Restoring the Water Commons

A facilitated dialogue about ecological thresholds, biomimicry, water governance and society

A Coalition for Alternative Wastewater Treatment Report

January 13, 2010
Seattle, WA

January 26, 2010
Washington, DC

The organization that prepared this report:
**Principal Investigator: Valerie I. Nelson, PhD

Coalition for Alternative Wastewater Treatment

The research on which this report is based was funded, in part, by the United States Environmental Protection Agency (EPA) through Cooperative Agreement No. X-830851-01 with the Water Environment Research Foundation (WERF). However, the views expressed in this document are solely those of the Coalition for Alternative Wastewater Treatment, and neither EPA nor WERF endorses any products or commercial services mentioned in this publication. This report is a publication of the Coalition for Alternative Wastewater Treatment, not WERF or EPA. Funds awarded under the Cooperative Agreement were not used for editorial services, reproduction, printing, or distribution.

TABLE OF CONTENTS

INTRODUCTION

Restoring the Water Commons: A Facilitated Dialogue about Ecological Thresholds, Biomimicry, Water Governance and Society.

Water is ubiquitous on our blue planet. It should be no surprise that water in its many manifestations plays a role in a number of the global ecological thresholds facing collapse, or that the impacts of climate change will be felt first with flooding, drought, and sea level rise. Too often we define our problems from a discrete point of view and fail to recognize the broader implications of our choices. The tragedy of the commons is a powerful metaphor for understanding how rational individual choices can unravel an ecosystem, a community, and a culture. Is water a transcendent commons that requires an integrated approach? What are the global thresholds that threaten the resilience of nature's systems? What role does water play in them? What can we learn from nature's ways to inform our thinking? If we truly begin to understand the threats we face and some of the tools to address them, how can we manifest solutions in our governments, regulations, and communities?

A small group of experts with deep expertise was challenged to help us address these questions. Over two full-day working sessions, we tapped the best thinking from multiple perspectives with an emphasis on science, the arts, and change management.

These meetings were funded by a Water Environment Research Foundation grant headed by Dr. Valerie Nelson. We focused on how water is connected to these multiple planetary boundaries, and how water infrastructure and urban planning experts should be thinking about redesigning the "paradigm" of urban management and urban design. We also considered how new infrastructure designs can "mimic" natural processes. We also developed a policy and "market transformation" agenda based on the answers to these questions.

	Boundary	Water Relationship	Human Mismanagement
1	Anthropogenic Climate Change •Loss of summer polar ice irreversible •Much warmer, greenhouse gas-rich state •Sea levels meters higher than present •Weakening or reversal of terrestrial carbon sinks •Boundary 350 ppmv CO_2: Current level 387 ppmv Radiative forcing: Boundary 1: Current 1.5	Observed Effects: •Reduced snow and ice cover •Precipitation changes/increases in severity •Increase in very dry land areas Predicted Effects: •Decreased water quality •Increased water stresses •Unpredictable conditions	•Pollution and GHG emissions externalized •Slow response from governments, corporations, and individuals to scientific conclusions •Continued political debate over nature and scope of issue
2	Rate of Biodiversity Loss •Changes in biodiversity due to human activities highest in human history •Boundary: 10 species per million per year Current >100, Pre-industrial 0.1-1	•Humans use almost all available fresh water •Human modified water systems interrupt habitats, conveyance of food and migration paths, provide new vectors for disease, pollution, and invasive species	•Habitat destruction/degradation •Unsustainable levels of hunting/fishing/poaching •Non-native species introductions •Anthropogenic climate change outpacing evolutionary coping mechanisms
3a	Nitrogen Cycle •Humans fix more N_2 than natural processes •Over fertilization pollutes waterways and coasts •Emissions of N_2O,NO, NH_4 form smog, deplete ozone •Boundary: 35 million tonnes of N_2 removed from atmosphere/year Current levels: 121 tonnes/year	•Nitrogen in fertilizers enterswaterways and coastal zones, causing algal blooms and eutrophication	•Over-fertiliation leads to nitrogen in runoff from farms and yards •Nitrogen is produced by humans in greater quantity than natural systems
3b	Phosphorous Cycle •Phosphorous runoff exceeds natural cycle process rate •Over fertilization pollutes waterways and coasts •Boundary: 11 tonnes of P into oceans/year Current levels: 8.5-9.5 tonnes/year	•Phosphorous in fertilizers enters waterways and coastal zones, causing algal blooms and eutrophication	•Over-fertiliation leads to phosphorous in runoff from farms and yards •Phosphorous mining and human waste outpaces Nature's ability to process •Destruction of tropical forests releases phosphorous, polluting waterways and depleting soil
4	Stratospheric Ozone Depletion • 5-6% of total ozone already destroyed •Increased UV transmission impacts ecosystems •Montreal protocol led to elimination of most immediate threat •Continuing risk from other ODSs •Boundary: Concentration of ozone: 276, Current 283	•Reduced ozone coverage allows increased UV radiation adds additional stresses to marine and aquatic habitats	•CFC use caused destruction of 5-6% of ozone. •Continuing emissions of CFC from old equipment, chemical stockpiles •Substitute substances can be greenhouse gasses. •Additional ODSs phased out in 2030, some remain unregulated
5	Ocean Acidification •Atmospheric CO_2 dissolves into seawater, changing pH •Increased acidity makes shell formation difficult •Corals, plankton are critical to marine ecologies •Boundary: Saturation of aragonite: 2.75 Current 2.90, Pre-industrial 3.44	•Increased atmospheric CO_2 leads to increased CO_2 in oceans •Increased acidity makes shell formation difficult •Increased stresses on corals, shellfish, and plankton, which are foundational species in marine ecosystems	•Continuing atmospheric CO_2 emissions •Lack of political will to address the problem
6	Global Freshwater Use •Human pressure now dominates function and distribution of freshwater •Dramatic river-flow and vapor-flow changes •Half billion people water stressed by 2050 •Boundary: 4000 km^3 human consumption/year Current 2600 km^3/yr, Pre-industrial 415 km^3/yr		•Interruption of water cycle at every step •Overuse in agricultural, urban uses •Heat, biological, and chemical pollution from human uses
7	Change in Land Use •Conversion of forests, wetlands to agriculture •Urban sprawl destroys or fragments natural systems •Boundary: 15% of global land converted to cropland Current 11.7%, Pre-industrial: Low %	•Conversion of land to agriculture disrupts natural water cycles •Human settlements demand huge water supply, distribution, and treatment systems •Runoff, absorption, and evaporative patterns changed	•Conversion of land to agriculture emits CO2, reduces natural habitats, stresses water systems, creates pollution •Patterns of development foster inefficient resource use •Forest destruction major contributor to climate change and biodiversity reduction
8	Atmospheric Aerosol Loading •Aerosols act to cool or warm atmosphere •May contribute to ozone depletion •Aerosols in lower atmosphere cause air quality degradation, health effects •Boundary not yet established		•Man-made sources greater than natural sources •Burning of oil and coal, smoke from burning of forests major sources •Aerosols reflect sunlight, cooling atmosphere, but some may contribute to greenhouse effect or ozone depletion
9	Chemical Pollution •Human emissions of metals, organic and radiative compounds impact planetary environment •Effects include reduced fertility and genetic damage •Boundary not yet established	•Wastewater treatment does not remove many chemical pollutants •Air deposition also adds chemical pollutants to water systems •Pollutants in water systems degrades them as ecosystems and as sources of water for human use	•Insufficient understanding and regulation of chemical impacts on humans and environments •Waste treatment systems incapable of removing all chemical pollutants •Overproduction and overdependence on chemical solutions to problems •Pollution is externalized in economic and political processes

WORKSHOP MATERIALS

Solutions	Interrelationships
•Improved energy supply and distribution •Efficient land use. Transportation efficiency, alternate fuels, and modal shifts •Energy efficiency in buildings •Industrial efficiencies, cogeneration •Land management in agriculture, soils restoration •Forest management, afforestation •Waste management, energy recovery, composting	Ocean Acidification Fresh water Land Use
•Find profitable alternates for forest destruction •Reduce resource use to sustainable levels •Reduce waste streams	Anthropogenic Climate Change Nitrogen/Phosphorous Cycles Ocean Acidification Fresh water Land Use Chemical Pollution
•Improved agricultural processes to minimize over-fertilization and overwatering •Reduced burning and harvesting of tropical forests	Anthropogenic Climate Change Biodiversity Ozone Depletion Phosphorous Cycle Fresh water Land Use Atmospheric Aerosol
•Improved agricultural processes to minimize over-fertilization and overwatering •Sequestration of phosphorous in the waste stream •Reduced fossil fuel use •Reduced burning and harvesting of tropical forests	Anthropogenic Climate Change Biodiversity Ozone Depletion Nitrogen Cycle Fresh water Land Use Atmospheric Aerosol
•Replacement of old equipment, elimination of chemical stockpiles •Phaseout of HCFCs •Additional regulation of other ODSs	Anthropogenic Climate Change Biodiversity Land Use Atmospheric Aerosols
•Limit CO_2 emissions	Anthropogenic Climate Change Biodiversity
•Recycling/conservation •Improved agricultural practices •Restoration of natural water cycles •Waste stream improvements	Anthropogenic Climate Change Biodiversity Nitrogen/Phosphorous Cycles Land Use Chemical Pollution
•Improvement in systems of food, fuel, and resource production and harvesting •Increased efficiency of human settlement patterns •Integration of agriculture and natural environments •Economic benefits of ecosystem protection must be found	Anthropogenic Climate Change Biodiversity Nitrogen/Phosphorous Cycles Fresh water Atmospheric Aerosols Chemical Pollution
•Reduced fossil fuel use •Reduced tropical forest destruction •Increased energy efficiency	Anthropogenic Climate Change Biodiversity Fresh water Land Use
•Reduced overuse of chemicals •Improved waste treatment systems •Improved understanding and regulation	Anthropogenic Climate Change Biodiversity Ozone Depletion Fresh water Land Use Atmospheric Aerosols

Seattle Narrative

On January 13, 2010 a full-day charrette was held at the offices of CollinsWoerman in Seattle, Washington. A small group of experts with deep expertise was challenged to address questions related to the current Water Commons crisis. The dialogue was facilitated by Steve Moddemeyer.

Attendees for this session were invited because of the quality of their thinking, their openness to collaboration with other like-minded experts with different backgrounds, and their ability to walk through these questions together. This full-day working session was planned to draw out the best thinking from multiple perspectives with an emphasis on science, the arts, and change management.

The participants were:

Lucia Athens, CollinsWoerman, lathens@collinswoerman.com

Jim Erckmann, Seattle Public Utilities, jim.erckmann@seattle.gov

Lorna Jordan, Lorna Jordan Studios, lpjordan@qwest.net

Steve Moddemeyer, CollinsWoerman, smoddemeyer@collinswoerman.com

Terry Moore, ECONorthwest, moore@eugene.econw.com

Valerie Nelson, Coalition for Alternative Wastewater Treatment, valerie508@aol.com

Jayde Roberts, University of Washington, jayder@u.washington.edu

Nancy Rottle, University of Washington, nrottle@u.washington.edu

Paul Schwartz, Clean Water Action Network, pschwartz@cleanwater.org

Jon Taylor, CollinsWoerman, jtaylor@collinswoerman.com

Polly Vail, WaterStreet, LLC, vailwalsh@gmail.com

Vicki Wilson, CollinsWoerman, vwilson@collinswoerman.com

Dan Williams, Dan Williams Architect, dan@dwa-design.com

Kathleen Wolf, University of Washington, kwolf@u.washington.edu

This meeting was funded by a Water Environment Research Foundation grant headed by Dr. Valerie Nelson. Participants focused on how water is connected to multiple planetary boundaries, and how water infrastructure experts and urban planners should be thinking about the redesign of the current paradigm of urban management and urban design. They also considered how new infrastructure designs can mimic natural processes.

The meeting began with individual introductions followed by an introduction of the concept of the Water Commons. It was followed by a discussion of the need for a paradigm shift and how past paradigm shifts have occurred. In the afternoon the group broke out into small groups to discuss the following questions:

1. What is the problem? We need adequate articulation of why water is central to life and why it should be everyone's concern.
2. What are the design principles from nature that should guide us as we rebuild urban water?
3. What are the solutions, both technical and process-related?

The groups came back together to present their findings. The meeting concluded with each person presenting one thing from the day's discussion that resonated with them.

Talking about water

While there is a dedicated group of people working on the issues of the water commons, a clear strategy for communication and illustration of the problems and solutions has yet to be developed. What is the scope of the water commons, and how can it be effectively described to laypeople, thought leaders, and decisionmakers? How are we illustrating the problems and the solutions? How do we insert the water commons into current political and environmental dialogue?

Quotes

"[This] one is one of those that are really easy to say, but maybe harder to do. We should be looking at the interrelationships in the entire system, and we should really be expanding out what our sense of that system is."

"We took question 1 to be, 'how would you describe the problem to somebody that doesn't want to understand the problem,'… [We're] trying to illustrate…that there used to be a demonstrable abundance of water, and that has changed. So we're saying, 'essentially we're running out of headroom.' [W]hat's been going on is population has been growing, per capital consumption has been growing, both of these things are increasing the use. It's being used for agriculture, industry, sanitation...and it's also being used as a waste dump. So all of these things are increasing the use of water. In the old days, the use was so small, that compared to the supply, the supply looked infinite. And now it no longer looks infinite."

"What we think we want to use the water for, what we are using it for, and how we are being constrained – all that has changed, but the allocation system has not changed, and the engineering system has not changed. Resisting that change are historical precedent, water allocation and water laws that lock that precedent in, big interests that don't want to see that allocation system change, and focus and motivation, the public goods problem of, 'why would I care? I can go and buy a bottle of water for a buck, and that's not that much, so [water scarcity is] fine. It's not worth getting involved.'"

"Another aspect of the problem is measurement, interpretation, and assumptions. People have really different ideas about what the risk is, what the tradeoffs are, and what is going to happen long-term and short-term, and as a result it's hard to get agreement on what the action should be."

"[W]e talked a lot about…system integration. We've got it here at three levels. [W]ater is not just drinking water, water is a transport system for pollutants, and it's got microbes in it, it's all kinds of other stuff. And we don't think all of that is dealt with, just the water itself. Secondly, water in the context of other natural systems, climate change, etc, is probably not dealt with well enough. And finally, the natural systems in the context of social and economic systems are not integrated well enough."

