Ecological review of the DRBC Draft Natural Gas Development Regulations

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Report and testimony

prepared for

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Prepared by

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EXECUTIVE SUMMARY

This testimony addresses the question whether the proposed DRBC Draft Natural Gas Development Regulations are adequate to protect the ecological resources of the Delaware River Basin. Section 7.4 of the regulations regarding water withdrawals for gas extraction and its relation to the Water Resources Program 2010-2015 was reviewed, as well as the efforts to establish an Ecological Flow Regime for the Upper Delaware River. The regulations are analyzed through the prism of the ecological data gathered by the scientists working on the Delaware River and is supported by a review of recent publications and scientific reports related to the Delaware River.

A thorough review of existing information made it clear to me that allowing massive shale gas extraction and particularly the construction of about 18,000 wells may pose a substantial risk to stream and river ecology within the watershed. A high number of existing and very complex uses makes it difficult to protect and enhance the current ecological status even without the added pressures of resource extraction. The tools and scientific foundation for the current decision-making and management process are still too inadequate to assure the protection of keystone species of the Upper Delaware River. A cursory analysis using two available habitat models indicates a potential for the substantial reduction of available habitat for brown trout and dwarf wedgemussels.

I concluded that the regulations are inadequate and contrary to current efforts of the DRBC to protect and maintain healthy aquatic populations, which is declared as the goal in the Water Resources Plan. The reliance on Q7-10 as a pass-by flow has no scientific justification and the reliance on more stringent state regulations is not realistic since they do not exist.

I recommend that the current moratorium on Natural Gas Development within the Delaware River Basin not be lifted until an instream flow management plan is developed for the entire

watershed and until evidence is provided that implemented measures will maintain the ecological integrity of the system. A comprehensive, multi-faceted model of the watershed should be developed prior to issuing any new water withdrawal permits, including those related to Natural Gas development projects. The model should be based on the reference river concept and include the possibility of balance between planned actions and ecological compensation measures, which would lead to the improvement of the current status of the river.

I. STATEMENT OF QUALIFICATIONS

1. **Education.** I received a Ph.D., M.S. and G.E. in natural resources management and water engineering with a focus on fisheries ecology from the University of Agricultural Sciences in Austria. My Curriculum Vitae is provided as **Exhibit 1**.
2. **Experience.**
    a. I am the founder and director of Rushing Rivers Institute, a non-profit organization promoting river science in river management.
    b. I have been a Research Associate at the Department of Natural Resources of Cornell University, a Research Associate Professor at the Department of Natural Resources Conservation at the University of Massachusetts and held the position of Research Associate Adjunct Professor and Director of the Northeast Instream Habitat Program at Mt. Holyoke College in South Hadley, Massachusetts. I currently hold a position of adjunct professor at the University of Nebraska – Lincoln.
    c. I am also a founding member of the International Aquatic Modeling Group, and a member of the American Fisheries Society, the River Management Society, the International Society for River Science, the International Association for

Hydraulic Research, and the Union of Concerned Scientists.

d. I developed the MesoHABSIM model and the associate SimStream software, a computer simulation system for fish and mussel habitat restoration planning that has been applied around the US and abroad and is currently used for the development of Protected Instream Flow Standards in the State of New Hampshire.

e. My primary research area is in the assessment and simulation of physical habitats for fish and invertebrate communities as a basis for ecosystem restoration. My recent projects focus on river habitat simulation, instream flows and comprehensive river restoration planning.

f. I have 25 years of extensive experience in the planning and implementation of river restoration projects, the design of nature-like bypass channels to support fish passage and the restoration of migratory species, as well as the assessment of ecological integrity.

g. I have assisted in the drafting of laws and policies to protect instream flow in the states of MA, NH and CT. These projects are designed to determine water allocation methods with the goal of balancing human needs with ecological needs.

h. I am very familiar with the Upper Delaware River, the adjacent area and issues involved in flow management. I was a project leader on the study of Dwarf Wedgemussel Habitat in the Upper Delaware River and a member of the Subcommittee for Ecological Flows for Delaware River Basin Commission.

II OPINIONS

1. My report is organized as follows. In the Background section, I describe the circumstances of the project and my professional perspective on the overall impact and proposed permitting conditions. In following sections, I address the technical issues and concerns associated with the proposed rule. The conclusions and recommendation sections provide a brief synopsis and the conclusions of my review.

