways via springs or seeps. This high-quality groundwater inflow is what allows the Duck River to achieve the distinction of having…

"… the greatest mussel species richness of any tributary system throughout the United States."

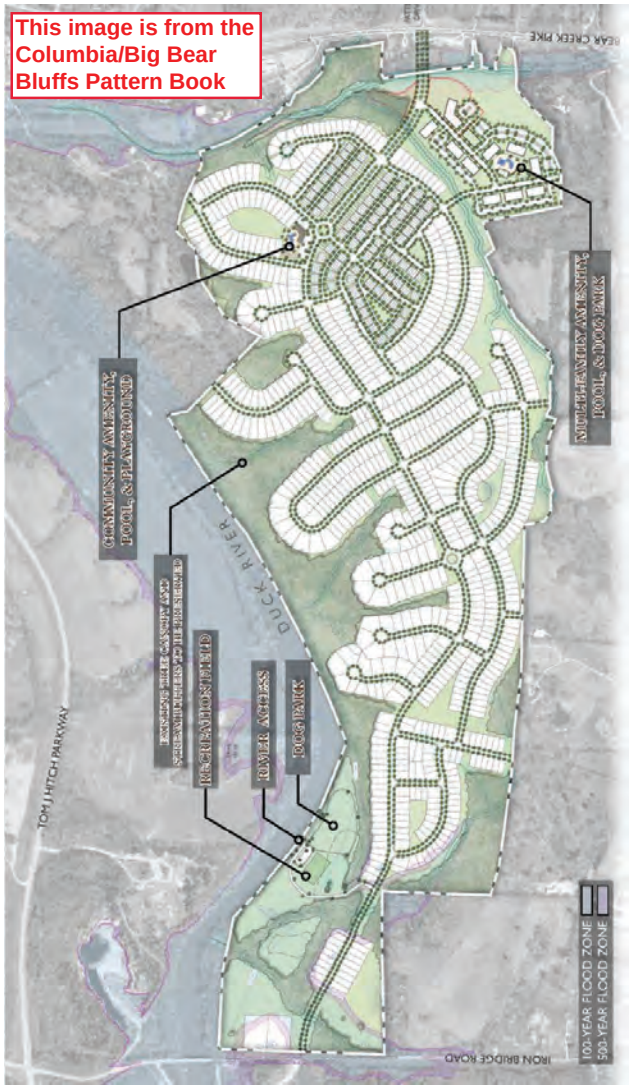
[9] The regulations are available online at: https://www.columbiatn.com/documentcenter/view/183
[10] The Patter Book is at: https://www.columbiatn.com/AgendaCenter/ViewFile/Item/896?fileID=7307



This image is from the Tennessee Property Viewer:
https://tnmap.tn.gov/assessment/



This image is from the Tennessee Property Viewer:
https://tnmap.tn.gov/assessment/



So how much forest must remain to keep the Duck River health? One study indicated that about half a watershed should remain in forest to maintain good to excellent aquatic resource health.[11]

The open space breakdown in the Columbia/Big Bear Bluffs *Pattern Book* indicates that only 58 acres of forest will remain if the site is developed as proposed.[12] If this is correct then the 413-acre site will go from about 50% to 14% forest, which is far below the threshold needed to preserve high-quality aquatic resources.

Construction Phase Soil Erosion & Sediment Pollution

Studies conducted in the 1960s, before the advent of modern erosion and sediment control, determined that the eroded soil and resulting sediment pollution released from a single construction site could damage up to three miles of downstream waters with recovery taking up to a century.[13]

Since the early 1970s, contractors have been required to use erosion and sediment control measures to minimize soil erosion and the release of sediment laden runoff into nearby waters. Measures that must be employed during construction in Tennessee are presented in the *Erosion and Sediment Control Handbook*.[14] The most common measures seen on construction site are the silt fence, wattle and sediment pond (basin) pictured below.







Soil is composed of gravel, sand, silt and clay size particles. While the measures shown above can be effective at keeping gravel, sand and larger silt particles from polluting nearby waters, they are far less effective in trapping smaller silt and clay sized particles. And it is these smaller particles which can be the most damaging to aquatic life, particularly filter-feeders like mussels.

Unfortunately, one cannot protect highly-sensitive aquatic species, such as mussels, unless these smaller particles are kept out of waterways. The sediment basin pictured above is quite muddy. The muddiness is likely caused by clay particles which take a long time to settle from suspension. During the most recent rain a large volume of clay sized particles likely flowed out of the basin and into a nearby waterway. Come the next rain and runoff event, the clay discoloring the basin in the photo above will have been displaced and discharged out into the nearest waterway.

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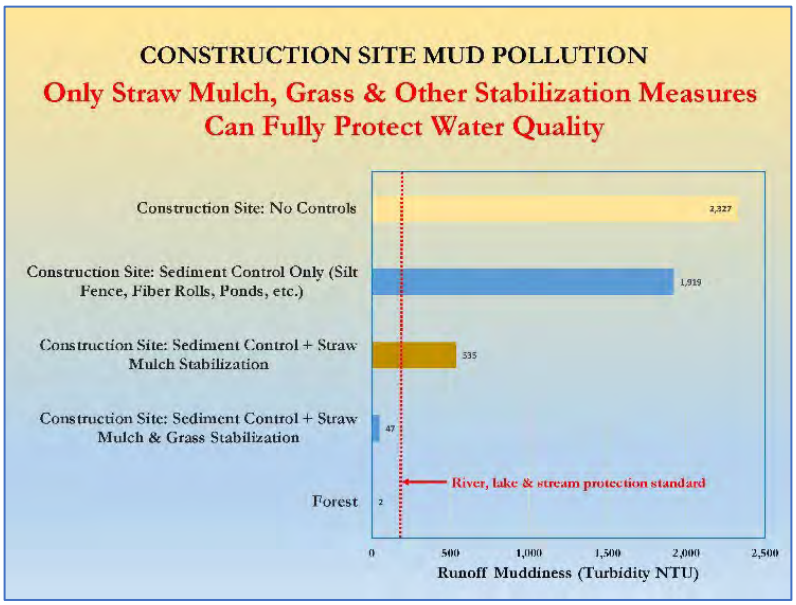
[11] This study, *IKONOS imagery for resource management: Tree cover, impervious surfaces, and riparian buffer analyses in the mid-Atlantic region* is available online at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.95.4037&rep=rep1&type=pdf

[12] The Pattern Book is online at: https://www.columbiatn.com/AgendaCenter/ViewFile/Item/896?fileID=7307

[13] For an example of these 1960s studies see *Effects of construction on fluvial sediment, urban and suburban areas of Maryland*: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/WR003i002p00451

[14] The handbook is available online at: https://tnepsc.org/handbook.asp

The most effective way to prevent clays and other fine particles from leaving a site is to protect all exposed soils with a thick layer of straw mulch and then grass. Of course, it would make little sense to apply mulch or grass seed while a site is being cleared and graded, but once earth-moving has ceased and bulldozers have moved on, then all exposed soils could be protected with mulch and grass. Road or parking lots bed would be protected with a base course of stone.