"[Speaking of post-disaster efforts in Kobe, Japan]…So there's a high level of engagement immediately after the event, [then] a little less urgency because contingency [plans were already in place], and then the actual implementation planning the happened over a number of years. How do we do that? How do we prepare that interim message scenario? Some things come to mind, right here in the City. What can people see and put their hands on? How many thousands of people have visited Seattle and seen SEA Street? So it's a matter of laying out as a general framework what's possible with water, then there are some great diagrams that act as a portal to more detailed statistics and other things. And then what are the places on the ground that likewise act as a portal to understanding? So what's the whole package, rather than a single event, a single, really tragic event, to have to launch all this?"

Nature and change

Natural systems have an inherent resiliency that allows them to persist even in the face of continual challenges. Species and systems are inherently designed to adapt to changing conditions through a range of strategies from behavior modification to migration to genetic selection. But nature also takes advantage of cataclysmic change – these are opportunities for new growth, and a reordering of complex systems.

Human systems rarely respond well to change or an unusual challenge. Our systems (and our mindsets) are not geared for adaptation in the face of slow change, but we also tend to react poorly to cataclysms. How do we learn from nature and improve ourselves so that we respond constructively to change? And how do we design infrastructure and other systems at the next level of resilience and cost-effectiveness, given the increasing evidence that our current modes of design and construction are no longer sufficient?

Quotes – natural systems, disturbance opportunities, learning from nature, resilience in our systems

"Our infrastructure should be able to provide functional diversity, so not just single function, but multiple functions should be built into the infrastructure that we are creating. As a part of this…instead of closing off opportunities for solving problems or for creativity, we should be maintaining that potential somehow in the systems that we are creating. We should be avoiding monocultural solutions. And then we came up with this concept about socio-hydro-diversity."

"That's the shift from a stormwater management system based on vegetation and retention into the underground piping. In fact, in some places the mismanagement of water leads to extreme desertification in prior civilizations. It's happening in China right now. As you drain soils you get deserts. Dust bowls. We've introduced a brittle quality into our communities by the way we've mismanaged water."

"Green infrastructure has begun to [show us] that if you change your stormwater management, you start…improving public health, air quality, you're creating landscaping jobs, you're getting competitiveness in the economy, you're adding resilience. They didn't intend it maybe, but they're beginning to discover that what they should be doing is not only worrying about a single stormwater function, but a wider mix."

"[N]ature actually does disturbances, and that's how it rebuilds complexity back in and creates the foundation for evolution. [Y]ou can have a very stable forest, for example, but then you have these opportunities where there's a fire or something that wipes it clean. And that's where you can get the evolution of species, you know, some things never spread, they go away. But it's an opportunity to create new life forms and new organizations. And that's where wealth and diversity and complexity come in."

"Natural systems…have built within them a plan as to how they rebuild. It's a billion-year evolution. Human systems refuse, especially in this country, to look at any long term planning. The human system automatically wants to do what they were comfortable with before."

Change and response

There is a disconnect between the place water holds in our mind and emotions, and its actual role in our lives. We need to recreate the intimate relationship between us and water systems in the world. We need a shift in consciousness – a paradigm shift – back to an understanding of our physical and spiritual dependence on water. Without this change, shifting people's behavior will be difficult or impossible.

We tend to avoid or reject change until our consciousness changes. Therefore, while it is important to push for change at the individual and societal level through example, incentive, and regulation, we must simultaneously search for ways to reconnect our water systems with our individual and cultural hearts and minds.

Quotes

"I've been having a problem with the use of the word 'paradigm' because I feel like we're talking about structural changes. But 'paradigm shift' is more about the ethic, it's more about changing the way people actually think."

"[I]f indeed we want to get people to go, 'wait, whoa! The crap hit the fan! I have to do something different.' That's a paradigm shift. Rather than, 'oh, this watershed system is being depleted, and we need to do something differently.' One is much more fundamental."

"I lived in Dade County when Hurricane Andrew came through. For the first maybe week and a half, they all came to us, and I was part of the President's committee on the rebuild and all that, they said, 'please build it back, but please don't build it the way it was before.' At the end of the second week, it was, 'would you please build my house back.'"

"I don't know how you write a plan for every bad thing that could happen. [I]t does seem to me that you can create a better vision for the future…a set of tools you're working on…and [increase] people's confidence that they can rebuild…"

"it sounds like we're talking about two things. One is…you've got a plan, and you're waiting for a disaster to implement it. [The

other is to] say, let's step back and take a second look and consider the alternatives. And look at whether there's another better way, given that this now is on the table, to do something that's going to provide multiple benefits and a better bang for the buck."

"One of the issues, however, is that if you're going to create a new paradigm, a new understanding of the way the world works, it's really handy to have evidence of that new paradigm, actual things that are built and done, that are happening, that you can then build your paradigm around. Because the paradigm is what you're taught, and what you see and what you experience, and what your culture implies as you're going into it."

"I think we need to operate at multiple levels – we need to be as rational as we can be, we need to be demonstrating this expanded objective function in the work that we do now, and that helps feed into what that new paradigm has to be. This will not happen overnight – it's like a multigenerational shift. But obviously we can plant the keys – we have to plant the keys now, because we really know we can't just go more than one or two more generations this way."

"[T]o the question of taking design principles from nature, you're talking about adaptation. You're talking about adapt or perish, more than a paradigm shift, because the world changed."

Water-Spirit Connections

In order to readjust our relationship with water, we need to advance a 'story' of water in our lives. What is that story? What are the deeper meanings of water that need to be uncovered and explored? While science has a strong role in helping understand one dimension of water, how do we use art, or music, or prose to help illuminate other dimensions? The best long-term strategy for addressing our current problems in the water commons is to help people forge bonds with water that drive change in behavior. How do we help forge those bonds?

Quotes – story of water, deeper meanings, art, connections to water

"How do we create infrastructure that will engage people in stewardship of those resources? That will have meaning to them so that they somehow become involved? [O]ur infrastructure should be transparent. It should reveal what it is doing to people and we should have this idea that it should be eco-revelatory."

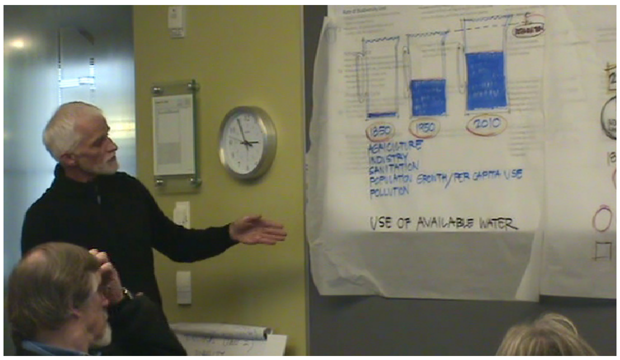
"Somehow we need to make our infrastructure hip and entertaining. We need more interpretive dance infrastructure. Of all the examples that came up…one that's been floating around our office – it's a You Tube video of a stairway that's next to an escalator. The problem was, 'how do you get people to use the stairway, instead of the escalator?' So each stair step is a like a piano key. You make music by stepping on the stairs. So the video showed all these people who got really involved in it, and before you knew it many more people were using the stairs than the escalator."

"[I]f you were going to start any of this, it would be nice to aim for the poetic…to actually articulate the centrality of water in nature. Steve [wrote], 'Water is a wonderful thing, it decorates our skies with clouds, it fills our low places and makes them beautiful, it nurtures life and quenches our thirst. It seeks any path to be one again with the great oceans that make our planet such a blue pearl in the vast expanse of space.' That's the centrality of what we're going to try to get at with water is the heart of all life"

"One thing that defines a movement…was a culture that involves art and music and spirituality. If you think about the movements that have had meaning that you know about, they incorporate all the song and all those things. We don't really inculcate that very well in how we deal with water. And our water utilities used to be seen as these beautiful paragons of virtue that people from around the globe would come to take a look at…I think that's largely lacking in the investments that we're making now"

“[Speaking of Waterworks Gardens] [T]he design team had a computer graphic of a bunch of trees hiding the treatment plant, but there was a very activist community that said, ‘we want people to understand why this treatment plant is there, and take responsibility for its need. Get in the middle of the project!’ So okay, it’s about treating water. So through this process of what would be interesting at this site, it’s a earth-water sculpture that treats stormwater, and when it’s clean it enhances a wetlands. Then there are 5 garden rooms that lay over the top of it, that follow the path of the water’s purification, from impure, working, mysterious, life sustaining…”

“I mentioned earlier today that we’re doing some work on assessment of citizen-based stewardship. Over 600 groups in two counties representing tens of thousands of hours of volunteer time on the ground for ecological recovery and system recovery in urban areas. I really believe, and empirically it suggests that people want to touch, smell, laugh with others, dine or eat with others and I think that’s a part of all this.”



Seattle Wrapup: Major themes that emerged from the Seattle Discussions on the Water Commons

I. Water and Nature are central to life

Water is central to life. During the day's discussions this theme emerged in several forms: Water as the source, as life-giver and as creator of valleys and channels; Water as the universal solvent, as a temperature sink, as a medium of exchange for global carbon levels; Water as poetry, as mystery, as reflection; Water as place-maker that creates drama in the city and acts as a universal attractant for people; Water as the destroyer causing fear and coping as it delivers life-ending diseases or as it floods our cities and drowns our weak; and Water's fundamental role in the principles of nature and how these principles find expression in water as a limiting factor for civilization, as a boundary for global capacity, and as the basis for earth's biological productivity.

Humans, too, have our inherent capacities. We gobble up the resources until we have a crisis. For example in parts of the world water used to look infinite – populations were small and demand was small – but now we are bumping up against the limits of supply. Yet, inherent within this crisis is an opportunity. During times of disturbance the old paradigm is laid bare in its dysfunction. It gives everyone the opportunity to build in a new way where adaptable resilient multi-purpose systems replace our single-purpose systems.

We can learn from nature where adapt or perish appears to be a maxim. Natural systems appear to have within them a "plan" on how to rebuild after disaster. Millions of years of evolution have created templates for restoration.

All in all, we can learn a lot from water. We can remember that our lives are primarily made of water. We can honor the power of the flow, light and color of water. And we can be dynamic like water and move to the marvelous.

II. Objective Function

We also talked about the "objective function". This is the range of objectives that we wish to optimize with our investments in resources. Whether we are a city or a utility we wish to efficiently deliver a range of outcomes consistent with our objectives. However, far too often we do not include the full range of objectives we seek. We have limited our objectives with water too much. Our objective function – our range of objectives is too narrow. What other objectives do we seek with water?

Our current objective function for water could be described as provide and treat water in order to protect public health while minimizing environmental impact for the least cost. Because of our understanding of global environmental thresholds, we know this is not enough. When we minimize environmental impact we do not automatically imply that we must protect and restore habitat for species richness. We only just now are beginning to look aggressively for strategies to decrease carbon emissions. We are doing very little right now to limit the dispersion of phosphorus into un-reclaimable forms. There were a number of objective functions that were discussed during the meeting:

1. Create infrastructure that will engage people in stewardship of resources
2. Include the idea of non-depletion of resources into measures of efficiency
3. Include the Idea of zero water balance into design and performance equations
4. Reveal what infrastructure is doing to gain a broader understanding of its function and purpose. It should be transparent
5. Design systems that are able to deal with the variability and uncertainty in the systems we are dealing with

6. Create infrastructure that is able to adapt to change including annual and seasonal cycles as well as longer-term trends and rare catastrophic events
7. Allow for a diversity of answers to reflect the diversity of communities and ecosystems. In other words - one size does not fill all
8. Bucky Fuller – don't throw anything away or at least save the parts
9. Maintain a certain level of disorder, because it may be tomorrow's order
10. Design infrastructure that recognizes limits and thresholds
11. Create infrastructure that doesn't deplete natural capital
12. Create infrastructure that creates new assets within natural capital
13. Redirect capital that creates more value or multiple values
14. People have really different ideas about what the risk is, what the tradeoffs are, and what is going to happen long-term and short-term
15. Close loops
16. Recycle
17. Reuse
18. Aim for zero waste
19. Identify and agree on feedback loops
20. Prioritize. What are the things that you need to maximize at least cost?
21. Maximize outcomes at least cost
22. Improve water quality in surrounding environment
23. Reduce toxic use and eliminate toxics introduced into the environment
24. Reduce or eliminate fossil fuel usage of your infrastructure
25. Stop the drying of soils
26. Increase the relationship of evapo-transpiration and vegetation
27. Increase resilience of systems
28. Stop nutrient losses
29. Stop the graying of otherwise beautiful garden places
30. Improve communities
31. Exchange capital intensive projects for job-intensive systems
32. Maximize economic potential of infrastructure investments

33. Stimulate clean-tech and venture capital manufacturing
34. Compete internationally
35. Create green jobs
36. Identify demand for water
37. Demonstrate how to meet demand
38. Develop strategy for dealing with shortages
39. Identify strategies of how to make it resilient
40. Demonstrate how it address global warming
41. Improve public health
42. Improve air quality
43. Create landscaping jobs
44. Enhance competitiveness of local economy
45. Reduce or eliminate toxics released into environment
46. Invest in utility infrastructure if it avoids problems or costs somewhere else
47. Change to global systems thinking
48. Understand that how we currently use and manage water is disrupting global systems and putting us in peril
49. Consider new ways of constructing our communities
50. Redesign our behavior and approach to water
51. Operate on multiple tracks –what can we do immediately with the next investment or opportunity by looking at a variety of alternatives and capacities to create an adaptive management and listening and flexible approach AND define a consistent plan or idea of what the future might look like.
52. Drive innovation
53. Create a sense of action
54. Create a sense of urgency
55. Make it personal
56. Look at where we want to be in 100 years
57. Include the environment as part of the economy

III. Design Principles and a New Paradigm

If we accept that water is central to all life and if we agree that an extensive list of objectives is required for our resource investments, then what are design principles that can inform our work? What are the design principles from nature that we can emulate?

We know that nature closes loops of nutrients, energy and water. We know that nature's systems run on available energy from the sun, wind, and the earth. We know that nature creates patterns of resilience that help systems rebound from disturbance. We know that the human body is designed to interact with nature and people are healthier when they experience nature. We know that the most diverse and dynamics natural places are where nature creates nodes that combine multiple ecosystems in one place.