Background

2. The dramatic impact of human-induced alterations on freshwater flora and fauna is widely reported (Gleick et al., 2001; UNEP, 1999). Running water ecosystems belong to the most severely human-impacted habitats on Earth (Nilsson et al., 2005; Malmqvist and Rundle, 2002). Of more than 3,500 species currently threatened with extinction worldwide, one-quarter are fish and amphibians.
3. In freshwaters, the projected decline in species diversity is about five times greater than in terrestrial ecosystems (Pimm et al., 1995). This rate is similar to that of great prehistoric extinctions (Malmqvist and Rundle, 2002).
4. It has been suggested that some 30-35% of all freshwater fish species are already extinct or in serious decline worldwide (Stiassny, 1999). Ninety-three percent of these reductions occurred during the last 50 years, indicating extinction of freshwater fishes is a serious and accelerating global trend (Harrison and Stiassny, 1999).
5. The freshwater mussel is one of the most imperiled animal groups in North America with only 25% of the existing species having stable populations (Williams et al., 1995). Freshwater mussels fulfill many crucial ecosystem services such as the filtering of large

amounts of water, which removes pollutants from the water. Hence, healthy assemblages of mussels are necessary to maintain high water quality standards.

6. Historical and ongoing urbanization of our landscape intensifies floods and droughts, causing damage to human property and stressing the fauna. Excessive water withdrawals due to human and industrial demands dry up rivers with increasing frequency.
7. The process of urbanization alters seasonal hydrographs by increasing peak flows and decreasing base flows (e.g., Bedient and Huber, 1988; Dunne & Black, 1970; Parasiewicz and Goettel, 2003; Petersen, 2001). In the Northeastern United States, this hydrological pattern appears to be a regional phenomenon and a lasting legacy of historic deforestation. Even in areas such as the Catskill Mountains that superficially appear to have recovered from the historical impacts of earlier timber harvests, similar effects can still be observed (Parasiewicz et al., 2010).
8. The change in our global climate further contributes to this impact by causing higher summer air temperatures, a longer summer season, and lower minimum river flows together with more frequent and severe flooding (Faloon and Betts, 2006).
9. The water in these reduced flows tends to warm up more quickly in rivers that have been widened by previous floods and historical logging operations. Shallow ponds, created by thousands of small dams, serve as natural solar collectors. Additionally, less cold water is entering the rivers from base flow because of increased ground water withdrawals. We are frequently now measuring summer water temperatures in excess of 80°F in long stretches of “coldwater” streams (e.g. Ballestero et al., 2007, Parasiewicz et al., 2007).
10. Consequently, scientists anticipate a loss of coldwater fauna from rivers and streams of the Northeastern United States and recommend that proactive management preventing

extended droughts and low flow levels by avoiding excessive water withdrawals must be a management priority.

11. Silk et al. (2000) eloquently suggests that "The natural ecosystem of any river is the product of millions of years of adaptation and evolution, which have created a myriad of variables and subtleties more complex than we can imagine." Due to this complexity and continuing conflicts of interest among competing water uses, a very precise planning and evaluation of potential development impacts is required.
12. Water allocation issues are not new, and many techniques have been developed in recent decades to address these problems (Stalnaker, 1995; Dunbar et al., 1998). Only recently we learned to recognize that not only is the quality and quantity of water released below a hydro-power or irrigation dam important, but also that modifications of hydrological patterns can have detrimental effects on aquatic life (Richter et al 1997).

Delaware River Watershed

13. The Catskill Mountains' and Poconos watersheds are generally rural, topographically steep areas with shallow, permeable soils overlaying restrictive bedrock or fragipans. Heightened flow peaks cause severe erosion, leading to the down-cutting and over-widening of river corridors (Parasiewicz et al., 2010). The notable lack of woody debris structure documented in the Stony Clove Creek study in the Catskill Mountains (Parasiewicz et al., 2003) was partially a consequence of increased flow peaks removing log jams before they can stabilize, but also due to frequent "cleanups" of woody debris as a flood protection and beautification measure.
14. These changes, in combination with reduced stream flows and groundwater levels, increase summer water temperatures and can cause anchor ice in the winter. Anchor ice

can create considerable damage to the aquatic fauna by forcing fish movements and increasing their mortality. In addition, many river corridors, especially those in urbanized areas, have been physically modified (e.g., straightened, widened, dredged or impounded), altering the character of the corridor (e.g. from braided to straightened) and leading to further modifications in the hydrological regime (Hewlett and Hibbert, 1967).