Turbidity is a measure of the clarity of water. The turbidity of construction site runoff is mostly caused by suspended clay particles. The graph to the left compares the turbidity of construction site runoff under four control measure scenarios. The vertical red line is a generally accepted turbidity threshold for protecting aquatic ecosystems. Note that only by protecting exposed soil with mulch and grass can one protect sensitive waters from the pollutional effects of construction site runoff.

Using recent Google Earth aerial photos, I examined several construction sites within the City of Columbia. Earth-moving equipment was not present on these sites. Clearly these sites had been brought up to rough grade weeks or months ago. Yet there was no evidence that these idle soils had been protected with straw mulch, grass or any other temporary stabilization measure. If existing sites are not being treated with measures needed to protect the highly-sensitive Duck River ecosystem, then it is unlikely that the Columbia/Big Bear Bluffs site will be.

A comprehensive, independent assessment should be made to determine if soils are being exposed to erosive forces long after the time when they should be protected with mulch and grass. An example of such an assessment is the CEDS *Greater Baltimore Construction Site Erosion Control Audit* I oversaw in 2015: https://ceds.org/wp-content/uploads/2019/06/2015GBSESPReport.pdf

The City should postpone annexation and upzoning of uniquely sensitive sites, like Columbia/Big Bear Bluffs, until all construction sites consistently benefit from effective use of mulch, grass and other stabilization measures once earth-moving has ceased.

Stormwater Runoff & Groundwater Recharge Loss

The following excerpt is from the Tennessee DEC stormwater permitting webpage:[15]

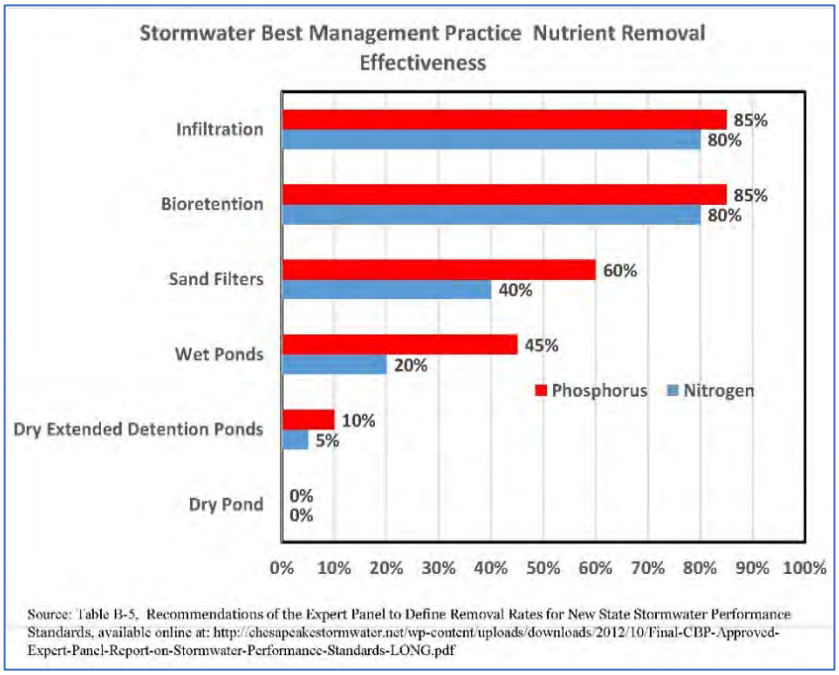
[15] See: https://www.tn.gov/environment/permit-permits/water-permits1/npdes-permits1/npdes-stormwater-permitting-program.html

"Stormwater runoff is generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. The runoff picks up pollutants like trash, chemicals, oils, and dirt/sediment that can harm our rivers, streams, lakes, and wetlands."

Converting a rural watershed to homes on quarter-acre lots, as proposed for Big Bear Bluffs, can increase the frequency and severity of flooding by a hundred-fold.[16] Those floodwaters can scour stream channels to a width two- to eight-times greater than that prior to development. Along with all that increased runoff comes a long list of pollutants including nutrients and a number of others that are toxic to aquatic life.

Additionally, much of that runoff is rainwater that soaked into the soil prior to development. Covering soils with buildings, roads and other impervious surfaces prevents this groundwater recharge. It is recharge that accounts for the high-quality water that enters streams and rivers from springs and seeps long after a storm has passed. In fact, during droughts all of the high-quality water carried by a river derives from groundwater recharge.

As with erosion and sediment control, efforts to manage stormwater from developed lands began in the 1970s. Today, the *Tennessee Permanent Stormwater Management And Design Guidance Manual* sets forth requirements to minimize adverse effects from proposed development projects like Cumberland/Big Bear Bluffs.[17] The graph below presents six categories of stormwater management measures or *Best Management Practices* (BMPs) and the generalized effectiveness of each in preventing nutrients washed from rooftops, streets and lawns from reaching nearby waters.



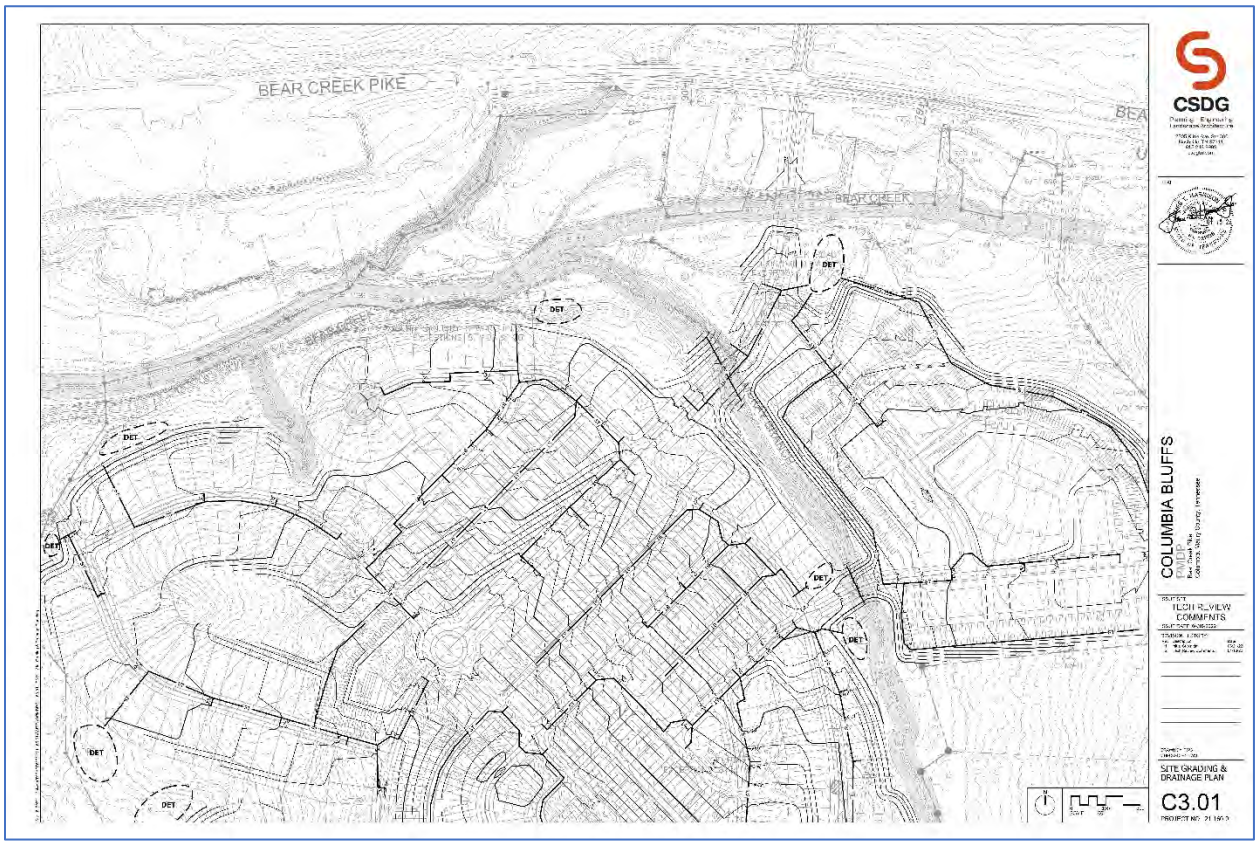
Source: Table B-5, Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards, available online at: http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/10/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Performance-Standards-LONG.pdf