To fully embody these lessons from nature and the broader objective functions listed above, is to create a new paradigm for understanding the world and our role in it. A paradigm is about the way people frame their world view. It is how they think. A paradigm results from what you are taught, what you see, what you experience and what your culture expects of you. So in a way, these meetings are not merely a professional exercise but the beginnings of a new way of thinking about things and doing things.

Once you have this new paradigm, it creates a need for the right kinds of knowledge, the right set of tools as well as buy-in and understanding to move infrastructure in this new direction. And this helps to create a new cultural understanding about innovation and technology that expands the boundaries of practice.

To achieve a new paradigm also involves critiquing the old ways that are not serving us well. It involves building the new ways and creating a systems aesthetic that reflects this new paradigm. This aesthetic involves engineering and architecture, art, music and spirituality.

What is included in this new paradigm? It is about creating personal and positive connections with the environment. It is about moving beyond the silos of thinking and using engineering, arts, design and economics to knit it all together. It requires being able to "talk markets to markets" and be prepared with counter-arguments when pressed. And it requires a long-run ambition with a long-run timeline to fully implement it. This suggests a generational shift. Where once we didn't look outside our own life, or outside our neighborhoods, or outside our country, or at our impact on nature, now we must routinely do systems thinking. We must routinely understand that there are natural limits to the sustainability of global ecosystems. We must understand the connectivity of our societies wherever they are in the world. And we must understand not only our impact on nature, but on our potential to be collaborators with nature to find and implement robust strategies that are truly sustainable.

To move this forward requires a number of actions. We must identify compelling stories to move the message forward. These stories must demonstrate where things are working with finite examples and the tools that were used. We must create the outline of a legislative agenda. An "omnibus water bill" can create a unified intellectual platform to draw upon. It will pull together best practice and create a readiness for opportunity. As it moves ahead it can give policy signals that helps markets to adjust.

WASHINGTON NARRATIVE

On January 26, 2010, a full-day charrette was held at the Mathematical Association of America in Washington DC. This meeting was designed as a follow up to the January 13 meeting in Seattle.

The group of participants in this meeting represented a cross section of technical experts, government officials, educators, planners, activists, and public affairs experts. The goal of this meeting was to create an action agenda for advancing the Water Commons in the United States by building upon the ideas generated in Seattle. The group was charged with developing concrete strategies for both raising the profile of water as an emergent environmental issue, and also solving water-related problems in local communities and nationwide.

This meeting was funded by a Water Environment Research Foundation grant headed by Dr. Valerie Nelson. Participants focused on how water is connected to multiple planetary boundaries, and how water infrastructure experts and urban planners should be thinking about the redesign of the current paradigm of urban management and urban design. They also considered how new infrastructure designs can mimic natural processes.

The questions first raised in Seattle continued to drive the discussion during the Washington charrette:

1. What is the problem? We need adequate articulation of why water is central to life and why it should be everyone's concern.
2. What are the design principles from nature that should guide us as we rebuild urban water?
3. What are the solutions, both technical and process-related?

Breakout sessions focused on two main aspects of the problem. The first group focused on the development of a 50-year framing policy (the 'Big Water Bill.') The second group looked at messaging tools for advancing the state of the national conversation around water issues.

The following sections attempt to capture the major themes of the discussion, illustrated by verbatim quotes. The final section outlines a proposed framework for individual and group actions, wrapping many of the issues and strategies raised during the discussion into a structure for strategic action.

The participants were:

Ed Clerico, Alliance Environmental
eclerico@allianceenvironmentalllc.com

David Conrad, National Wildlife Federation
Conrad@nwf.org

Robert Goo, Environmental Protection Agency
goo.robert@epa.gov

Tom Hudson, CollinsWoerman
thudson@collinswoerman.com

Andy Lipkis, Tree People
alipkis@treepeople.org

Steve Moddemeyer, CollinsWoerman
smoddemeyer@collinswoerman.com

Valerie Nelson, Coalition for Alternative Wastewater Treatment
valerie508@aol.com

Paul Schwartz, Clean Water Action Network
pschwartz@cleanwater.org

Sarah Slaughter, MIT
slaughte@MIT.EDU

Becky Smith, Clean Water Action Network
bsmith@cleanwater.org

Nancy Stoner, Natural Resources Defense Council
nstoner@nrdc.org

Rich Sustich, University of Illinois
sustich@illinois.edu

Polly Vail, WaterStreet, LLC
vailwalsh@gmail.com

Vicki Wilson, CollinsWoerman
vwilson@collinswoerman.com

Our current vision of water is a barrier to action

Despite growing awareness of the significance of water in the life of the Earth, water issues remain outside the consciousness of decisionmakers, the general public, and even the mainstream environmental movement. While we retain an unconscious connection to water, we are often oblivious to the centrality and fundamental nature of water.

For almost every recognized environmental problem, water is a part of the system in which those problems arise.

While there is a broad constellation of issues for which water is a primary or secondary concern, what binds them together into a recognizable pattern is a holistic view of the role of water in every facet of life. This holistic view – this conception of the Water Commons – has yet to be clearly defined.

Quotes

"One of the things, maybe it's partially generational, I know that world population has doubled since I was a kid. So, it's a lot more crowded than it used to be and we've also spent billions or trillions of dollars managing water..."

"There's a tragedy at the Water Commons because we have perhaps gotten so smart that we've broken things into pieces and that the whole is what's being sacrificed."

"One of the biggest complaints heading into Copenhagen was that water was completely stripped from the conversation and here we have a country that is living with this faith-based mythology that climate change doesn't exist or somehow not human formed."

"I think this is about empowering people and I think it goes back to the issue of value. Are we valuing water appropriately and understanding the meaning of water to our society and to ourselves? People are already taking action by buying bottled water, so they are empowering themselves. And so the question is, how can we change their focus and their perspective. It's kind of like the food movement. Whole Foods is driving the organic foods market. We can do the same thing with water. And it gets back to the issue of the community scale, how are you empowered as an individual and as a community? And how do we communicate that? That you do have the opportunity to both protect your resource and utilize it wisely. And how do we convey that message and get people to understand that it's within their sphere of influence and I think that's one of our challenges."

"Do any of you know the TV show called "Emergency!" about L.A. county fire department paramedics? There was only one…and it was the first tested paramedic system in the country, where a fire department took Vietnam-trained paramedics, hooked by radio to doctors and hospitals—and pretty nurses to keep people watching the show—and they showed the country how lives were getting saved through this marvelous technology. In fact, they built the mythology that the entire department and city worked that way. Everybody, millions of Americans, watched and then millions of people in other countries watched as people who they knew in those situations, in accidents and stuff like that, used to die, were then being saved. And they saw a city in their construct of reality was doing it and they demanded it of their local governments, their city councils, their states, their congressional people and the system we see built out around the world, was built practically on a myth. It was built on one model, one demonstration model that hyper-accelerated through an entertainment media that was the educator and created a market for policy change. I say this because we have access to that. This is a power we have that can supersede the battles. If we can create that vision, that transformative vision, that touches spiritual stuff and community stuff and gives people a whole bunch of handles, though entertainment, drama, sex, anything."

"We were also talking about, as an overall objective, to maximize the benefits of the positive externalities of water systems. We talked a lot about negative externalities, but we don't talk a lot about the positive externalities. So if you think about, if you have a beautiful, winding stream it's beautiful, it cleans the water, it also has vegetation growth which captures the CO2—s o there again you're creating abundance, like Valerie's comment. And we talked about beneficial use of waters, for instance, commerce, transportation and production. The idea would be that balance of the beneficial use of water systems for the greatest good to the region and the community."

Our current paradigm is broken

Large monolithic structures, whether in infrastructure, economics, or politics, rarely work responsively or efficiently.

The re-democratization of American society can be paralleled by shifts in how we envision, design, and implement other systems. Individuals need to feel that they have the power to effect change – one needs to feel that the problem or the adversary is not so large and so monolithic that there is no way to overcome it.

Proximity breeds awareness. Scarcity breeds economic valuation and spiritual connection. Crisis breeds action. The challenge is to foster awareness, valuation, connection, and action without proximity, scarcity, and crisis.

Who owns water? What is the role of the Water Commons in the future? How does the work to privately control water impact our relationship to water? Is water a human right, or is it a privilege?

Quotes

"It doesn't matter what I do, it's incomplete. Everything you do matters. Instead of that being overwhelming, to actually make that alive for people. And so they can start engaging. All of us are managers of the water and that's ingrained in some, but it [really is] all of us or nobody. For me that is the real challenge. I'll close on this thought, some are grappling with early onset climate change and succeeded in reducing their average water usage for cities to 30 gallons of water per person per day, from starting at 300. And they did it by successfully engaging people and understanding that they were managers. And by giving them money to have systems, it wasn't cost effective but it converted them to managers."

"One of the things that I hear tying human rights to water that I'm seeing in a lot different companies is that people don't believe that public infrastructure is going to work anymore. They don't think that water actually gets purified and what they're doing is setting up their own purification as well as power systems. And we've already seen the privatization of the transportation systems with corporate jets and all the rest of that. One of the things that becomes really critical in this aspect is that people with money have those services and people without don't. And what we're seeing is that the possibility of the fraying of the democratic fabric of the country. If you go to Mumbai, it's very clear that those who have money have water, power, transportation and basic infrastructure services and the poor don't."

"So what strikes me the most about the Bushmen is that, in terms of economy, they value the water. And I think that's one of the biggest problems we've got. In general, it's not even a privilege or a right, it's just there. I went out to water the cattle and it's a huge ritual and it's a group ritual. There are more cattle than people. They are surrounded by giant piles of thorn bushes to keep everything out of it and it's quite a process to get into it, get out of it, and it's almost ceremonialized. Perhaps the single most valuable person is called a borehole mechanic, [a person] who makes wells. And you have to go out of the country to get the training for it. And those people are really precious because no standing water is drinkable. Let's say if there's a borehole, they've got these deep holes, extremely dangerous conditions. It's so valuable that everybody thinks about the economy of water every day."

"[W]ater is such a local issue. Whereas climate change people have been moved towards it, because at some point in time their awareness rose to the point where they get it. And they see that they have a role in it. And they get the kind of action that is required. It doesn't exist with water. Because in most communities, for the most part, people don't get it and they wouldn't see that they have a role in it. With the 5,000 children that are dying [around the world from water mismanagement], they're not dying here and it's hard for people to see that they have a role in what happens for those 5,000 children…"

"So we started looking at is what it is possible to use water as one of those re-democratization tools in America to really engage, inform and inspire regular people about issues that they can make a difference in that are relevant to where they live and empower them to do that. But for them to do that, they need tools, they need to know what their issues are and they need to have some idea of what those solutions are."

"Part of the problem with GE and the economic models, is that our whole system is based on efficiencies of companies… So why should the American public question GE having control? That's the way our system produces wealth for us, isn't it, so what's the problem with GE doing it? So water is at the heart of all life, if we're going to not allow our conversation to become about commodification, in which case we could say, price it, sell it, for rich or poor people, or let GE run it because that's how we let everything else run. We tend to look at water, fundamentally, as a commodity. Not just that there is adequate supply, we look at it as a commodity."

The Water Commons Coalition needs an explicit plan

The final outcome of the charrette was the realization that a clear strategic plan is necessary to move the dialogue forward and increase the impact of the group on public opionion and public policy. The general outline of the plan is as follows:

1. Build the team. Who is on the team? Who is not? How does the team, with all its various individuals and organizations, work together and coordinate efforts? Break down silos. Develop effective methods of internal and external communication.

2. Set the vision. Tell a compelling story. Provide positive and negative visions of the future. Make stewards of all of us.

3. Develop a process and a product. Build the framework for a 50-year water bill. Find the case studies and prototypes. Do or enable the basic science. Find or develop tools for measuring, treating, and conserving water. Develop the system of tools and strategies for moving forward on multiple fronts. Build assessment and measurement into every step.

4. Get the word out. Use every media type to spark awareness and build knowledge. Be ready to back up media attention with a coordinated plan, and to take advantage of opportunities as they arise. Be advocates, activists, teachers, and spiritual leaders. Sell the new paradigm.

Quotes

"And in terms of action items, one of the things that would be great, whether it's this group or another group, is to identify a bunch of those solutions that can be immediately implemented by individuals and by communities. That can move along a really, really fast cycle."

"[T]o get back to [the] point about needing to find forums where you can politically bring these issues to the table it just seems to me, what we're talking about how on a theoretical level it is so obvious that water should be treated now as a human right. A hundred years from now, that will be a lot easier to understand, maybe 50 years from now. But the places where the action is are where the supplies are on edge. Climate change is going to create more and more situations around the world where the longer-term droughts and things like that are going on. And it seems to me that we need to be on top of where, geographically and politically, these issues need to be raised because I think you can't teach everybody at once. And if the debate is taking place in the political realm, hopefully the media will cover it, people will start to explore. The common solutions versus the pure economic solutions, the one driven by insurance companies, insurance rates and stuff like that."

“[T]he way all the agencies are structured right now, by federal rules, by local design, by state rules…keep them all from preventing them from working as a whole. It’s understanding city as a whole system and managing it as such, instead of as separate bureaucracies. [T]here are outcomes that could actually happen pretty quickly with some rule changes would allow local and state agencies to incentivize and collaborate and we can talk about that.”

“[Haiti can inform us on] how you’re ready to take advantage of a problem that pops up on the radar screen. Because we certainly had more than our share [of disasters] in the United States in the last 20 years and there is sort of a nanosecond of a moment to catch a wave, and then it’s gone.”

“I heard a really wonderful four-point piece on influencing and changing: and if you’re able to change someone’s behavior, that makes you an advocate; if you’re able to change someone’s thinking, that makes you an activist; if you’re able to change someone’s feelings, you’re an artist or a teacher; and if you change someone’s conscientiousness, that makes you a spiritual leader. Those levels of change really made sense to me …”

“I have felt that we don’t have a vision for water in the United States. We don’t have a national water policy; we don’t know where we’re going with water; we have such a hodgepodge of often self-cancelling programs where we don’t have the natural world in proper focus. We don’t have a sense of efficiency either economically or environmentally. So I just have felt that we really ought to work on a vision, and I’ve mentioned that a few times, of water that actually is a sustaining vision.”