15. The most apparent consequences of such changes in hydrological patterns are a reduction in fish densities and modification of the fish community structure from specialized riverine species towards more generalized species. This phenomenon has been documented in several recent studies in the Northeast Region (eg. Parasiewicz and Goettel, 2003; Armstrong et al., 2001).
16. The Delaware River is considered an exceptionally healthy river mostly because of the length of its free flowing section (see Eric Sildorf's expert report submitted to the DRBC). Among outstanding characteristics, there are a considerable number of freshwater mussel species, including the federally endangered dwarf wedgemussel (*Alasmidonta heterodon*), as well as a large number of migratory fish species, notably American eel and American shad.
17. Proximity to northeastern metropolitan areas as well as low population density makes the Upper Delaware River also a very valuable recreational resource for boaters, hunters and others searching for outdoor adventure and tranquility. The region is famous for its fly-fishing, creating a valuable recreational industry. The watershed is home to the National Park Service Wild and Scenic River program and multiple natural conservation areas.
18. However, the Upper Delaware River is not without a human footprint. The legacy of deforestation and an industrial past is still visible in its over-widened, shallow river

channels and flashy hydrology with rapidly changing flows from very low to very high. The watershed is also under great pressure for hydropower use and as a drinking water supply for New York City (Parasiewicz et al., 2010).

19. The flows in the river are strongly influenced by releases from upstream reservoirs: Cannonsville on the West Branch, Pepacton on the East Branch, Wallenpaupack on the Lackawaxen River, Mongaup on the Mongaup River and Neversink on the Neversink River. A Supreme Court decree was needed to manage the downstream salt wedge in Philadelphia by mandating the minimum flow releases. Due to complex management objectives, the current flows in the river can be erratic and unpredictable.
20. Consequently, the habitat conditions are quite unstable and high water temperatures have caused fish die offs and potentially reduced mussel populations in the past. As documented by an investigation of dwarf wedgemussel habitat, the existing populations are limited to a few locations that maintain hydraulic stability. Repeated surveys on the Neversink River documented a sharp decline of the dwarf wedgemussel population over the last 20 years (see analysis in **Exhibit 2**).
21. Our own observations in the summer of 2005 documented the thermal impact on the fish fauna with scores of dead and dying fish floating in the river (see **Exhibit 3**).

Watershed Management

22. The Delaware River Basin Commission recognizes the unique value of the watershed and its vision statement commits to be "the leader in protecting, enhancing, and developing the water resources of the Delaware River for present and future generations." It includes "Protection and enhancement of ecological integrity" as a guiding principle of the Water Resources Plan. The DRBC adopted Special Protection Waters regulations to further

protect a large portion of the watershed.

23. Despite great multiyear efforts to develop an ecologically sustainable flow management plan, the DRBC has yet to develop a comprehensive and scientifically sound scheme that would take into account a multitude of water uses as well as the protection and recovery of federally endangered species.
24. The efforts to develop the Flexible Flow Management Plan are still debated and do not include measures to protect federally endangered species such as the dwarf wedgemussel.
25. A water withdrawal permitting rule that would be ecologically and scientifically sound also does not exist. This is demonstrated by the example of the Natural Gas Water Withdrawal permit issued to Stone Energy Corporation, which allows the withdrawal of 75% of average daily flow all year round. This determination neither takes into account the seasonality of biological processes nor is backed up by any quantitative scientific investigation of habitat needs of fauna in the Lackawaxen River.
26. Similarly, the neighboring states of Pennsylvania and New York neither have well-defined and scientifically-sound instream flow policies nor water withdrawal permitting rules. Hence, the DRBC cannot rely upon the states to assure appropriate protection measures as proposed in the natural gas regulations.
27. Considerable effort is underway to close knowledge gaps as indicated in the Water Resources Management Program of DRBC. However, many of the planned objectives and products are not completed yet. It obviously will require additional time and funding to develop a truly comprehensive planning foundation for the basin.
28. The developing of such a scheme would require establishing a river specific target state, including a number of ecological targets that would guide the conservation and

sustainable management of the watershed.

29. The reference river concept is critical to management because it establishes a baseline for determining the degree to which a given river deviates from optimal conditions, making it possible to identify the river's specific restoration and conservation needs. In addition, an assessment strategy that is based on reference conditions would provide insight as to the most efficient means to fulfill these needs, and allow for the reliable evaluation of the strategy's success. Without such a reference condition, management activities can easily deteriorate into endless cycles of adaptive management with arbitrary endpoints and attendant scientific disagreement. This has been discussed and recommended in my report for Trout Unlimited published in 2001, but it has not been included in the Water Resources Management Program (Parasiewicz, 2001).