[16] See Urban Hydrology for Small Watersheds at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf

[17] The Tennessee Permanent Stormwater Management And Design Guidance Manual is available online at: https://tnpermanentstormwater.org/manual.asp

A practice which is good at trapping nutrients is generally good at safeguarding waters from metals and other stormwater contaminants. But only infiltration and bioretention measures can maintain groundwater recharge at near predevelopment levels and achieve the highest pollutant removal. However, not all sites and soils are suitable for these highly-effective measures.

Below is Sheet C3.01 from the applicant's Preliminary PUD Master Plan_04182022.[18] This sheet and three others show a number of areas labeled "DET." These DET areas appear to be proposed stormwater *detention* facilities.



The graph on the preceding page shows that detention ponds only remove 5% to 10% of nutrients entrained in stormwater runoff. It is possible though that these DET areas could be converted to the more effective wet ponds and achieve 20% to 45% nutrient removal. Even if this is so, ponds only remain wet if runoff does not infiltrate into underlying soils. Therefore, the wet ponds would not maintain groundwater recharge at predevelopment levels. To resolve this very serious shortcoming, infiltration or bioretention facilities could be located throughout the site to achieve the much higher degree of pollutant removal as well as groundwater recharge. Unfortunately, soils on the 413-acre site appear mostly unsuited to these highly-effective measures.

Hydrologic Soil Groups (HSG) is a system for rating soils according to infiltration and runoff characteristics. The ratings range from "A" to "D". The sandy-gravelly HSG "A" soils

[18] Preliminary PUD Master Plan: https://www.columbiatn.com/AgendaCenter/ViewFile/Item/1581?fileID=9000

produce the least runoff and allow the greatest degree of infiltration and groundwater recharge. The clayey or wet HSG "D" soils produce the greatest runoff with minimal infiltration and recharge.

HSG "A" and "B" soils are best for attaining the maximum pollutant removal and recharge benefits of infiltration or bioretention facilities. HSG "C" are marginal and "D" soils are unsuitable for infiltration-bioretention BMPs..

The map on the next page is from the USDA Web Soil Survey site.[19] The soils colored pink and dark blue belong to HSG "A" and "B". Of the 413-acre site, only 114 acres are on these HSG "A" and "B" soils. Because of the paucity of permeable soils, the Columbia/Big Bear Bluffs site is mostly unsuited for the highly-effective stormwater BMPs essential to preserving highly-sensitive aquatic ecosystems such as the Duck River.

BIG BEAR BLUFFS RECHARGE & COLUMBIA WATER SUPPLY

It appears that the 2015 *Maury County Regional Water Supply Strategic Plan*, by the Tennessee Duck River Development Agency, may be the most recent, comprehensive examination of Columbia area water supply conditions.[20] Table 2, below, appeared on page 6 of the report, and shows progressively worsening drought-year water shortages in the coming decades.

Table 2. Current and projected water supply deficits at Columbia for the Duck River

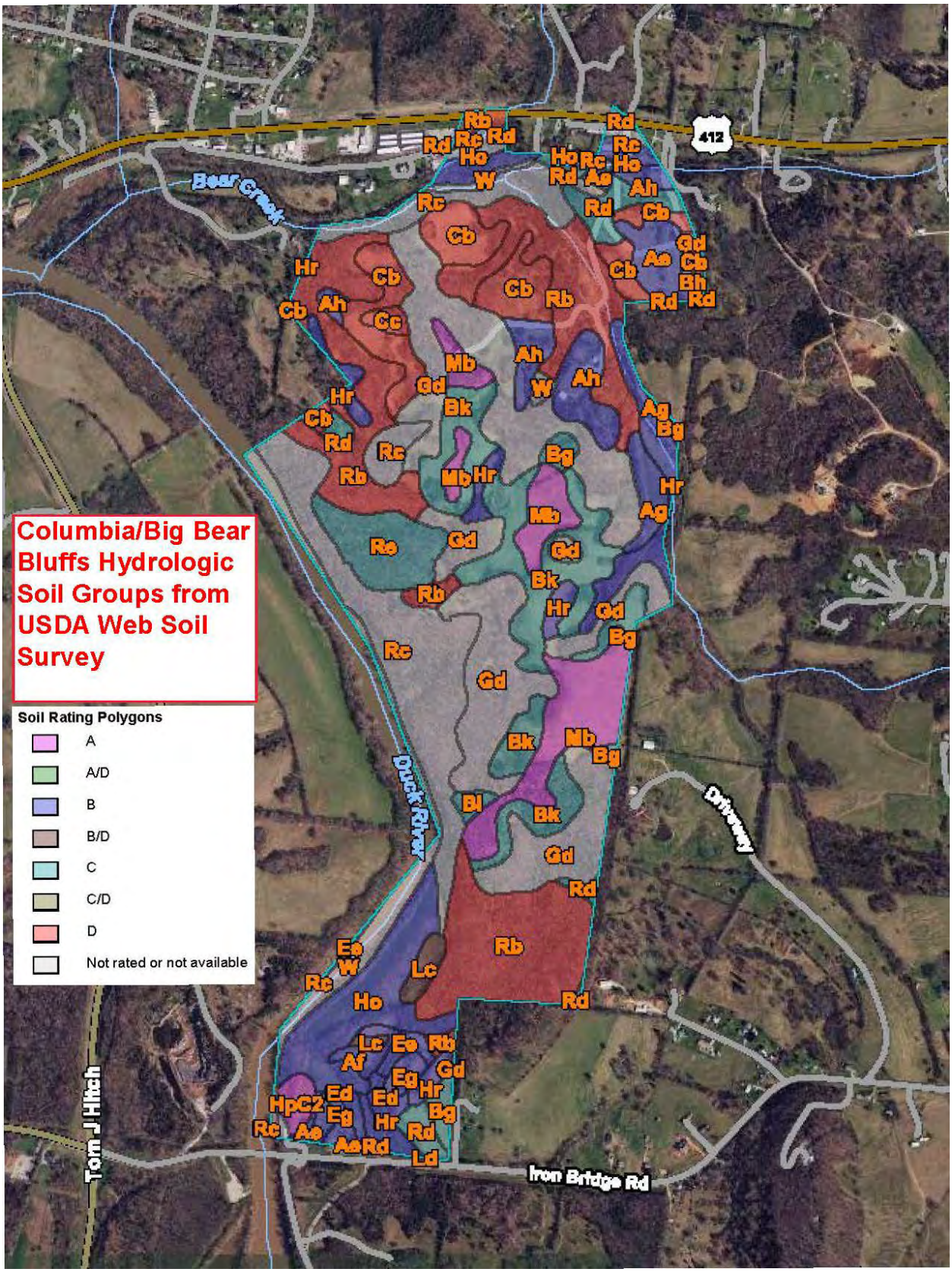
Deficit	2010	2020	2030	2040	2050	2060
Potential water supply deficit at Columbia based on critical drought year of record and maintenance of 100 cfs at Duck River Mile 132.8 (MG)	300	500	700	900	1150	1400
Potential water supply deficit at Columbia based on critical drought year of record and maintenance of 100 cfs at Duck River Mile 132.8 (mgd)	4	10	15	21	27	32