The final segment of the charrette was a brainstorm of ideas for teambuilding, communication, and implementation:

- Write the Big Water Bill – but break it up into pieces appropriate to various allied individuals and organizations
- Use the Big Water Bill as a strategic document
- Establish a vision for water in the United States, and a mechanism for keeping the vision up to date
- Choose a body (for example, the Office of Water in the EPA) to manage and direct the Big Water Bill
- Create a website to support coordination and information sharing
- Condition the use of SRF or other federal funding programs based on their impact on water systems and resources
- Create Infrastructure Challenge grants(?)
- Establish a national policy of ‘no net loss’ or ‘net zero’ for water
- Implement water offsets – 2 cents from every bottle of water goes to support water research
- Create ‘Victory Gardens’ for water
- Revise the Clean Water Act to include an anti-degradation aspect
- Look to the Healthy Watershed Initiative as an example
- Look to the Energy Bill as an example of segmentation
- Create a water reuse standard/national sustainable site standard for water

Group needs a strategic plan:

- Look to the Living Building Challenge as a model
- Decide what communities and groups should be part of the Coalition
- Identify the drivers of the process?
- Choose the form of the Bill or the Plan?
- Strategize methods of protecting the work from attack
- Use shared values as the key strength of the Coalition
- Use values as a way to screen potential members of the Coalition
- Recruit funders, sponsors, investors, campaign strategists
- Map allied other players, academics, universities. Identify others who are reinventing the wheel
- Define the game outside of normal political process
- Look to integrated planning process and Strategic Growth Council in California as examples
- Create a Rapid Response team for immediate crises

Figure 1: Water Commons Action Program

Washington Wrapup:

Strategic Plan diagrams for the Water Commons

Figure 1 illustrates and locates many of the tactics discussed at the meeting within a framework for action. The green arrow in the center of the diagram lists the steps of a strategic planning process – one outcome of the meeting was an understanding that the Water Commons Coalition is currently in the teambuilding and values identification stage. These two steps inform each other – deciding on shared values helps filter and define the size and composition of the team, while a robust team will help define a set of values that is appropriate in scope and depth. Once the core team and shared values have been established, team buy-in (commitment) sets the foundation for the crafting of a mission and a vision for the Coalition. Along the way, a series of tools and tool systems are used to build knowledge, communicate and collaborate, fundraise and implement, and provide feedback. These tools help drive action both within the Coalition, and between the Coalition and its partners, decisionmakers, and the general public.

Figure 2 illustrates the interaction of internal and external actions, and how together, when coupled with the actions of other individuals and organizations, the wheel of progress for the Water Commons begins to turn. Each wheel has its own set of driving forces that can help speed the entire system – and without the contribution of each wheel, the system cannot function efficiently.

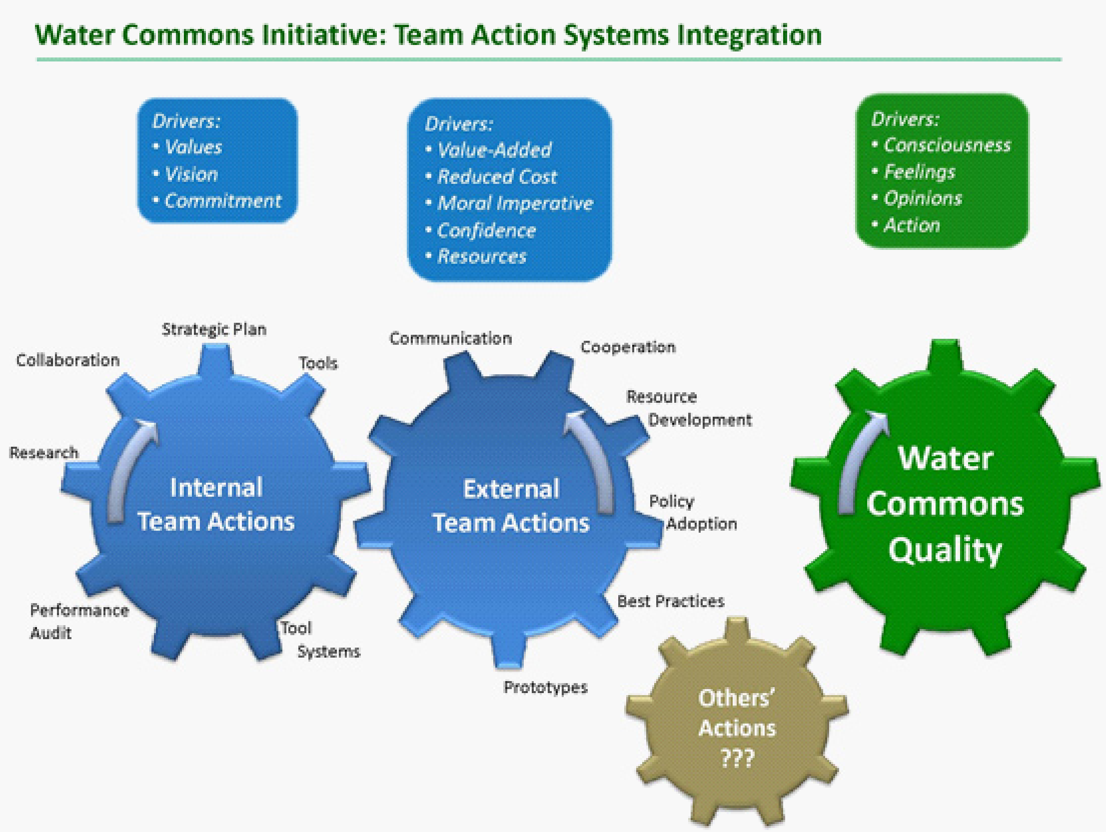


Figure 2: Water Commons Initiative: Team Action Systems Integration

READINGS

21ST CENTURY WATER MANAGEMENT: RESTORING THE COMMONS

Valerie I. Nelson
Valerie.i.nelson@gmail.com
(978) 283-7569

Abstract

This Project will explore the major building blocks of a new water paradigm for the 21st Century. These inter-locking elements include:

A description of how mismanagement of water is threatening the ecological and societal Commons;

An articulation of how new technologies and designs that mimic and work with nature can offer a sustainable path forward;

A delineation of the new roles that government and civil society will need to play in pricing, regulating, and managing water services.

A framework of recommendations for a new Water Covenant and policies will emerge from this process.

Traditional water management has relied on a low-tech, industrial-scale engineering and economic model developed in the 1800's. With a goal of public health protection, big pipe systems were built to transport clean water in and wastewater out of urban neighborhoods.

Economies of scale have also driven the use of large, centralized infrastructure, since the marginal cost of adding a new customer is less than the average cost, in each of the separate domains of water, stormwater, wastewater, and flood control. Low water and sewer rates have been based on extraction of water as a free natural resource, moving water from one basin to another, moving mass volumes of fresh water into brackish and salt water environments, and dumping wastes into the environment with minimal penalty. The damage from these approaches is manifested in eutrophied lakes and estuaries, falling levels of groundwater and streamflows, loss of habitat, absorption of toxins by humans and other organisms, and reductions in public health and community well-being. Federal subsidies and mandates have reinforced, if not outright locked-in, this approach.

An emerging paradigm relies instead on design principles found in nature: in particular, integrated systems, efficiency and reuse, and adaptation to local context. Many of the new high-performance treatment technologies, such as membranes, "mimic" biological and chemical designs that scientists are discovering in nature. Just as recently found in the energy arena, there are alternative approaches that can restore natural resource patterns and functions found across a landscape. These "smart, clean, and green" approaches create a wealth of services and benefits at the local level and can help restore the ecological and societal well-being of the global Commons as well.

A paradigm shift from mechanical to natural systems practices will require a solid understanding of what is at stake, how a new water paradigm will better address these needs, and how the mission statements and economic calculations in the sector need to be re-structured by public policy and civic dialogue.

This Project will assemble and synthesize the insights of a diverse group of ecologists, engineers, architects, economists, and policy analysts that have been studying new approaches in water management, or that have explored similar paradigm shifts in energy, agriculture, and other fields. A facilitated workshop of these experts will be convened in the fall of 2009.

Background:

Conventional systems of water management have been considered one of the 20th Century's greatest public health accomplishments. Large networks of water and sewer lines and treatment plants brought clean water into the cities and transported away disease-carrying sewage. With passage of the 1972 Clean Water Act, the nation also established a goal of fishable, swimmable surface waters and funded and enforced increasingly stringent regulatory standards for the partial removal of pollutants by treatment plants. The 1974 Safe Drinking Water Act focused on setting up engineering barriers to protect drinking water from pathogens, but in doing so ramped up the cost of providing water treated to a potable standard that is also used for many non-potable uses. Municipal utility management was the norm. Rural towns with private wells and septic systems were expected over time to build similar public water and sewer systems as well.

In recent years, however, a concern has been growing that this "paradigm" of big-pipe water management is not sustainable, both from a natural resource and a financial perspective. The appropriation of huge volumes of water from ecosystems and the release of polluted effluent into rivers and the oceans have been increasingly disruptive to ecosystems. Regulations have required removal of some pollutants, but relied on "dilution" in receiving water as well.

Signs of stress are seen in falling groundwater levels and decreasing dry-weather stream flows (and unnatural flow increases during wet weather), eutrophication of lakes and estuaries, disappearance of wetlands, dead zones in coastal areas, and other changes in hydrological functions. Climate change is expected to exacerbate patterns of droughts and heavy rainfalls, putting both water supplies and flood control measures at risk. Reductions in evapotranspiration are being studied as potentially significant contributors to global warming.

Drinking water systems lose huge amounts of water (a US average of 20%) from their distribution pipes, treatment technologies were not designed to minimize emerging biological and chemical contaminants, and treating all water to new and more stringent standards is both increasingly difficult and expensive and, except for the small amount of water needed for potable uses, is extremely wasteful of energy, chemicals and money. Most cities and towns have been unwilling to charge ratepayers the full cost of repairing and replacing the existing inadequate infrastructure, and so collapsing pipes and breakdowns in treatment plants have become more frequent, while innovation is generally off the radar screen.

The 2007 Baltimore Charter for Sustainable Water Systems suggests an alternative approach to water management that "mimics and works with nature". Natural systems create an abundance of value and diversity, where species cooperate and one species' waste is another species' resource. Introduced into these naturally-balancing ecosystems has been the highly-disruptive human extraction and use of resources of the industrial era.

The genius of science and design in the 21st Century is, in contrast, the discovery of "smart, clean, and green" ways to capture the value of resources. "Smart" because they unlock the complex designs of nature and use information and signaling to achieve efficiencies. "Clean" because they capture and use resources and methods that don't involve significant externalities in extraction or disposal. And, "green" because they rely on vegetation, and in the process begin to restore the natural ecosystem and its wide and deep benefits.

In practical engineering terms, this new design model includes: provision of potable-quality water for drinking water and direct human contact purposes only; prevention of pollution before it gets into the waste stream (including the wholesale re-engineering of some products through green chemistry to mitigate or eliminate ecological damage); reduction of energy needs by avoiding the pumping and long-distance transport of water and wastewater; wastewater recycling and non-potable, "fit for purpose" reuse instead of disposal; rainfall harvesting and reuse to supplement water supplies; energy and nutrient recovery from wastewater; habitat and natural system restoration; re-vegetation to restore evapotranspiration capacity; and restoration of green infrastructure in urban areas to help beautify cities and revitalize neighborhoods.

A birds-eye view of the new infrastructure would reveal "networks" of decentralized and repurposed and at times hybridized, systems. Some of the innovative treatment and resource recovery technologies would be "embedded" in subdivisions, apartment complexes, or individual homes and offices. Other functions would be taken over by vegetative "green infrastructure", such as green roofs and walls, trees, and swales along roads, and restored streams, riparian areas, and wetlands. Water and sewer lines might be slip-lined and repurposed for potable or reclaimed water, water storage and distribution, and heat recovery. Monitoring and control technologies would be key elements in managing these systems and in protecting public health and the environment.

These engineered and green networks mimic the natural systems of nodes and links in nature, where water both recycles and supports life at a local scale, but also is a linkage and transport mechanism across a landscape and into the atmosphere. These systems in cities and towns can cost less to provide water and sanitation services than current approaches and can also add significant benefits in terms of air quality, energy savings and production, recreation, beauty and aesthetics, increased property values, and jobs. Innovative pricing, incentives, and new performance-based regulatory mechanisms will be required to ensure that these sustainable practices are adopted and that the remaining watershed and global "externalities" are also addressed by developers, homeowners, and municipalities.

The analogy for such "network" design that is increasingly-known to the public is in the energy sector, where a shift to a distributed and efficient network that relies in significant part on clean natural system services is underway. The existing power grids use large electrical networks and power plants, as well as oil and gas pipelines, that deliver energy to homes and businesses at subsidized rates and produce large externalities in air pollution and greenhouse gas emissions.

In contrast, the new grid will incorporate clean natural sources of energy, including wind, hydroelectric, and solar, at distributed locations and will encourage more energy-efficient building designs. Metering and incentives for peak generation and off-peak use of energy are the equivalents of "fit for the purpose" water provision. "Smart grids" also rely on sophisticated information and control systems. Both energy and water networks require supportive financial incentives and regulatory mandates.

A few leading-edge infrastructure experts are now suggesting that these "networks" of engineered and green energy and water systems need to be integrated and also be co-engineered with transportation, solid waste, buildings, and other urban infrastructure management. The lessons of nature are that such integration will lead to significant synergies of design, cost-savings, and an abundance of positive benefits for society.

For example, an "eco-block" incorporating architectural innovations, wind and solar power, green roof and wall cooling, rainwater harvesting, water reuse and energy recovery, and nutrient recycling into community gardens, can be nearly "off-the-grid" in both energy and water, and can be located at transportation "hubs". These new designs of infrastructure may cost less in dollars and will both improve the quality of life in urban communities and begin to protect and restore the ecological Commons.

Paralleling the shift in technologies will be a shift in the institutions and markets for resource management. Municipal utilities were appropriate for each single-service "monopoly" centralized system in water, stormwater, and wastewater. But embedded and green infrastructure "nodes" in homes, subdivisions, and commercial establishments engage a wide range of private firms, non-profit groups, and other city agencies (such as parks and recreation, housing, job training, etc), and the developer and property-owner will have many more choices for technologies and design and ongoing maintenance services. Municipalities and other local governments will have more complex and highly-productive new roles in coordinating municipal utilities and agencies internally and in overseeing the new private and non-profit sector externally through ordinances, incentives, education, and inspections.