Impact of Natural Gas Development

30. Recent heated debates highlighted numerous impacts of massive natural gas exploration operations such as proposed in Marcellus shale. With regard to the influence on the freshwater fauna we can expect three major issues:

31. Contamination.

    a. As demonstrated in the testimony of Rubin, there is a considerable risk of contaminants reaching the streams and rivers of the Upper Delaware watershed. This can be due to gas and fracking chemicals percolating into the ground water, or to the surface water through blowouts or sedimentation. This would affect not only the water supply for humans but obviously also the aquatic fauna. As demonstrated in the Anderson and Kreeger testimony, this could have lethal consequences for freshwater mussels including the federally endangered

Alasmidonta heterodon. Mitigating the risks of contamination is also essential for pollution intolerant species of fish such as trout and macro-invertebrate fauna. Long term contamination usually leads to a reduction in the number of species and overall low densities of animals.

32. Flow reduction

a. In addition to analyzing the total amount of water used by individual mining wells, the cumulative effect and changes in the flow patterns need to be considered. According to DRBC estimates, with adding 10,000 wells the total amount of withdrawal in a peak year should range about 19 mgd, which translates to about 30 cfs. I used this number to model the impact on the dwarf wedgemussel habitat with the MesoHABSIM model developed by Rushing Rivers Institute following the Dwarf Wedgemussel Habitat study. The historical flow records were reduced by approximately 30 cfs and entered to the model for the calculation of a frequency of rare events that would pose a threat to the mussel fauna. Such stress days occur when persistent durations of low flows are exceeded. The model concluded that this simple reduction would double the frequency of persistent subsistence flows. This is critical, because in the past, USGS scientists observed "gaping" or thermally stressed dwarf wedgemussels in 2005. The increasing duration and frequency of such periods could have devastating effects on the fauna and hinder the efforts to restore the mussel populations. Although a MesoHABSIM model for additional cold water fish and invertebrate species is not currently available, it is clear that through increase of water temperature alone, the effects of such extended durations of low flows may have detrimental

effects on cold water fish species and macro-invertebrate fauna. The same experiment was conducted by applying the USGS-developed Delaware River Decision Support System (Bovee et al. 2007). The results indicated a sharp decline in habitat availability for the majority of the species, and specifically almost 80% of the reduction of spawning habitat for trout in the West Branch of Delaware **(Exhibit 4**). This simulation still did not include the effects of watershed development as described below.

b. Since it is very likely that the number of wells will be much higher than 10,000 (some estimates indicate as many as 32, 000), it is obvious that negative effects described above would be even more dramatic.

33. Increasing floods and droughts

a. Probably the most dramatic impact is to be expected from the development activities accompanying natural gas development across the landscape of the Delaware River Basin. With 18,000 wells as estimated by DRBC we can expect massive construction on road building, impoundments, and forest clearing that will cause increased frequency and intensity of flooding as well as the frequency and duration of droughts. This will sharply exacerbate the impacts of global climate change, which has very similar consequences. In effect, we can expect less and warmer water in summer, degradation of water quality and therefore shifts in fish and invertebrate community structure towards fewer, but more generalist (pond) species.

b. Although in some areas such as the mainstem of the Upper Delaware, drought could be counteracted by releasing water from New York City reservoirs, past

experiences have shown that due to a multitude of interests and climatic unpredictability it is not that simple. Nothing can be done to prevent floods such as those that occurred in 2006 and 2007 except to enact measures to limit the damage of such events.

Proposed DRBC Natural Gas Development Regulations

34. The proposed draft of the Natural Gas Development regulations does not adequately address all of the above issues. Section 7.4(d)(1)(xi), specifying a pass-by flow rule that requires that the Q7-10 flow will remain in the river is based on water pollution standards and is not adequately protective of aquatic fauna. It is not supported by scientific evidence and fails to take into account the seasonality of biological processes. Hence, it violates the Natural Flow Paradigm (Poff et al. 1997), which is a recognized standard in instream flow planning. Although the rule refers to more stringent regulations of host state agencies, those are however also non-existent in Pennsylvania and New York.
35. The proposed rule calls for non-point-source pollution management plans (Section: 7.4(d)(2)(i); however, it fails to address the maintenance of a balanced hydrograph. Furthermore, with estimated 18,000 expected wells, it is my opinion that a significant increase in runoff cannot be prevented. Even if storm water impoundments were created that would meter the water into the rivers during low flow periods, the problem of increased water temperature in the summer remains unresolved.
36. Water contamination through the diffusion of gas to the ground or surface water or measures preventing blowouts are not addressed anywhere in the rule.
37. Probably the most disturbing aspect of the proposed regulation is its inadequacy in information about the watershed and expected impact, which would serve as a foundation