The competition for limited water resources in the Duck River basin is becoming increasingly intense. Perhaps nothing exemplifies the growing tension more than the lawsuit filed by the Marshal County Board of Public Works last August. The suit sought to overturn a permit decision by the Tennessee Department of Environment and Conservation (TDEC) that included protective Duck River flow restrictions.

The Southern Environmental Law Center supported the TDEC decision on behalf of the Nature Conservancy and the Tennessee Wildlife Federation. Both organizations viewed the flow restrictions as essential to balancing water supply needs with those of the highly-sensitive aquatic communities inhabiting the Duck River. Of course, Marshal is the next county upriver of Maury County and Columbia.

[19] The USDA Web Soil Survey is at: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

[20] The *Maury County Regional Water Supply Strategic Plan* is available online at: http://www.duckriveragency.org/Maury%20County%20Strategic%20Plan%20Report.pdf


Columbia/Big Bear Bluffs Hydrologic Soil Groups from USDA Web Soil Survey
Soil Rating Polygons
A
A/D
B
B/D
C
C/D
D
Not rated or not available
Bear Creek
Duck River
Driveway
Tom J Hitch
Iron Bridge Rd
412

I understand the suit was recently settled. It is also my understanding that the settlement included launching the Duck River Pilot Project, the goal of which is to take a comprehensive look at options for providing the water needed by existing and future residents and other users while keeping enough flow in the Duck River to preserve its very diverse and important ecosystem along with the many recreational uses it supports.

BIG BEAR BLUFFS RECHARGE & WATER INFLOW UNIQUELY IMPORTANT

As previously mentioned, Columbia/Big Bear Bluffs occupies a mere 0.05% of the Duck River watershed at the Columbia water intake 1.8 miles downriver of the site. Though the 413-acre site may seem insignificant when compared with the massive watershed, the groundwater recharge then inflow from the site could become of far greater significance come future droughts.

According to Table 2, in the U.S. Geologic Survey report *Recharge Rates & Aquifer Hydraulic Characteristics For Selected Drainage Basins In Middle & East Tennessee*, an average of 4.8 inches of recharge occurs annually in the Columbia portion of the Duck River watershed.[21] For the 413-acre Columbia/Big Bear Bluffs site, 4.8 inches of annual recharge works out to nearly 54 million gallons of groundwater recharge per year.[22] This also means nearly 54 million gallons/year of high-quality inflow to the Duck River. This recharge and inflow enter at a point less than two miles upriver of the Columbia water supply intake.

The next major Duck River water withdrawal point is 32 miles upstream of Columbia at the Spring Hill Water Department intake. During a drought, the groundwater recharge and inflow stemming from forest and other open lands along the 32 miles of river between the Columbia and Spring Hill intakes would be of far greater importance. The Big Bear Bluffs site occupies 1.25 miles or 2% of the 64 miles (32 miles for each of two banks) of shoreline between the Columbia and Spring Hill intakes.

Given this 2%, the potential importance of the high-quality inflow from the site becomes far greater when contrasted with the 0.05% of the watershed it occupies, particularly in light of how near the site is to the Columbia intake. For this and many other reasons, the City of Columbia should safeguard these immediately upriver lands within the growth boundary from large-scale forest removal and intense development.

BIG BEAR BLUFFS MOST SENSITIVE PORTION OF COLUMBIA GROWTH AREA

Map 4 - Future Land Use Map & Special Areas, on the next page, is from the 2018 *Connect Columbia* comprehensive growth plan.[23] The red dashed line represents the Columbia Growth Boundary. I added Big Bear Bluffs site and the Columbia Duck River water supply intake labels to the map.

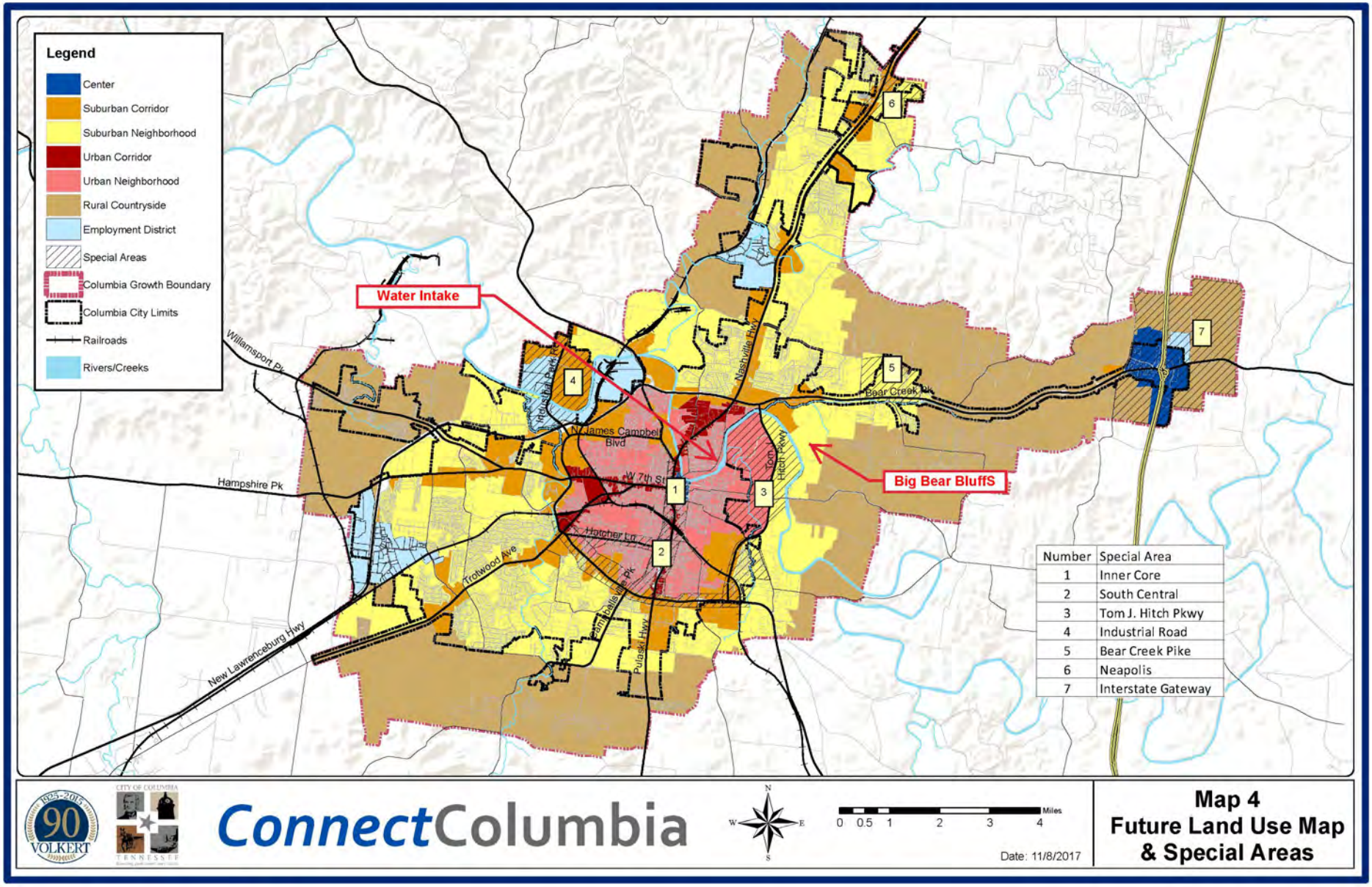
Note that Big Bear Bluffs is one of very few parcels within the Growth Boundary located upriver of the water supply intake and along the portion of the River with the highest mussel species