Finally, the solutions to water management in the 21st Century will require a high level of interdisciplinary collaboration and broad public engagement. Here also, nature serves as a model for the benefits of collaboration and cooperation, or social capital, in society, as opposed to the specialization and hyper-individualism of the

20th Century. Networks of conversations and pilot projects will serve as the foundation for creative invention and enhancement of the "Common Wealth".

Full-Cost pricing and Planning

This project will focus on the key driving elements in the emergence of the 21st Century water paradigm, which began to surface in the 2005-2006 workshop series convened by the Coalition for Alternative Wastewater Treatment. The description at that time of a problem statement for this Project included the following language:

One of the most significant barriers to the full and appropriate use of decentralized water resource systems is the failure to consider externalities of central system approaches. Siloed utilities and individual communities are allowed, subsidized, or forced by court decrees to proceed with highly-disruptive projects that cumulatively cost more and create greater environmental damage than an approach which both decentralizes and integrates various water resource sectors across a region.

Examples of externalities that are not normally internalized to projects include: construction of water lines, followed by increased use of water that is tied to uncontrolled growth and an increased number of malfunctioning existing septic systems, and then the pressure to build sewers and large treatment facilities to deal with growth and existing failures of septic systems, followed by even more increases in development to help pay for these systems, and substantially increased stormwater runoff that releases pathogens and nutrients into surface waters, and sanitary and storm sewers that drain groundwater aquifers and exacerbate water supply problems.

During the fall, 2005 workshops, Garrett Hardin's "Tragedy of the Commons" was discussed as a framework for understanding this problem. Possible solutions could include:

- Pricing – true costs to customers
- Conditions for grants and loans – Integrated Water Resource Plans
- Permit requirements – NPDES, UIC, and others

Two of the six high-priority, short-term projects recommended by participants pertained to:

Research on full monetary and non-monetary benefits and costs of soft and hard path approaches, and pricing or other mechanisms to better align local decisions with long-run environmental and economic sustainability

Exploration of how to tie federal subsidies and permits to an integrated water supply and water quality plan in a watershed.

Updated Problem Statement

In the intervening three years, a series of water crises, Congressional hearings, and other conversations have expanded and deepened this topic considerably. The core insight remains – costs can be incurred or opportunities foregone when decisions are made by individual utilities, homeowners, developers, companies, municipalities, and other parties to the sector that only reflect short-term and narrowly-defined self-interest in minimizing costs and/or maximizing profits.

Hardin's model was based on the over-grazing of open-access, community land (the British village green or "Commons"). The individual herdsman had no incentive to cut back the grazing of his own cows, since others would just take his place. But, cumulatively and over the long-term, the land would degrade and collapse in its capacity to support grazing for local herdsmen. Solutions to this "Tragedy" were to develop government regulations that restrict use or privatized the land. The costs of over-use would be directly experienced and "internalized" by each herdsman, who could over time capture the benefits of practices that protect ecosystem function. Later critics of Hardin pointed out that community-based management systems could also guard against over-use.

In water and water-related sectors, a concern is that a global "Tragedy of the Commons" may be on the horizon as well. As Jared Diamond has pointed out, past civilizations have turned lush landscapes into deserts through profligate use and mismanagement of water.

The new literature on "resiliency" suggests there are tipping points in nature, where ecosystem collapse is difficult if not impossible to reverse. For example, a lake can absorb and store some nutrient pollution, but at some point the lake "dies", and the eutrophied water body can't be cleaned and revitalized at a reasonable cost. There are similar concerns for tipping points in the capabilities of seas and oceans to absorb carbon and acids.

Water is connected to so many ecosystem and societal functions and services, from the elemental to the spiritual, that the phrase "water is at the heart of all life." is often used to describe those relationships. The first goal of this Project is to examine water's many connections to the "Commons" and to identify those links, in particular, that may be stressed in the future to the point of collapse.   These may include depleted water supplies for potable, commercial and industrial uses, desertification (drying and degradation of soils), redistribution of phosphate stores from where needed for growth of plants to water bodies causing choking algal growth, toxic overloads of the receiving environment, unnecessary energy use to move and treat waters, and disruption of evaporation cycles that result in climate change, and others.

There are numerous other impacts on the Commons that may fall short of "collapse", but that nevertheless represent a degraded quality of life on Earth.   "Commons" is a useful term to describe the space in which natural organisms, including humans, interact. There is an ecosystem web of life with complex interdependencies of species, natural resources, energy, and soils and water. There are also complex interdependencies of people in human societies and economies, which in turn rely on nature's services for their survival. The Commons can be used to describe that space of interactions and interdependencies that affect the well-being of all the individual participants, both human and non-human.

This is a particularly interesting and critical moment in history, when both the ecological and societal Commons are threatened. Climate and other natural systems are under increasing stress globally, but so is the economy. New discussions are being held about the need to restructure relationships in the Commons so that ecological, social, and economic systems are restored to health.

Advocates of a "green economy" assert that governance reoriented to ecosystem protection and restoration, in particular greenhouse gas reductions, can also be good for society and the economy. Climate change can be slowed, while at the same time "green jobs" are created, air pollution is lessened, and costs of energy are reduced. Advocates for a new paradigm in water management make similar arguments.

President Barack Obama and others looking at a fundamental restructuring of the economy hasten to state that these conversations are not about "socialism" or "central planning", but rather about identifying the disincentives and "market failures" in the current economy that need to be addressed. Properly-functioning markets are an efficient means of resource allocation, but participants need the proper information, signals, and incentives for internalizing and incorporating actions and behaviors that benefit the Commons.

The "sweet spot" is when all sides benefit, as for example, when education enhances the earning power of the individual as well as the productivity of the overall economy.   Another example promoted in the fiscal stimulus bill is weatherization of homes, where the homeowner sees lower energy costs, but jobs are also created, and ecosystem damage is minimized.

The new Administration also recognizes that social and economic development will depend on a better integration and coordination of services, particularly at the local level. In urban policy, for example, President Obama has espoused an approach that would integrate education, health, job creation, infrastructure, green space, and housing renewal programs in targeted neighborhoods. One of the effects of this new strategy may be to grant more authority to local governments and to loosen the rigidity of specialized mandates from the state and federal levels.

Finally, there is an impulse in society for restoring public spaces and social interactions, whether it be in farmer's markets, revitalized Main Streets, information networks, democracy forums, and others.

These three strategies, a restructuring of markets, an integration of services at the local level, and expanded public opportunities for creative invention, will support the emergence of a complex natural systems-based approach in water management, as well.

This Project: Three "Framing Statements" Needed

Three interlocking factors go into design and implementation of a new Social Contract for Water:

- Defining the Water Commons – identifying the full range and scope in which conventional water management has damaged or threatened the ecological and societal Commons;
- Clarifying the design architecture of a new water paradigm – describing how "smart, clean, and green" practices can restore the health and productivity of the Commons;
- Setting a policy and civic agenda to advance the new paradigm -- designing a set of pricing, regulatory, planning, and local institutional reforms to correct for market failures and to enhance the Water Commons.

This exercise is of critical importance. Not only are there potential Tragedies of the Commons in sight that need to be avoided, but without a comprehensive vision for the future the water sector lurches from one crisis to another. The core industrial model is left standing, in large part because of short-term thinking and rigid institutional and governance structures. For example, fears of water shortages have typically led to proposals for big desalinization plants or ever-larger water diversions instead of efficiencies and reuse, or concern for the environment.

Similarly, national conversations about the energy-water nexus focus on big power plants and big water and wastewater transport and treatment approaches, rather than smaller integrated approaches or "leapfrog" designs. This incrementalism is increasingly unsustainable, but will be perpetuated if there is not a comprehensive vision and demand for a paradigm shift.

I. Defining the Water Commons

In the earlier workshops, participants urged an assessment of the adequacy of water supplies and water quality over the next fifty years, or what one might call "enough clean water" for the variety of human uses and the environment. In the interim there has been an increasingly complex discussion about the nexus of water management with a range of ecosystem and societal services. At least one state has instituted an analysis of adequate water availability in 100 years in its approval requirements for new developments.

The first goal of the Project is to develop a global, long-term statement of how water impacts and supports the Commons. A recent column by Wes Jackson and Wendell Berry, "A 50-Year Farm Bill", offers an interesting example of such a "framing statement" in agriculture:

> "We need a 50-year farm bill that addresses forthrightly the problems of soil loss and degradation, toxic pollution, fossil-fuel dependency and the destruction of rural communities."

A similar framing statement for water management might contain the following elements:

> "We need a 50-year water bill that addresses forthrightly the problems of water shortages and quality degradation, toxic pollution, fossil fuel dependency, drying of soils and impacts on vegetation, acceleration of global warming, lack of resilience in response to climate extremes and

other shocks, soil nutrient losses, the deterioration of urban, suburban, and rural communities, impacts on public health protection, and loss of jobs and economic growth potential."

A review of the literature suggests the following relationships of water to key concerns in the Commons:

Ecosystem services – water supplies and ecosystem health

The concept that mismanagement of water is compromising valuable ecosystem health and services has been receiving increasing attention. Both water quality and water quantity impairments were a key focus of the Millenium Ecosystem Assessment. The Nature Conservancy has been at the forefront of research suggesting that untouched natural habitat can be more valuable to society than extraction of resources in the industrial model. EPA has established an Ecosystem Services program and is funding pilot studies in Florida and the Carolinas. Water is a centerpiece of efforts to quantify ecological benefits and to develop collaborative assessment and decision-making structures.

Energy

A more recently-discussed concern is the high energy use and associated greenhouse gas emissions from pumping, transport, and treatment in the highly-centralized water management paradigm. As EPA, WERF, and other professional organizations study this issue, an expanding suite of options has emerged to enhance energy-efficiency at treatment plants, and the stimulus package includes grants for energy-efficiency and recovery projects in the water sector. New paradigm advocates are positing reduced pumping costs through decentralization, and generation of revenues and reduced emissions from biogas recovery and heat recovery from sewage. Architects are exploring the links of water and energy systems in new building designs.

The use of water in energy production, transport, and use has also come to the fore in the last couple of years. Electric power companies are increasingly concerned about the security of water supplies for power plants, and critics of subsidized ethanol production point to high water and nutrient requirements. A bill is pending in the Congress to research the energy-water nexus, but almost exclusively from the centralized power and water perspective.

Climate Change – disrupted evapotranspiration

A small but growing group of biologists and ecologists is asserting the preeminent role of evapotranspiration in dissipating solar energy. Robert Kravcik in Slovakia and Marco Schmidt in Germany are key advocates of an argument that urban developments and infrastructure have drained water off the land and cut down massive amounts of vegetation, thereby creating global versions of the "heat island effect". Conventional building ordinances promote urban gray roofs, storm sewers, deep and leaky sanitary sewers, and depletion of ground water supplies. Restoring water ecosystems and reintroduction of vegetation and waterways to cities and towns would moderate urban temperatures.

Nitrogen Cycle

Both EPA and the National Academy of Engineering Grand Challenges project have identified disruptions and releases in the nitrogen cycle as a key ecosystem concern. Excessive nitrogen is considered the primary reason for unwanted marine water growths and oxygen demand that degrade recreation activities in the near coastal waters of the US.

Phosphorous – limited supplies

Nicholas Ashbolt from EPA and Cynthia Mitchell from Australia have weighed in on the emerging concern that phosphate, which plants need to grow, will be depleted by mid-century, and that it is urgent to begin recovering phosphorous from the wastewater stream. Under the present paradigm, phosphorus is displaced to receiving waters in runoff and sewage treatment plant effluents where it causes unwanted algal growth and depreciates recreational use opportunities, particularly in freshwater lakes and rivers.

Resilience – fragile systems

Hurricane Katrina and other natural disasters, along with projections of climate change instabilities, have highlighted the brittle quality of conventional water management approaches. A large centralized system is more vulnerable to shocks and equipment failures than a series of smaller, modular units. The latter provides substantially fewer opportunities for catastrophic damage to structures and receiving waters. Excessive use of potable water for non-potable purposes also reduces the cushion in water supplies during periods of drought.

Toxic Chemicals – pharmaceuticals, endocrine disrupters, and chemicals

USGS has been monitoring the increases in new contaminants of concern. The number of case studies of ecological impacts of these chemicals on receiving waters is continually growing, and it will continue to grow as humans become increasingly dependent upon these compounds. Since existing treatment facilities were not designed to remove these chemicals, this problem may become prominent in the near future.

Gray communities – lower quality of life and public health

In 1969, Ian McHarg described poignantly in Design With Nature the removal of vegetation and the resulting graying and pollution of cities and towns, with tremendous loss of physical and emotional well-being of residents. Water management has been a significant factor in this degradation, since urban streambeds were typically used to remove waste products and many have been covered to lay sewer lines at these low elevations, and stormwater drainage systems pipe water rapidly away from cities instead of using it for vegetation, cooling evaporation, etc. New studies on broad measures of public health reinforce the importance of water-related factors, such as air quality, bio-diversity, temperature control, recreational opportunities, and aesthetics of restored streams, trees, and other vegetation in cities and towns.

Economy – lowered standard of living

A variety of “economic” questions affect the ecological and societal Commons. The traditional economic arguments about water management have revolved around costs of drinking water and sanitation services and who should pay. EPA, for example, has been asserting in recent years that asset management, watershed trading, and public-private partnerships can introduce efficiencies into the water sector, thereby freeing up resources for more productive uses in the water sector or elsewhere in the economy.

A central argument for a new water paradigm is also, in part, that embedded and green technology and networks can provide conventional water services at a significantly lower cost. But these approaches also add significantly more in human health and community benefits as well. An increase in society’s spending on the totality of water management could be more than justified by this increasing “value” in the sector.

Achieving these benefits requires a form of integration that cuts against the grain of the established classic market structure, however. Markets are highly-complex systems, where trillions of transactions a day efficiently allocate resources to producing products that customers want. Adam Smith’s “invisible hand” metaphor encouraged the belief in society that individual advancement, or even “greed”, was good for the collective. But Smith also argued that “specialization” and trade would lower costs. In contrast, nature’s designs involve a complexity of designs and practices, and of values at all scales. The new water paradigm will require integration of planning, utility engineering and management, and architectural design within the water sector and across energy, transportation, health, and other infrastructure.

A second concern is in correcting for “market failures”. The “Tragedy of the Commons”, as discussed, is a metaphor for institutional misalignment and incorrect pricing of natural resources and the resulting destruction of ecosystems. Taxes, subsidies, and regulations all would alter behavior of market participants, either by limiting purchases or sales that collectively threaten the environment (negative externalities) or promoting purchases or sales that collectively enhance the environment (positive externalities).