for the decision-making process and regulation. It is surprising that, in an area of high ecological importance and the presence of powerful economic interests (New York City, Philadelphia, Pennsylvania Power and Light and mining industry), there is no comprehensive model of the watershed allowing for the simulation of future scenarios. Such models have been developed and implemented in other areas. One example is the Michigan Water Withdrawals Assessment Tool (http://www.miwwat.org/), which could be a starting point for more accurate models to be applied in the Delaware River Watershed.

Conclusions and Recommendations

38. The Upper Delaware River Watershed is a precious resource with a multitude of outstanding characteristics and users. The maintenance of watershed's ecological integrity requires careful and wise management. Such management is currently under development and measures that prevent degradation of aquatic fauna under climate change scenarios are not in place yet.
39. Adding more complexity and massive additional uses before such a program is in place is counterproductive at this point, as obviously more time and resources are necessary to complete ongoing scientific efforts and take control over current issues in a way that will allow the protection and enhancement of ecological integrity.
40. Therefore, I recommend that the current moratorium on Natural Gas Development should not be lifted until an instream flow management plan has been developed for the entire watershed and evidence is provided that implemented measures will maintain the ecological integrity of the Delaware River Basin.
41. A comprehensive computer simulation model of the watershed hydrology, geology, aquatic habitat, water quality and biological processes should be developed as a

foundation for the rule making. It should allow quantifying all potential consequences of permitted actions with special attention to the biological response of flora and fauna to the anticipated impacts. The model needs to be capable of simulating future scenarios, including global climate change. Such a Multi-model has been postulated by Wiley et al. (2010) for the Great Lakes Basin, clearly demonstrating that the necessary technology is readily available. Hence, creating it is only a matter of investing the appropriate resources and time.

42. Furthermore, the model should include the possibility of a balance between planned actions and ecological compensation measures, which would lead to the improvement of the current status of the River. This would offer an appropriate payback to the society for the ability to extract the natural resources of the region.

43. The DRBC cannot meet its regulatory obligations without having the scientific evidence-based foundation that modeling provides.

44. It would be only socially just if the costs of model development and of compensation measures were carried out by the interested industry and current large-scale users of the Upper Delaware River Watershed. Such an approach is increasingly popular and acceptable among socially responsible industries looking to sustainably use and manage available resources.

II. REFERENCES

45. In preparing this report, I completed the following tasks:

a. I reviewed the following documents:

i. DRBC Draft Natural Gas Development Regulations

ii. DRBC Water Resources Plan

iii. Water Resources Program 2010-2015

iv. Preliminary Analysis of Water Withdrawals and Wastewater Production from the Marcellus Gas Play in the DRB

v. Stone Energy Corporation Surface Water Withdrawal for Natural Gas Exploration and Development Projects West Branch Lackawaxen River Withdrawal Site Mount Pleasant Township, Wayne County, Pennsylvania.

vi. Experts reports in the matter from November 2010 posted on the DRBC website:

1. Erik Silldorff, Ph.D.
2. Patrick M. O'Dell, P.E.
3. Robert M. Anderson and Danielle A. Kreeger, Ph.D.
4. Conrad Daniel Volz, DrPH, MPH
5. John K. Jackson, Ph.D. and Bernard W. Sweeney, Ph.D.

vii. Other pertinent information available on the website of DRBC

viii. Experts reports for the DRBC Consolidated Administrative Hearing on Grandfathered Exploration Wells from November 2010 prepared for Delaware Riverkeeper Network:

1. Michele C. Adams, P.E. LEED AP
2. Ronald E. Bishop, Ph.D., CHO
3. Peter M. Demicco, RPG
4. Susan L. Harvey
5. Glen C. Miller, Ph.D.
6. Emmet M. Owens, P.E.

7. Paul A. Rubin

8. Daniel Thau Teitelbaum, M.D.,P.C.

d. I have cited and referred to the following literature in this testimony:

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