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[21] The report Recharge Rates & Aquifer Hydraulic Characteristics For Selected Drainage Basins In Middle & East Tennessee is available online at: https://duckriveragency.org/Rivermaps/wrir_90-4015.pdf

[22] 4.8 inches of recharge/year ÷ 12 = 0.4 feet of recharge/year x 43,560 square feet/acre = 17,424 cubic feet of recharge/acre/year x 413 acres = 7,196,112 cubic feet of recharge/year x 7.48 gallons/cubic foot = 53.8 million gallons of recharge/year for the 413-acre Big Bear Bluffs site.

[23] Connect Columbia is available online at: https://www.columbiatn.com/577/Connect-Columbia-Comprehensive-Plan


Legend
Center
Suburban Corridor
Suburban Neighborhood
Urban Corridor
Urban Neighborhood
Rural Countryside
Employment District
Special Areas
Columbia Growth Boundary
Columbia City Limits
Railroads
Rivers/Creeks
Water Intake
Big Bear BluffS
Williamsport Pk
Hampshire Pk
New Lawrenceburg Hwy
Trotwood Ave
Hatcher Ln
W 7th St
N James Campbell Blvd
Nashville Pkwy
Tom J. Hitch Pkwy
Bear Creek Pk
Pulaski Hwy
Ferry Dallas Rd
Industrial Rd
1
2
3
4
5
6
7
Number | Special Area
1 | Inner Core
2 | South Central
3 | Tom J. Hitch Pkwy
4 | Industrial Road
5 | Bear Creek Pike
6 | Neapolis
7 | Interstate Gateway
ConnectColumbia
N
W
E
S
0 0.5 1 2 3 4 Miles
Date: 11/8/2017
Map 4
Future Land Use Map
& Special Areas

richness based on the 2017 study referenced on page 3, of these comments. Given the close proximity of the site to these highly-sensitive features and the poor suitability of the site for highly-effective stormwater protection measures, this 413-acre parcel is arguably the last area within the Growth Boundary that should be considered for annexation and upzoning.

Instead, the City of Columbia should consider the value of amending Future Land Use Map & Special Areas and the comprehensive plan to switch the 413-acre site from the current Suburban Neighborhood future land use designation to Rural Countryside. Consideration should also be given to establishing a new Conservation category, which is used by many local jurisdictions throughout the U.S.

Some of the provision essential to allow a reasonable amount of development on lands designated Conservation while preserving ecological benefits, could include:

- Preserving at least half the site as forest,
- Minimum 100-foot forest buffers along all waters,
- Uses would be restricted to residential or other low-intensity uses,
- Buildings would be clustered so runoff would flow to soils suited to highly-effective stormwater BMPs, like infiltration and bioretention, and
- Buildings would be served with wells and advanced treatment septic systems; not public water-sewer.

COMPREHENSIVE PLAN AMENDMENT-REZONING CRITERIA NOT MET

Sections 3.18.7 and 3.19.6, of the City of Columbia Zoning Ordinance[24], lists criteria the Planning Commission is to use in reviewing then making recommendations regarding a comprehensive plan amendment and a rezoning request. The following analysis pertains to criteria relevant to the adverse impacts to the Duck River documented in these comments. The staff report and the other documents posted on the Planning Commission's May 11th and July 6th agendas were mostly silent with regard to these impacts.

Comprehensive Plan Amendment

Section 3.19.6, lists four criteria for reviewing the Columbia/Big Bear Bluffs comprehensive plan amendment request. The probable adverse effects of the project to the Duck River fails to meet two of these four criteria.

A. Whether the proposed change would be consistent with the intent, goals, objectives, policies, guiding principles and programs of any adopted plans;

The Columbia's Land Use Plan[25] section of the Connect Columbia comprehensive plan[26] includes the following text relevant to the potential Duck River impacts of the Columbia/Big Bear Bluffs project:

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[24] The Columbia zoning ordinance is available online at: https://www.columbiatn.com/documentcenter/view/167
[25] The Land Use Plan is available online at: https://www.columbiatn.com/DocumentCenter/View/186/Connect-Columbia---Land-Use-Plan-PDF
[26] The Connect Columbia plan is at: https://www.columbiatn.com/577/Connect-Columbia-Comprehensive-Plan

Page 6: The natural environment, that is, the environment existing prior to urban development or related disturbance, often has a significant impact to the pattern of land-use and development in a community. Simply put: all development occurs within a natural environment, and that environment imposes constraints and limitations on all development. Ignoring these factors can prove to be extremely costly to specific property owners and to the community as a whole.

With regard to the natural environment, the 2017 study referenced in these comments indicated that the portion of the Duck River at and upstream of the Columbia water intake was the most ecologically diverse and sensitive portion of the river system. It is also the river section which would have the greatest effect on the quality of water withdrawn for consumption by Columbia area residents. The large area of forest on the 413-acre site provides high-quality inflow to this portion of the Duck River. These factors make the 413-acre parcel the most sensitive within the portion of Columbia Growth Boundary area adjoining the Duck River.