There are other types of “market failure” as well, where economies will underperform because individual and societal benefits and costs are misaligned. For example, participants in the market may lack necessary information, be unable to pay for investments, unfairly usurp resources from others, or otherwise act irrationally. There has been growing interest in the problems of inequality in the economy and the need to discover the next big wave of productivity increases, which could potentially both be addressed in a “green economy”.

Recently there has been a renewed interest in Adam Smith’s other belief, that the success of markets depends on a society of trust and goodwill or “social capital”. Various academics and advocates have begun to argue for restoration of what might be termed an “economic Commons”. Well-being is not just achieved by individual purchases of goods and services, but also by social interactions in the public sphere, such as in parks, community gardens, coffee shops, town hall meetings, protest marches, voluntary associations, professional meetings, academic classrooms, and on the internet. These interactions have inherent value, but also serve as the foundation or seedbed for new ideas and creative designs. Revitalized public spaces are significantly enhanced from “greening” and designs with nature.

The language of the “Commons” is also being used to articulate the benefits of local economies. By keeping dollars circulating locally, more wealth is created for local citizens. Direct personal interactions uncover opportunities for collaboration and new niche products. Waste can be reduced as resources are recycled. Income is distributed more equitably. Other measures of community health improve as well. In the water sector, embedded and green infrastructure create significantly more short and long-term jobs for local residents than traditional, capital-intensive water or sewer line construction. The multiple benefits of the new water paradigm are also key elements in community economic development and revitalization.

Finally, there is a broad sense that the global economy has not only suffered from financial mismanagement, but needs a burst of demand and new thinking around a richer set of “values”. David Leonhardt in a recent New York Times article boldly asserted that without support for a large new field of innovation, increased productivity and value-creation, the world economy will remain stuck in an underperforming state. Previous growth spurts have followed railroad investments, personal computers, and the internet.

Leonhardt describes the emerging concepts around the “green economy” as the new driver for growth, with substantial increases in productivity of buildings and infrastructure, with large-scale job creation, and with potential for valuable community and ecosystem restoration. Water management innovations are a key part of this potential and will emerge from the renewed public and civic conversations about sustainable water management and the Commons.

The “green economy” of embedded and green infrastructure networks also depends heavily on highly-skilled engineers, architects, construction laborers, landscapers, etc. for installation and ongoing maintenance. Income flowing to this workforce has the potential to right the growing imbalance in the share of GNP claimed by capital vs.

labor. The "human capital" of the new skilled workers in water and other sustainable resource management can lead to higher productivity in the economy and a rebuilding of middle-class incomes.

II. Clarifying the Architecture of a New Water Paradigm – Design Practices and Values

The internal design structure of a new water management paradigm consists both of a new set of technologies and practices and a new range of values generated by the approach. New technologies and practices provide the means and opportunities for improvement. The increased value of services provides the reasons for heading down a new path. Some of these new services or benefits can be captured directly by customers in the existing marketplace, while others represent long-term restoration of the wider Water Commons.

In the first instance, the new technologies and practices can either be incrementally cheaper than conventional approaches or provide additional quality, reliability, and services. In the second instance, avoidance of imminent Tragedies of the Commons or achievement of other large-scale improvements can be the driving force behind advocacy to price and regulate water management in new ways.

The inter-relationships of new designs and new values generated are just beginning to be demonstrated and understood. One "niche" example would be membrane treatment technologies for non-potable reuse of wastewater, which could be both cheaper for the customer than provision of potable water for all uses, and have significant ecological value in reducing the extraction of water from nearby rivers and aquifers. Decentralized systems utilizing low-cost collection methods and soil-based dispersal or reuse are significantly less expensive than a centralized traditional sewer and large treatment plant, and the former enhances opportunities to reuse the water within the community, instead of dumping it into a receiving stream several drainage basins downstream.

The invention of better technologies can be a driver for opening up new markets, while a growing perception that reuse needs to play a greater role in guaranteeing water supplies and protecting watersheds can help advocates lower regulatory barriers.

Enhancing the Commons through Smart, Clean, and Green Design

There are some broad hints for how a comprehensive restructuring of infrastructure institutions and policy can serve society and ecosystems well. Traditionally, it has been thought that environmental protection is at the expense of social and economic wealth and consumption. But the new paradigm suggests that this is a false dichotomy. Because nature can be worked with in a smarter and cleaner way, ecosystem services can be restored in cities, and many of the costs of municipal services reduced. More importantly, communities can be revitalized and the green jobs economy expanded.

These win-win opportunities stem from the core principles and practices of the new paradigm. An important opportunity is the immense productivity of natural systems that can be captured by society in ways that involve far less environmental degradation. The industrial model has been based on the linear model of mining or "extracting" resources, using once, and dumping wastes.

But natural systems have "cleaner" resources that can be tapped with much less damage to the ecosystem. Resources can be used more efficiently and wastes can be productively turned into resources as well. Opportunities also exist in integrated design, rather than in narrower specialized thinking and practice. To paraphrase, the "sum of the conventional parts" in the traditional approach has been much less than the "whole" in infrastructure services. Integrated design can increase productivity of the larger system, while also serving the separate functional needs of the parts.

Another resource to be tapped from nature is the efficiency and high-performance of its organisms and systems.

Biologists and chemists are looking more and more to nature for models to re-engineer products and processes. Membranes in nature can work, for example, without injections of energy that we so far still need for water and wastewater treatment.

Finally, as Ian McHarg wrote in the late 1960's, by locating activities in the most appropriate places in a watershed, natural resource "streams of value" can be tapped with less cost and disruption. McHarg laid out guidelines for locating farms, ports, forests, wildlife corridors, cities, etc. There are lessons to be learned, as well, from "networks" of "nodes" and "links" in nature that assure resilience and adaptability to external shocks to the system.

Examples of these transformative shifts are now appearing in manufacturing, energy, and agriculture. As companies investigate manufacturing processes, they are discovering that efficiency improvements and capturing of resources instead of generation of waste can actually save money. In the energy sector, energy-efficient appliances and clean sources such as wind and sunlight, vegetative cooling, and use of building designs that incorporate them can save money, reduce greenhouse gases, and generate jobs.

In agriculture, complex plant and livestock rotation and harvesting can utilize solar energy and recycle nutrients, thereby avoiding the need for expensive petroleum-based fertilizers, while producing healthier food with less runoff. Such farming practices actually increase the health of soils, rather than deplete them.

Some of these innovations are about relearning intelligent ways that more "primitive" societies used to meet their needs. Older cities in the deserts, for example, could rely on thick walls and street designs to capture desert winds to cool buildings down. Engineers and architects in Masdar in Saudi Arabia are trying to learn from these practices.

Science can transfer these lessons into new technologies as well. Cities can install wind turbines and solar panels to capture energy. Wastewater treatment plants can extract methane for energy from waste sludges and capture and use heat produced in the process. A forest moderates temperatures, through evaporative cooling and condensate warming, and a city can similarly use vegetation to lower heat in buildings and save energy. Rural villages all over the world have typically recycled nutrients from food to sewage and back onto the farmfields, and modern "eco-sanitation" is seeking to replicate this process with public health protection.

Other fields are incorporating the principles of integrative design. Integrative medicine assumes that treating the "whole patient", rather than the specific symptoms can be cheaper and better for long-term health. President Obama's "cluster" economic development strategy also recognizes the synergies of co-locating academic institutions, business incubators, and trained workers in similar fields.

As of yet, these practices and concepts in water fall under the various categories of "smart, clean, and green", "integration", or "biomimicry", etc., but there is no overarching design frame or "unifying theory" that has emerged. Other sectors are much farther along in this regard. In manufacturing, the central concept is "closed-loop" or "cradle to cradle" engineering. In agriculture, a starting point is reliance on solar energy instead of petroleum to generate calories for food.

A key goal of this project is to identify, to the degree possible at this early stage, the central driving forces and reasons behind the power and productivity of the new water paradigm. One possible statement could be: "restore and replicate natural systems at the local scale. The benefits to the larger Commons will follow." But, the densities of cities and the import and export of natural resources complicate this design principle, as will be discussed. Another metaphor is the "network", but the analogies for nodes and links need to be identified. Another phrasing recently introduced is "self-diagnosing, self-healing, and self-repairing systems".

Short-term productivity advances – cost-savings and new services

Advocates of the new water management paradigm have begun to assert that "smart, clean and green" approaches offer distinct advantages in the near-term. This is important because efforts are underway to continue to use of the current infrastructure as a platform and build in new systems in the niches where they either save the customer money or create new value. These opportunities include green schools, federal buildings, multi-family housing, military bases, new subdivisions, and infill developments.

Entrepreneurs and advocates can push for the installation of new technologies by arguing that they are both cheaper and better than current approaches. Widespread implementation would be good for society, in that fewer resources would be needed for a given level of service and additional benefits or services would be provided that customers appear to want. They may also advantage the Water Commons.

Examples of these cost-savings and value-added services in the new water paradigm are at the building, neighborhood and municipal scale. In the early stages of "low impact development", it began to be clear that developers could both save money on installation of stormwater management in a new subdivision and also garner higher home prices from buyers who liked the open space, recreational areas, wildlife habitat, etc. These factors have become a major tool in convincing developers to adopt "green" practices and municipalities to adopt local ordinances that facilitate and encourage such practices.

Similarly, a municipality can both save money and generate additional value from a new way of approaching water management. Integrated water and energy planning, such as satellite wastewater treatment facilities that replace high energy-use and high maintenance cost pumping stations can lower energy costs for the water utility and provide for reuse opportunities and possibly generate revenue from biogas recovery and water reuse. "Green infrastructure" can also produce improved air quality, recreational, aesthetic and other benefits for residents. When the city merges capital planning across all relevant agencies, these "added value" impacts can be calculated. If "green jobs" are created for this work, then the city can also benefit from increased payroll taxes and possibly lowered crime, higher property values and other economic development impacts.

Long-term Enhancements of the Water Commons

Cost-savings and added value are extremely useful as an argument for building scattered examples of the new paradigm in the short-term, but are inadequate as a defense for a shift in the water paradigm in the long-term. This is because the current prices and values in the marketplace upon which decisions are made fail to take account of all the significant concerns of the Water Commons.

For example, if limited phosphate rock is a long-term challenge, then the value in the market for recovery of wasted phosphates in sewage treatment plant effluents, rather than disposal of phosphorus, should be established by the government through either penalties for disposal or mandates for recovery. Recovery could generate some short-term revenues from sale as fertilizer, but the remaining incentive would reflect the low discount rate for a societally-determined long-term shortage. Similarly, if vegetative cover and soil moisture are determined to be a useful approach to moderating global temperatures, then governments could provide financial incentives for green roofs and tree plantings and for keeping water local.

Identification and prioritization of the various concerns in the Water Commons thus becomes the foundation for establishing the envelope of objectives for water management, within which the new design model is developed and shaped over time. Increasing water shortages are likely to be a high priority, but an exclusive focus on this concern could lead to a perpetuation of existing central system models, when a multiple-objective approach could provide even better relief and additional important benefits.

Setting a Policy and Civic Agenda for a New Water Paradigm

Current policies, institutions, and advocacy in water management are mired in conventional practice and thinking. Legislation in years past was directed at provision of clean water to cities (and farms) and at reducing exposure to contaminants in sewage in a manner known at the time, through long-distance transport of both. Subsidies and regulations have perpetuated this design approach. Clean water advocates have largely accepted the notion that more funding and tighter enforcement would be the keys to improvement without considering the entire picture of the benefits of changing the basic approach.

A series of water crises and science-based design opportunities are challenging this system, but the tendency is still to think incrementally and cautiously. With some flexibility in regulatory programs and some support for innovation, scattered pilot projects can get built by developers or municipalities. These are not without value. Demonstrated success (or failure) with new technologies and designs can expand the knowledge base and lower the risks of reform.

But a new Covenant or Social Contract in water does require a fundamental rethinking of governance and civic activism. This project will work through the farthest of leading-edge concepts about what is at stake in the management of the Water Commons. It will also seek to characterize the internal design principles and identify participants in a new approach. The final element is a deconstruction of existing, perverse policies and institutions and a construction of more appropriate approaches.

The “full-cost pricing” concept from the earlier workshops remains critical, in that current low prices for water and wastewater services encourage the wasting of increasingly scarce water resources. Failure to charge for eco-system damage similarly encourages disruption of water hydrologies and increased releases of pollutants. Reduced subsidies for profligate water use, and potential imposition of taxes and other penalties for ecosystem disruptions, could encourage a widespread search for and adoption of water-efficient designs, fit-for-purpose treatment, and reuse and reclamation in the marketplace.

Higher pricing of water is now being recommended by corporations that rely on large and stable water supplies, including power plants, bottling companies, computer chip manufacturing, and others. These companies argue for the advantages of market pricing in allocating resources and in spurring efficiencies and innovation. Resistance to such “commodification” of water comes from social justice groups who argue that access to water should be a human right and that no one should be priced out of the market. A limited focus on water supplies could also lead to a heavy reliance on expensive and energy-intensive desalination plants, which would not address the full range of needs and opportunities of the Water Commons.

Early thinking about a transition to 21st Century “smart, clean, and green” infrastructure practices and institutions suggests a more thorough analysis is necessary to write legislation. Reference points for a new policy and civic agenda are in the larger conversations about the failings of markets and the need for a restored social and economic Commons described earlier. New policies and advocacy for sustainable energy and agriculture also offer important analogies.

Market Corrections

The literature on market failures offers some important insights. Generally, economists speak of four primary market failures, along with four concerns that are not well-addressed by the classical model. The “failures” which adversely affect societal outcomes are:

- **Externalities** – both positive and negative impacts on others
- **Monopoly power** – can private water and wastewater utilities extract high prices from customers or otherwise misallocate resources and under-perform because they have no competitors?
- **Public goods & services** - such as research or national defense, that will not be produced by individual companies, because the benefits accrue to the broader public and cannot be captured in sales in the market
- **Information** – do producers and consumers make poor decisions because of lack of information?

Additional concerns that are not part of the classical market model are:

- **Equity** – should cross-subsidies be made to help low-income customers, companies, or communities?
- **Behavioral anomalies** – do utilities, developers, and consumers need to be encouraged to act in more “rational” ways to promote their self-interests?
- **Power dynamics** – have engineers or private companies had the power to prevent shifts in water management that would benefit society at large?
- **Market transformation and growth patterns** –is there a role for government or private foundations (such as the Clinton Foundation) to open and jump-start markets for the development of lower-cost and higher-quality technologies in water management to emerge over time?

This project will clarify the location and range of these concerns in water management, including both those market imperfections that unnecessarily compromise the ecosystem and societal Commons, and those market corrections that support a burst of design and engineering potential in buildings and infrastructure.

The design of an optimal mix of government strategies will depend on calculations of the responsiveness of various actors, on equity issues, and other institutional factors. For example, higher water rates may lead homeowners to purchase water-efficiency appliances, harvest rainwater, or reuse graywater and blackwater. But, a danger is that homeowners will not shift their behavior, but rather just pay more for water (this is considered a low “elasticity” of response). In those instances, requirements and mandates may need to be imposed by government. In addition, homeowners may lack the upfront funding to retrofit their homes, and in these instances, rebates and subsidies will be required to assist them in doing so.

A key insight from the energy sector is that market participants include far more than energy utilities and multi-national corporations in coal, oil and natural gas. Homeowners and other property-owners become much more active customers for energy-efficient appliances, solar panels, etc. Scientists and venture capitalists develop new markets for renewable technologies at a variety of scales. Architects incorporate LEED and other Green Building standards in their plans and drawings. Planners and a range of municipal agencies and civic organizations search for more efficient designs and strategies.

Improvements should also be internalized at the lowest scale possible, a principle termed “subsidiarity”. In water management, there are the following scales: building, subdivision or neighborhood, municipality, watershed, and global ecosystem. Generally, at each scale market participants may need some encouragement or information to adopt practices or technologies that are in their interest. A heavier hand of pricing or mandates will be required to deal with externalities that they impose collectively at higher scales.

Many social and economic concerns will be addressed at the municipal level. Ecosystem functions are best-managed within watersheds, which differ in needs from water-short to water-plentiful regions. Truly global concerns relate to climate impacts from reduced evapotranspiration and high energy use, nitrogen cycles issues, limited phosphate supplies, and broad measures of shared prosperity and health.

An “artful” new policy frame will seek to maximize the strengths of markets, but direct those markets toward protection and restoration of the Water Commons, rather than “commodify” water. Current policies protect public health in important ways, but also thwart the discovery of efficiencies and innovative technologies and designs. Market forces do need to be unleashed, but only if goals, incentives, and safeguards are in place to advance the public interest, including the health and functioning of ecosystems and communities.

The varied numbers of financial incentives, planning procedures, and mandates that can be devised, in combination, are fairly well-known in efforts to lower the externalities for greenhouse gas emissions. They include:

- Gasoline taxes
- Vehicle mileage requirements
- Carbon trading schemes
- Low-income weatherization grants
- Life-cycle, multi-criteria planning requirements for utilities to assess options
- Mandated reductions of energy use in federal facilities
- Decoupling of utility revenues from the need to sell more power
- Preferential lending to those utilities that
- Tax credits for solar panels
- Investment tax credits for innovative wind and solar projects

Some of these are viewed as temporary. In early phases of design and use, costs are higher to the consumer than they eventually will be. Experience shows that as markets mature in the environmental sector, performance of technologies improves and costs of production decline significantly.

The analogies in water management could include:

- Rebates for water-saving appliances
- Higher water rates to induce conservation and reuse
- Subsidies targeted at low-income ratepayers who install new technologies
- Mandates for onsite stormwater management practices
- Integrated full-cost assessments for federal grants and loans
- Water use trading
- Water banks, where nonprofits pay for reductions in water use
- Development of ecosystem service markets, modeled on carbon trading markets

Other institutional changes, such as new leasing systems where the developer, can capture the longer-term benefits of reduced water use (and not the tenant).

Integrated Governance

The new water paradigm achieves significant value through integrated architecture and engineering design at the building, neighborhood, municipal, and watershed scales. Green building rating schemes such as LEED have instigated inter-disciplinary collaboration and the discovery of substantial cost-savings and productivity advancements. At the municipal level, cities such as Los Angeles and Seattle are demonstrating the significant benefits of inter-agency planning.

This integration of design and planning should be incentivized, and potentially required, over time by the federal government. A start would be the kind of planning exercise proposed in the earlier workshop series, as a condition for any and all federal grant or loan programs. Currently, most federal departments focus on a narrow mission. HUD, for example, does not reward green practices in multi-family housing projects, in spite of their demonstrated value. EPA wastewater funding through State Revolving Funds does not require an integrated resource plan.

Potentially, the federal government could move to "sustainability block grants" as more is learned about the value of integrated urban approaches.

The role of federal, state, and local regulatory programs in perpetuating a conventional infrastructure paradigm is more problematic. Generally, local developers are forced to deal separately with a wide range of conservation, health, building, planning, and other agency rules and permit requirements and are allowed less flexibility in design than they would need to advance a 21st Century "smart, clean, and green" agenda. Ordinances should be drafted to encourage, rather than stymie, this approach.

Municipalities are also greatly constrained by federal and state mandates in water quality, water supply, education, fire safety, endangered species, and other services. Separately, these mandates advance siloed agendas for the public interest, but collectively they may constrain the ability of communities to implement more holistic, sustainable approaches. This is one of the tensions in green infrastructure, for example, where the NPDES enforcement program allows large underground storage tunnels to deal with combined sewer overflows, rather than distributed retention in green roofs, swales, etc. State fire codes have also perpetuated wide streets and cul-de-sacs and sprawl development. One of the goals of this project will be to discuss the impediments to integrated design in existing legislation and to recommend appropriate reform.

Restoring the Societal Commons

Developing and implementing a new water paradigm requires significant interdisciplinary collaboration and participation by civil society. Congress, the new Administration, foundations, and a wide variety of professional and advocacy groups need to create substantial spaces for conversation and invention. Markets alone can experience the "creative winds of destruction" as new products drive out the old. But, in water management, there are complex and intricate relationships among markets, agencies, civil society, and the public that prevent market-driven change. A water paradigm shift requires an affirmative government and civil society vision and commitment for change, which will only emerge from a substantial collaborative dialogue.

Initially, this dialogue is necessary for thinking through and pushing the kinds of changes in institutions and markets that will be needed. But over the long haul, a revitalized civic Commons will continue to be needed to assist communities in establishing values and developing coordinated plans and will be important as the source and seedbed for widespread invention as well.

Framing a new Water Covenant

Scattered, partial conversations assert the need for a more ambitious and holistic approach to predicted water-related crises and opportunities, but none are responsive to the full scope and need for a paradigm shift in water management. This project is an initial effort to clarify the external objectives and internal structures and mechanisms for that shift. A preliminary example would include the following three framing statements:

Defining Water Management Impacts on the Commons

Traditional approaches to water management have created problems of water shortages and degradation, toxic pollution, fossil fuel dependency, drying soils and vegetation, acceleration of global warming, lack of resilience in response to climate extremes and other shocks, nutrient losses, the deterioration of urban, suburban, and rural communities and public health, and the loss of jobs and economic growth potential.

Implications of a Paradigm Shift in Water Management

Networks of smart, clean, and green infrastructure that work with and mimic nature have the potential to provide water efficiently for all uses, restore natural water systems, moderate climate change, recycle scarce resources, and revitalize communities and economies.

Governance and advocacy innovations to promote restoration of the Commons

Measures to correct for market failures and externalities will include funding for research, education, and pilot projects, rebates and tax credits, creation of ecosystem markets, and mandates for integrated infrastructure that creates multiple benefits for healthy communities. Creativity and innovation will be supported in the restored public spaces and conversations in a civic dialogue among communities of architects, engineers, planners, watershed advocates, builders, scientists, manufacturers, and community advocates for green jobs and healthy communities.

It is possible that a new Water Covenant will emerge in coming years focused more or less exclusively on just the problem of growing water shortages. But this project will attempt to do justice by the full complexity of challenges and opportunities for a new design model.

Systems Frame vs. Triple-Bottom Line Accounting

Development of a new Water Covenant involves the overlaying of three systems: global ecosystems; design of human settlements and infrastructure; and political economy. At the moment, systems thinkers in each of these sectors are largely unaware of progress or opportunities in the other.

Global climate and ecosystem analysts are ill-informed about the potential for new infrastructure models that could be more sustainable. Advocates of smart, clean and green infrastructure have not made a connection of their approaches to issues in the broader Water Commons. And, economists and policy advocates are not speaking to emerging issues in the water sector.

Triple Bottom Line accounting suggests that there is some small area of overlap between sectors or factors in the environment, society, and the economy. This approach perpetuates the segregated thinking of industrial economies, where the idea is that some small overlapping part of each system is maximized in a joint solution.

In contrast, the three environmental, social, and economic systems need to be viewed from the start as interconnected. Vegetation and waterways can be restored in cities to provide energy and water services. Markets can be adjusted to advance lighter urban footprints and healthier communities. And, civil society can be revitalized in the rebuilding of the “Commonwealth”.

The touchstone for the new paradigm is in the phrase “water is at the heart of all life.” Inevitably, such concepts as “cooperation”, “interconnection”, “resilience”, and “abundance” will emerge. Unlocking the correct metaphors and design principles for water’s work in the Commons has not yet been done, but efforts in this project will be made to do so.

Literature to Date

- Aqua-Tex Scientific Consulting, Nature's Revenue Streams
- Aqua-Tex Scientific Consulting, Resources from Waste: Integrated Resource Management
- Ashbolt, Nicholas and Jim Goodrich, Reconfiguration of water-energy systems for healthy and sustainable urban water management
- BC Hydro et al, Green Value: Green Buildings, Growing Assets
- Braungart, M. et al, Ecological Design and Engineering for Urban Environments
- Carpenter, S, Science for Managing Ecosystem Services: Beyond the Millennium Ecosystem Assessment
- Daigger, G., Evolving Approaches to Urban Water Management
- Daily, G, Ecosystem Services: From Theory to Implementation
- DeKay, M., Integral Theory for Sustainable Design: Levels of Complexity
- Diamond, J. Collapse: How Societies Choose to Fail or Survive
- EPA, Ecosystem Services Research Program: Coastal Carolinas Research
- Fraker, Harrison and William Wurster, Sustainable Neighbor "Eco-blocks" in China
- Hawken, P. et al, Natural Capitalism: Creating the Next Industrial Revolution
- Inslee, J. and B. Hendricks, Apollo's Fire: Igniting America's Clean Energy Economy
- Institute for Sustainable Futures, Ecosystem Services: What Benefits Do They Provide?
- International Bank for Reconstruction, How Much is an Ecosystem Worth? Assessing the Economic Value of Conservation
- Janssen, M., Toward a Network Perspective of the Study of Resilience in Social-Ecological Systems
- Kenway, S., Triple Bottom Line Reporting: A Communication Tool on the Journey Towards Sustainable Performance for US Water Utilities
- Kirschenmann, F. Spirituality in Agriculture
- Kravcik, M., Water for the Recovery of the Climate: A New Water Paradigm
- Lakoff, G., The Obama Code
- Leonhardt, D., The Big Fix – Can Barack Obama Really Fix the U.S. Economy
- McHarg, I., Design With Nature
- Mitchell, C. Costing Sustainable Outcomes
- Museum of Modern Art, Design and the Elastic Mind
- National Research Council, Sustainable Critical Infrastructure Systems – A Framework for Meeting 21st Century Imperatives
- National Science and Technology Council, Net-Zero Energy, High-Performance Green Buildings
- Novotny, V., A Paradigm of Sustainable Urban Drainage and Water Management
- Office of Science and Technology Policy, A Strategy for Federal Science and Technology to Support Water Availability and Quality in the United States
- Ostrom, E., Governing the Commons
- Pollan, M, Omnivore's Dilemma: A Natural History of Four Meals
- Pollin, R. Doing the Recovery Right.

- Schmidt, M, Global Climate Change: The Wrong Parameter
- Shannon, M, Science and Technology for Water Purification in the Coming Decades
- Smith, T. Predictive Network-Centric Intelligence: Toward a Total-Systems Transformation of Analysis and Assessment.
- Walker, B. and D. Salt, Resilience Thinking: Sustaining Ecosystems and People in a Changing World
- Williams, P., Bringing Advanced Information Technology to Water Management: Proposed Educational Organization
- World Economic Forum, Thirsty Energy: Water and Energy in the 21st Century
- World Health Organization, The Final Report of the Commission on the Social Determinants of Health

Research Strategy

The objective of this project is to articulate a unifying statement on "what is at stake in the Water Commons, how the new water paradigm will better address these needs, and how the mission statements and economic calculations in the sector need to be re-structured in a Water Covenant for public policy and civic dialogue."

Currently, researchers, engineers, public officials and advocates work in various pieces or parts of this emerging challenge. In particular, ecologists study the ecosystem, engineers and architects study the new designs, and economists study the political economy. The premise of this project is that a new direction for water management will be achieved only when all three "systems" are integrated.

The methodology of the project is two-fold: first, bring together experts in each of the three systems, in order to explore the interrelationships and interconnections of the various perspectives; and second, review unifying perspectives that have emerged for sustainable agriculture, energy, manufacturing, and transportation to see if there are good analogies for water.

The framing challenges for a new Water Covenant posed in this project will be addressed in further literature review and interviews with ecologist, designers, and economists, and in a three-day retreat. The background material in this proposal will be distributed to solicit feedback from a sample of ecologists, designers, and economists. Questions include: have the issues and theories been properly characterized? Are there additional insights or mechanisms? Is there additional literature that provides important insights? Are there individuals who should be invited to participate in a retreat?

The central focus of the project will be in the three-day retreat, potentially in collaboration with the Johnson Foundation which hosts conferences at the Wingspread Conference Center near Racine, Wisconsin. It will be important at the outset to identify and select a qualified facilitator, who can assist in the design of the retreat. Key questions concern the appropriate number and mix of participants, and the framing of an agenda that supports a creative synthesis of concepts across the three systems and questions.   For example, a smaller number of participants may be preferable so that the group as a whole can synthesize the materials (vs. a large group with break-out groups that divide up the discussions).

One approach might be to invite a small number of participants to prepare in writing a short summary of emerging issues in their respective field of expertise, including issues in the Water Commons, characterization of the new design paradigm, or shape of a Water Covenant.   These summaries could be used as initial background presentations in the workshop, along with statements from sustainable agriculture and related fields. Participants would then be challenged to draft and agree upon a joint declaration for a new water paradigm.