Much of the forest on the site will be removed if the Columbia/Big Bear Bluffs project is approved. While the use of highly-effective stormwater measures could resolve the loss of forest, most of the soils on the site are unsuited for these measures. Therefore, a dramatic increase in stormwater pollution and loss of groundwater recharge will result. Given the lack of use of highly-effective measures on existing construction sites, it is likely substantial clay-sediment pollution would also result from developing the Big bear Bluffs site.

It is for these reasons that amending the comprehensive plan to allow the Columbia/Big Bear Bluffs project will result in a very significant impact to the natural environment of that portion of the Duck River that is of greatest importance to the City and its residents.

Pages 9-10: The existing pattern of land-use within an area has a direct impact on the hydrology of an area. The more impervious surface an area has, the more severe the stormwater run-off problems become. In an area with troublesome drainage problems all community decision-makers should be sensitive, aware, and active about land use decisions and the direct hydrologic impacts of those decisions. Each new development should be thoroughly examined for its impact on the hydrologic system of the study area.

The Columbia/Big Bear Bluffs site lacks soils suitable to the highly-effective stormwater management measures essential to safeguarding the portion of the Duck River hydrologic system adjoining the site. The site contains the portion of the Growth Boundary area of greatest importance to the health, safety and welfare of City residents. The loss of so much forest adjacent to this portion of the Duck River and construction-phase clay-sediment pollution will compound the impact.

C. Whether the proposed change would create substantial adverse impacts in the adjacent area or the City in general; and

> For the reasons described above, the proposed change would cause substantial adverse impact to the adjacent area which is the portion of the Duck River of greatest importance to the City and surrounding residents.

Rezoning
Section 3.18.7B, of the City of Columbia Zoning Ordinance, sets forth the criteria the Planning Commission is to use in the review and formulating of recommendations regarding a rezoning request. The Columbia/Big Bear Bluffs rezoning request fails to meet the following criteria:

1. The rezoning is in agreement with the general plan for the area;

> As explained above, the Duck River impacts resulting from the proposed rezoning are not in agreement with the Connect Columbia comprehensive plan.

3. It has been determined that there will be no adverse effect upon adjoining property owners unless such effect can be justified by the overwhelming public good or welfare;

> The proposed rezoning will have a very substantial adverse effect on adjoining property owners and those in the larger area with minimal justifying benefits to the public good or welfare.

6. The availability of adequate school, road, parks, wastewater treatment, water supply, and stormwater drainage facilities.

> Most of the soils on the site are unsuitable for the highly-effective stormwater drainage facilities needed to accommodate the intense development allowed by the rezoning. Therefore, rezoning would jeopardize the Columbia water supply.

Because of the numerous criteria Columbia/Big Bear Bluffs fails to meet, the Planning Commission should recommend denial of the Comprehensive Plan amendment and rezoning request. At the very least though, the Planning Commission should postpone a recommendation until the additional information in the last section of this letter becomes available.

NEED TO POSTPONE BIG BEAR BLUFFS ANNEXATION-UPZONING
A decision to annex then upzone the Columbia/Big Bear Bluffs site should be postponed until the:

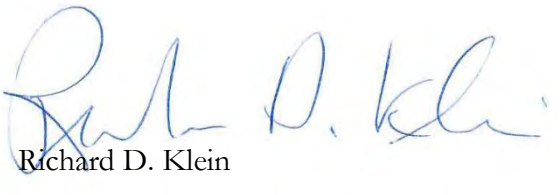
- City studies the value of amending the Connect Columbia comprehensive plan with a Conservation category and including the Big Bear Bluffs site in this category,

- The Duck River Pilot Project comprehensive analysis is completed and shows how continued growth in the watershed can be managed while balancing the needs of mussels and other uniquely important and sensitive ecosystem communities, and

- An independent study is carried out by independent, nonprofit watershed or other environmental organizations of construction sites in the Columbia area to determine if the use of highly-effective erosion and sediment control measures is as low as recent aerial photos indicate and, if so, changes are implemented that achieve a high degree of success in getting disturbed soils under a protective blanket of straw mulch and grass. An example of such an independent study is at: https://ceds.org/wp-content/uploads/2019/06/2015GBSESPReport.pdf.

My resume is attached to this letter. I can be reached at 410-654-3021 or Rklein@ceds.org should you have any questions.

Sincerely,



Richard D. Klein

COMMUNITY & ENVIRONMENTAL DEFENSE SERVICES

Richard D. Klein, President
24 Greenshire Lane
Owings Mills, Maryland 21117

(410) 654-3021
E-Mail Rklein@ceds.org
Web Page:ceds.org

QUALIFICATIONS
LAND USE IMPACTS UPON
AQUATIC SYSTEMS

RICHARD D. KLEIN

EMPLOYMENT HISTORY

COMMUNITY & ENVIRONMENTAL DEFENSE SERVICES

1987-Present		President

MARYLAND DEPARTMENT OF NATURAL RESOURCES

1977-1987	Save Our Streams Program	Conservation Associate Natural Resources Manager
1973-1977	Water Quality Services Division	Conservation Associate
1969-1973	Anadromous Fish & Stream Survey Project	Conservation Aide Conservation Associate

EXPERT TESTIMONY ON THE EFFECTS OF LAND DEVELOPMENT UPON AQUATIC SYSTEMS

Though I am not certified as a biologist, chemist, engineer, or any other specific professional classification, my 49 years of experience in evaluating the effects of land development upon aquatic systems has allowed me to qualify as an expert in circuit court, the Maryland Court of Special Appeals, and the following administrative bodies:

Decision-Making Body	Case
Anne Arundel Co., MD Board of Appeals	Back Bay Beach Project Chesapeake Terrace Rubble Landfill Woods Landing II
Baltimore Co., MD Board of Appeals	Eck Property Georges Transfer Greystone Golf Course Villa Julie College

Baltimore Co, MD *continued*	
Zoning Commissioner/Hearing Officer	Bridle Ridge
	Burns Property
	Glyndon Meadows
	Glyn Garth
	Greystone Golf Course
	Honeygo Rubble Landfill
	Locksley Conserve
	Magers Landing
Cecil Co., MD	
Board of Appeals	Old Line Village
Charles Co., MD	
Board of Appeals	St. Peters Church mining site
Board of County Commissioners	Chapmans Landing
District of Columbia	
Zoning Commission	Arkenderry Mews
Dorchester Co., MD	
Board of Appeals	Hunting Creek rubble landfill
Easton, CT	
Planning & Zoning Commission	Running Brook Farm
Conservation Commission	Running Brook Farm
Howard Co., MD	
Board of Appeals	Greenwood Place
	Prince Property
	Donaldson Funeral Home
Planning Board	Covenant Baptist Church
Kent Co., MD	
Board of Appeals	Eastern Shore Bible Church
Planning Board	Eastern Shore Bible Church
	Bramble Contractor Yard
King George Co., VA	
Board of Supervisors	Hopyard Farm
Circuit Court	Guest et al v. Board of Supervisors
Department of Environmental Quality	King George landfill
King County, WA	
Hearing Examiner	Beaver Lake Estates II
	Bordeaux at Beaver Crest
	Greens At Beaver Crest
	Norris Estates
Louisa Co., VA	
Board of Supervisors	Edgemar Rezoning Request
Martha’s Vineyard Commission, MA	Meeting House Golf Club
Maryland Office of Administrative Hearings	Villa Julie College

Maryland Wetlands Administration	Baldwins Choice
	Riddle Farm
Montgomery Co., MD	
Planning Board	Marriott/Milestone Project
	Residences at Great Falls
Zoning Hearing Examiner	VanGrack/McNeil Project
	Miller Property
Pilesgrove Township, NJ	
Planning Board	Point Airy Place
Prince George's Co., MD	
Planning Board	The Woodlands Project
	Schelford North Farm
Zoning Hearing Examiner	Cross Road Trail rubble landfill
	Villages of Belmont
Prince William Co., VA	
Planning Board	Waverley
Queen Anne' County, MD	
Board of Appeals	Days Cove Rubble Landfill
Board of County Commissioners	Rubble landfill zoning text amendments
Planning Board	Rubble landfill zoning text amendments
Saint Mary's Co., MD	
Board of Appeals	Cedar Cove Marina Boatel
	Persimmon Rubble Landfill
	Renie Quade Property
	Woods at Myrtle Point
Board of County Commissioners	County solid waste plan
	First Colony
Planning Commission	First Colony
	Willowbrook
	Woods at Myrtle Point
Tinicum Township, PA	
Board of Supervisors	Quarry Valley Country Club
Worcester Co., MD	
Board of Appeals	Captains Pointe
Board of County Commissioners	Captains Pointe
	Lighthouse Sound

EDUCATION

In 1973, I began pursuing a degree in environmental science so I could engage in professional level work within the Department of Natural Resources (DNR). After completing my first year of college it became apparent that DNR would permit me to perform professional level work regardless of academic credentials. At that point I elected to expand my knowledge of

environmental science through independent study and the training provided through the Department. I did not complete a degree program.

EXPERTISE GAINED THROUGH EXPERIENCE & OBSERVATION

TRAINING

While working under the supervision of DNR chemists, biologists, engineers, and other professionals, I acquired expertise in a wide range of methods for assessing the physical, chemical, and biological characteristics of aquatic systems. These systems included freshwater streams and rivers, ponds, lakes, reservoirs, wetlands, tidal waters, and groundwater. Following is a summary of the specific assessment methods I learned how to employ:

- Collection of water samples for chemical and bacteriological analysis; operation of various water quality meters including those designed to measure dissolved oxygen, stream flow, tidal currents, specific conductance, turbidity, pH, chlorine, chloride, fluorescence, and water/air temperature. I also learned how to operate weather monitoring equipment, well sampling equipment, data loggers and recorders, and robot water quality monitors. I spent several months analyzing water samples for chemical and bacteriological parameters in the DNR laboratory.

- I was instructed in procedures for surveying streams, rivers, tidal waters, and lakes for factors which may effect fishery resources. These factors included pollution, discharges, stormwater runoff, erosion and sedimentation problems, fish migration barriers, sources of thermal pollution, stream shade and buffer deficiencies, livestock grazing effects and other agricultural impacts, construction site impacts, physical destruction of aquatic habitat, and a number of other factors. I employed these procedures in surveying nearly a thousand miles of Maryland streams, rivers, tidal waters and impoundments.

- I was also instructed in procedures for collecting and identifying fish, aquatic insects, crustaceans, aquatic plants (including algae), shellfish, and other aquatic organisms. I was taught how to assess the condition of individual organisms and to use aquatic communities to assess the health and condition of streams, lakes, tidal waters, and other aquatic systems.

- I learned how to study groundwater systems through monitoring wells and other methods. My responsibilities included sampling monitoring wells at landfills, sewage sludge disposal sites, wastewater treatment facilities, and other locations.

- I was also instructed on proper procedures for designing and conducting various studies of aquatic systems. This included sampling station selection, quality control/quality assurance, data analysis, and interpretation of data results based upon Maryland water quality standards and various other criteria. I was also instructed on the preparation of reports on the findings of studies of aquatic systems.

PROFESSIONAL RESEARCH & ACTIVITIES-DNR

While I was with the Water Quality Services Division I studied the quality of stormwater runoff from developed lands. This experience included sample collection, laboratory analysis, study design, and interpretation of the results. In 1978, I conducted my first independent professional study, which focused on the relationships between land development and the health of aquatic systems. The paper addressed the effect of land development upon groundwater recharge and base flow, water temperature, pollutant loadings, channel erosion, and the overall relationship between percent impervious area and the health of fish and macroinvertebrate communities. The results of my study were published in the scientific journal *Water Resources Bulletin* (15(4):936-952) under the title of *Urbanization and Stream Quality Impairment*. This paper serves as the primary basis for percent impervious area limits found in the Maryland Chesapeake Bay Critical Areas law and many local land use laws. My paper also served as one of the primary justifications for the two-acre lot exemption contained in the Maryland Stormwater Management regulations.

I developed a method for quickly assessing the health of freshwater streams and rivers using aquatic insects, crustaceans, and other macroinvertebrates.

I managed 15 major DNR investigations of the effects of developed lands upon the quality of aquatic systems. These investigations utilized the macroinvertebrate assessment technique I developed.

I designed and managed a study of the effects of Savage River Reservoir upon the Savage River, in Garrett County, Maryland. The study was designed to assess the effects of the reservoir upon channel morphology (stream bed particle size distribution, channel width and depth), base flow, water depth and velocity distributions, and various facets of stream ecology, including effects upon aquatic insects, crustaceans, and fishery resources. I interpreted the data generated through the study and prepared the report of findings.

I conducted a study of the effects of Prettyboy and Loch Raven Reservoirs upon the temperature, chemistry, aquatic insects, and fishery resources of Big Gunpowder Falls.

I conducted studies of the temperature regime of streams and the effects of the following factors upon stream temperature: stormwater runoff from developed lands, absence of shading vegetation, effects of varying amounts of shade upon stream temperature, discharges of heated water from industrial activities, and impoundment effects.

I conducted a study of fish migration barriers formed by highway crossings in Maryland.

I managed a study of the effects of existing stormwater management ponds and lakes upon stream channel erosion. The study was carried out by DNR staff under my supervision.

I developed a program for training citizens to evaluate the quality of erosion and sediment control measures on construction sites. I supervised a number of large citizen inventories of erosion and sediment control quality at the county and watershed level.

I developed and managed the Gwynns Falls Restoration Campaign. This was the first attempt to restore a degraded suburban-urban stream in Maryland. It was a joint project of Baltimore County, the City of Baltimore, and the Maryland Department of Natural Resources. My duties included developing a watershed restoration plan, overseeing a $100,000 study to establish "before" conditions in the stream system, and managing the staff assigned to the project. I chaired the joint city, county, and DNR committee overseeing the campaign.

I was the author of the DNR handbooks entitled *The Preservation & Enhancement of Stream Quality* and *The Restoration of Urban Streams*. I also wrote DNR publications on the use of the Universal Soil Loss Equation and Manning's equation for calculating land development effects upon flood water volumes.

I designed and supervised the installation of eight stormwater infiltration structures. These were the first stormwater infiltration structures installed in an existing developed area in Maryland.

I compiled a review for DNR of the scientific literature of the effects of sediment pollution from agriculture, logging, mining, and construction activity upon aquatic systems.

I compiled another review of scientific literature for DNR entitled Effects of Urbanization Upon Aquatic Resources.

I was assigned the responsibility by DNR's Tidewater Administration to develop habitat protection criteria for all of Maryland's fish and shellfish resources. This responsibility included review of the scientific literature as well as coordinating research conducted by most of the agency's other professional staff. The criteria covered physical habitat requirements along with temperature preferences and the lethal-sublethal effects of temperature, toxic substances, and all other environmental contaminants.

PROFESSIONAL RESEARCH & ACTIVITIES: CEDS

Since starting Community & Environmental Defense Services (CEDS) in 1987, I have evaluated the environmental effects of thousands of land development projects. Though most of these evaluations were performed at the request of citizen organizations, my clients have included development companies as well as local and state government.

I prepared watershed management plans for the following Maryland waterways: Cuckold Creek, Middle River, Town Creek, and the Saint Mary's River. Much of the plans are devoted to the effects of current and future watershed development.

In 1990, I conducted a survey of 90 construction sites in the Chesapeake Bay watershed on behalf of the Chesapeake Bay Foundation. The purpose of the survey was to assess erosion and sediment control quality along with stormwater management measures. The results of the survey were presented in a book entitled *Turning The Tide* (Island Press).

Methods for assessing and minimizing the effects of land development upon aquatic systems were included in my book, *Everybody Wins: A Citizen's Guide to Development*, which is published by the American Planning Association.

I prepared a guidance publication entitled *Protecting The Aquatic Environment From The Effects of Golf Courses*. The publication begins with a review of a study I conducted of 11 golf courses in Maryland and Pennsylvania. Next, the scientific literature regarding the environmental effects of golf courses in reviewed. I then presented a number of recommendations for siting, designing, and managing golf courses to enhance the aquatic environment. The findings presented in my publication were cited in a literature review commissioned by the U.S. Golf Association, *Environmental Issues Related to Golf Course Construction and Management.* I wrote a chapter in the second edition of *Handbook of Integrated Pest Management for Turf and Ornamentals*, which is published by the U.S. Environmental Protection Agency. The chapter is entitled Siting and Design Considerations to Enhance the Environmental Benefits of Golf Courses. The chapter is based upon my publication *Protecting the Aquatic Environment From The Effects of Golf Courses*. I presented by findings at a 1991 conference sponsored by the U.S. Golf Association and the Golf Course Superintendents Association of America. I also presented a paper at the 1991 New York State Turfgrass Conference and the 1991 conference on golf courses held in Honolulu, Hawaii. A paper I wrote appeared in the March/April 1991 issue of the Green Section Record, which is published by the U.S. Golf Association. In 1991, I was retained by the Office of State Planning, State of Hawaii, to evaluate the potential environmental effects of three golf courses proposed for construction on the island of Oahu. I have conducted assessments of more that one hundred golf courses located throughout the United States.

I conducted a review of the scientific literature regarding the effects of boating activity and boating facilities upon the aquatic environment. The results of this review were presented in my publication *The Effects of Boating Activity & Related Facilities Upon Tidal Creeks*. Recommendations contained in this publication were incorporated into a U.S. EPA guidance document entitled *Guidance specifying management measures for sources of nonpoint pollution in coastal waters*. The State of Maryland also adopted my recommendations as part of the marina regulations administered by the Tidal Wetlands Division of the Department of the Environment.

I wrote a 300-page book entitled *How To Win Land Development Issues*. This book guides citizens through a process for finding Equitable Solutions to development related concerns.

In 2010, I conducted a series of workshops throughout Maryland on the new Environmental Site Design requirements. More than 200 engineers, government officials, nonprofit staff and volunteers attended the workshops.

PROFESSIONAL COMMITTEES

I served as the County Executive's representative on the Baltimore County Soil Conservation District.

I served as a representative of the Department of Natural Resources on:

- the 208 Technical Advisory Committee which oversaw the Nationwide Urban Runoff Project administered by the former Baltimore Regional Planning Council.
- the subcommittee of the General Assembly that drafted the Maryland Stormwater Management Act.
- the Instream Flow Committee of the Interstate Commission on the Potomac River Basin.
- I served on the Acid-Rain Task Force convened by Trout Unlimited.

I served on the Golf and Environment Roundtable convened by the National Golf Foundation, the U.S. Golf Association other national golfing organizations, and a number of national environmental organizations.

I served on two committees formed by the Maryland Department of the Environment-the Solid Waste Accord and the Rubble Landfill Workgroup .

HONORS & AWARDS

Environmental Excellence Award - Maryland Department of the Environment.
Maryland Governor Schaefer's Salute To Excellence.
Outstanding Conservationist; Maryland State Game & Fish Protective Association.
Conservation Award; Izaak Walton League of America.
Certificate of Commendation; Tawes Award for a Clean Environment.
The Joe Brooks Conservation Award; Maryland Chapter - Trout Unlimited.
Outstanding Water Conservationist; Maryland Wildlife Federation.
Gurney Godfrey Award; Maryland Fly Anglers.
Certificate of Appreciation; Maryland Classified Employees Association.
Outstanding Individual; American Planning Association - Maryland Chapter.

PUBLICATIONS

Urbanization and stream quality impairment. *Water Resources Bulletin* 15(4):948-963

Everyone Wins: A Citizen Guide to Development. Planners Press, American Planning Association, .Chicago, Illinois.

Critical Watershed Analysis: Tailoring Watershed Management Practices to Benefit Sensitive Aquatic Communities, presented at the Conference on Putting the LID (Low-Impact Development) On Stormwater Management, September 21 - 23, 2004, The Inn and Conference Center—Marriott, College Park, Maryland.

Siting and design considerations to enhance the environmental benefits of golf courses. In: *Handbook of Integrated Pest for Turf and Ornamentals*, edited by Anne R. Leslie, U.S. Environmental Protection Agency, Washington, D.C.

Protecting the aquatic environment from the effects of golf courses. Community & Environmental Defense Services, Post Office Box 206, Maryland Line, MD 21105.

Enhancing the environmental benefits of golf courses. *U.S. Golf Association Green Section Record* March/April 1991 and presented at the 1991 Golf Course Superintendents Conference in Las Vegas, Nevada.

Effects of sediment pollution upon the aquatic environment. Maryland Tidewater Administration, Tawes State Office Building, Annapolis, MD 21401.

Effects of urbanization upon aquatic resources. Maryland Tidewater Administration, Tawes State Office Building, Annapolis, MD 21401.

The effects of boating activity and related facilities upon tidal creeks in Maryland. Community & Environmental Defense Services, Post Office Box 206, Maryland Line, MD 21105.

Restoration of Urban Streams Maryland Tidewater Administration, Tawes State Office Building, Annapolis, MD 21401

Preservation & Enhancement of Stream Quality Maryland Tidewater Administration, Tawes State Office Building, Annapolis, MD 21401.

Numerous reports assessing the potential environmental effects of proposed development projects.