A key factor in the success of the project will be the recruiting of knowledgeable and imaginative experts in the following fields: ecology, biology, engineering, architecture, economics, civil society, and policy and governance. Leading thinkers in the fields of sustainable agriculture, energy, and urban design will also be invited to participate.

PLANETARY BOUNDARIES – DISCUSSION DRAFT

Lee S. Roberts
lroberts@collinswoerman.com

This document was created as a background primer for participants in the Water Commons workshops. It is inspired by and based on two fundamental articles on planetary boundaries - *A Safe Operating Space for Humanity*, by Johan Rockstrom, et al, that appeared in the journal Nature in September, 2009; and the related article, *The Nine Planetary Boundaries*, by Sturle Simonsen, that was posted to the Stockholm Resilience Centre website the same month. These initial attempts to identify the environmental thresholds beyond which our planet cannot recover became a touchpoint for the workshop discussion on the Water Commons. This document attempts to identify the role that water plays in each of the nine identified boundaries and the interrelationships between them.

BOUNDARY 1: ANTHROPOGENIC CLIMATE CHANGE

We have reached a point at which the loss of summer polar ice is almost certainly irreversible. From the perspective of the Earth as a complex system, this is one example of the sharp threshold above which large feedback mechanisms could drive the Earth system into a much warmer, greenhouse gas-rich state with sea levels metres higher than present. The weakening or reversal of terrestrial carbon sinks, for example through the ongoing destruction of the world´s rainforests, is another such interdependent tipping point. Recent evidence suggests that the Earth System, now passing 387 parts per million by volume (ppmv) CO_2, has already transgressed this Planetary Boundary. A major question is how long we can remain over this boundary before large, irreversible changes become unavoidable.[1]

Parameter[2]	Pre-industrial value	Current Status	Proposed Boundary
Atmospheric carbon dioxide concentration (ppmv)	280	387	350
Change in radiative forcing (watts per metre^2)	0	1.5	1

Radiative Forcing is the term for the net difference between incoming and outgoing energy in the atmosphere – this difference is governed by a range of factors – intensity of solar energy, reflection by clouds or atmospheric gasses, absorption by the atmosphere or surfaces of the earth, and emission by various materials. Additional ***atmospheric Carbon Dioxide (CO2)*** emitted by human activities is currently the primary driver of net increase in radiative forcing in the Anthropocene epoch[3], although methane, nitrous oxide, and CFCs have also contributed.[4]

Water Relationship

Climate change threatens natural water systems throughout the globe – changing weather patterns are already

1 Simonsen, Sturle H. (2009). The nine planetary boundaries. Stockholm Resilience Centre Research document. Retrieved from http://www.stockholmresilience.org/research/researchnews/tippingtowardstheunknown/thenineplanetaryboundaries.4.1fe8f33123572b59ab80007039.html

2 Rockström, Johan, et al. (2009). A safe operating space for humanity. Nature 461. 472-475. Retrieved from http://www.nature.com/nature/journal/v461/n7263/full/461472a.html

3 The Anthropocene epoch is defined as the period of the Earth's history within which human activities are the greatest contributors to climate change. This is in contrast to the Holocene epoch, the 10,000 years of relatively stable world climate patterns that have allowed human societies to thrive. See David Biello (2009). Grappling with the Anthropocene: Scientists Identify Safe Limits for Human Impacts on Planet. *Scientific American* News, September 23, 2009. Retrieved from http://www.scientificamerican.com/article.cfm?id=scientists-identify-safe-limits-for-human-impacts

4 Gallaher, Micke, et al. (2005). Global mitigation of non-CO_2 greenhouse gases. EPA-ARS Technical Report. Retrieved from http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=197768

causing reduced snowpacks in mountains (that lead to increased winter water flows and decreased summer flows in natural water systems), increased frequency of droughts and flooding, reduction in polar ice coverage and sea level rise. Future effects will continue these trends with increasing risks of non-linear, unpredictable weather behavior and irreversible changes.[5]

In addition, climate change may lead to increased ocean circulation, bringing water from the depths up toward the ocean surface – the decreased CO_2 carrying capacity of water near the surface will result in these waters re-emitting their stored CO_2 back into the atmosphere.

Human Mismanagement

Understanding of the effects of greenhouse gas emissions is relatively new and still evolving, and regulations on creation and emission of these compounds are still subject to some scientific and much political debate. Control of greenhouse gas emissions is seen as an economic cost, rather than an opportunity. The ramifications of increasing greenhouse gas emissions touch every facet of contemporary life in the developed world, but the change in behaviors and systems is slow. Despite considerable international attention to the problem, very few nations have successfully begun to reverse trends of increasing emissions.[6]

Solutions

The International Panel on Climate Change identifies both short- and long-term mitigation strategies in many sectors, many with currently commercially-available technologies. These strategies are can be combined with (or may become unnecessary due to) lifestyle changes.

Energy supply – Improved supply and distribution, renewable sources, co-generation, carbon capture and storage.

Transport: Improved fuel efficiency, hybrid, biofuel, and clean diesel vehicles, modal shifts from road transport to rail and public systems, and non-motorized transport. Land use and transportation planning also impact transportation needs.

Buildings: Daylighting, efficient lighting, improved appliances and HVAC equipment, improved insulation, passive and active solar design.

Industry: Efficient electrical equipment, heat and power recovery systems, material recycling and substitution, control of emissions.

Agriculture: Improved land management to increase soil carbon storage, restoration of high-value soils and lands, improved cultivation and livestock management, dedicated energy crops, and energy efficiency.

Forestry: Afforestation, reforestation, and reduced deforestation, biofuel production and wood product management.

Waste Management: Methane recovery, waste incineration with energy recovery, composting, improved wastewater treatment, and waste minimization.[7]

5 IPCC (2008). Executive Summary. IPCC Technical Paper on Climate Change and Water. (April 9, 2008). Retrieved from http://www.ipcc.ch/meetings/session28/executive_summary.pdf

6 According to the United Nations Framework Convention on Climate Change (UNFCCC), 38 countries have pledged to reduce CO_2e emissions. (The United States and China, the two largest CO2e emitters, have made no such pledges.) Of these 38, only the United Kingdom and the Principality of Monaco are on track to meet their pledges. From Biello, David (2008). From bad to worse: Latest figures on global greenhouse gas emissions. *Scientific American* News, November 17, 2008. Retrieved from http://www.scientificamerican.com/article.cfm?id=from-bad-to-worse-with-greenhouse-gas-emissions

7 IPCC. (2007). Summary for Policymakers. *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. B. Metz, et al (Eds). Retrieved from http://www.ipcc.

Interrelationships

Global climate change will affect different regions in a wide variety of ways, but will certainly affect **freshwater** supplies and availability for use. **Land use** decisions greatly impact the amount of greenhouse gas emissions, especially in the areas of transportation, energy generation and use, and conversion of natural habitat for human habitation, agriculture and food production. Terrestrial vegetation is a major source of natural carbon sequestration – land use changes often release vast quantities of this stored carbon into the atmosphere, as well as reducing potential for future storage. Atmospheric CO_2 is the primary contributor to **ocean acidification**.

ch/publications_and_data/ar4/wg3/en/spm-en.html

BOUNDARY 2: RATE OF BIODIVERSITY LOSS

In the Millennium Ecosystem Assessment of 2005, it was concluded that changes in biodiversity due to human activities were more rapid in the past 50 years than at any time in human history, and the drivers of change that cause biodiversity loss and lead to changes in ecosystem services are either steady, show no evidence of declining over time, or are increasing in intensity. These large rates of extinction can be slowed by judicious projects to enhance habitat and build appropriate connectivity while maintaining high agricultural productivity. Further research is needed to determine whether a boundary based on extinction rates is sufficient, and whether there are reliable data to support it.[8]

Parameter[9]	Pre-industrial value	Current Status	Proposed Boundary
Extinction rate (number of species per million per year)	0.1-1	>100	10

Water Relationship

Human uses/degradation of water systems is a significant portion of human impacts on species survival and biodiversity. In addition, water is a conveyance of food and a method of species migration and dispersion, as well as a possible vector for pollutant and invasive species impacts.

Human Mismanagement

Habitat destruction/degradation – humans have transformed, degraded or destroyed half of the world's forests, the richest sources of biodiversity on the planet.

Unsustainable levels of hunting, fishing, and poaching – we use about half of the world's net primary productivity, most of the world's fresh water and almost all of the world's oceans' productivity.

Non-native species introductions – introduced species appear to have contributed to at least half of all documented extinctions since 1600, many of them in island habitats isolated from other species until human involvement.

Anthropogenic climate change is outpacing evolutionary genetic coping mechanisms. The distribution of species is linked to climate, but many species cannot migrate at the rate of current climate change.[10]

8 Simonsen

9 Rockström

10 Allan, X. (2006). Threats to global biodiversity. Lecture in Global change: Human Impacts. A course at University of Michigan Program in the Environment. Jan 4, 2006. Retrieved from http://www.globalchange.umich.edu/globalchange2/current/lectures/biodiversity/biodiversity.html

Solutions

It is critical that we find ways to reduce our overall resource use in order to lessen our impact on natural systems and environments. It is important that we find alternates for forest destruction that allow for economic development and sustainable resource harvesting. We must reduce pollution by improving our waste management practices.

Interrelationships

Freshwater system mismanagement and overconsumption leads to decreased habitat for various species. Human **land use** patterns disrupt, fragment, or remove habitat, food and water sources, and migration routes. **Chemical pollution** affects reproductive health of many species. **Nitrogen** and **Phosphorous** in water bodies encourages algal blooms which lead to eutrophication and destruction of marine habitats. **Ocean acidification** reduces ability of shell-growing ocean species to form shells – these animals are the foundation of ocean biospheres.

BOUNDARY 3a and 3b:
NITROGEN CYCLE/PHOSPHOROUS CYCLE

Human modification of the nitrogen cycle has been even greater than our modification of the carbon cycle. Human activities now convert more N_2 from the atmosphere into reactive forms than all of the Earth´s terrestrial processes combined. Much of this new reactive nitrogen pollutes waterways and coastal zones, is emitted to the atmosphere in various forms, or accumulates in the terrestrial biosphere. A relatively small proportion of the fertilizers applied to food production systems is taken up by plants. A significant fraction of the applied nitrogen and phosphorus makes its way to the sea, and can push marine and aquatic systems across thresholds of their own. A concrete example of this effect is the decline in the shrimp catch in the Gulf of Mexico due to hypoxia caused by fertilizer transported in rivers from the US Midwest.[11]

Parameter[12]	Pre-industrial value	Current Status	Proposed Boundary
Nitrogen cycle: Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	0	121	35
Phosphorous cycle: Quantity of P flowing into the oceans (millions of tonnes per year)	~1	8.5-9.5	11

Water Relationship

Activated nitrogen is soluble, is persistent in fresh and salt water, and is the primary cause of unwanted marine growths and eutrophication of water bodies.

Phosphorous is being removed from soil for human use, and then enters water bodies through runoff or in wastewater systems. Phosphate supply for land plants is depleted, and phosphorus causes unwanted algal growth thus decreasing water quality, especially in freshwater systems.[13]

Human Mismanagement

Human use of nitrogen (primarily as fertilizer) and phosphorous (for fertilizer, detergents, and other uses), has disrupted natural cycles by overwhelming the systems and organisms that naturally process these elements.

Atmospheric nitrogen is ‘fixed,’ or converted into compounds usable to plants, by bacteria in soil or that live in symbiotic relationships to plants. Nitrogen, in a fixed form, is critical to plant growth and photosynthesis. Nitrogen in animals can be traced back to an original plant source. As organisms die or expel waste, nitrogen (as part of organic compounds) is processed by bacteria into ammonia or returned to the atmosphere.

Through collection of natural nitrogen sources (guano is a significant source), cultivation of nitrogen-fixing plants, or production of ammonia in industrial processes, humans have more than doubled biologically-available nitrogen, and concentrated it in agricultural settings. The portion of nitrogen fertilizers not taken up by crops enters water systems causing spikes in plant growth and eutrophication of water bodies.

Nitrous oxide, a significant greenhouse gas, is a product of the burning of fossil fuels and of the increased amount of usable nitrogen in global systems, and can also contribute to ozone depletion. Other nitrogen-based byproducts of

11 Simonsen
12 Rockström
13 Nelson, Valerie I. 21ST Century Water Management: Restoring the Commons.

human activity contribute to smog production and acid rain.[14]

The natural phosphorous cycle is relatively slow, so human use of phosphorous has very disruptive effects. Phosphorous is naturally present in rock, and through weathering is deposited in soils, where it is taken up by plants. Animals consume plants, and phosphorous is returned to soils and water through excreted waste or decomposition. Phosphorous is a critical part of the energy cycle within all forms of life – it is also important in bones and teeth of vertebrates.

Phosphorous is used in fertilizers, cleaning agents, fluorescent light bulbs, pesticides, and food products. In the waste stream, phosphorous causes algal blooms and eutrophication. Phosphorous is also released into water systems when tropical forests are cut or burned.[15]

Solutions

Improved systems of fertilizer application in agricultural use. Sequestration of phosphorous in waste streams. Reduction in fossil fuel use and burning of tropical forests.

Interrelationships

Eutrophication of water bodies damages ecosystems and may impact **biodiversity**, and **fresh water** availability. **Land use patterns** impact demand for and use of nitrogen and phosphorous as fertilizers, deforestation can also lead to nitrogen and phosphorous release in the atmosphere and in water systems. Nitrogen compounds contribute to **climate change**, **ozone depletion**, and **atmospheric aerosol** emissions.

---

14 Vitousek, PM, et al. (1997). Human Alteration of the Global Nitrogen Cycle: Causes and Consequences. Issues in Ecology 1: 1–17. Retrieved from http://www.epa.gov/watertrain/pdf/issue1.pdf

15 Environmental Literacy Council. (2002). *Phosphorous Cycle*. Retrieved from http://www.enviroliteracy.org/article.php/480.html

BOUNDARY 4: STRATOSPHERIC OZONE DEPLETION

The stratospheric ozone layer filters out ultraviolet radiation from the sun. If this layer decreases, increasing amounts of ultraviolet (UV) radiation will reach ground level and can cause a higher incidence of skin cancer in humans as well as damage to terrestrial and marine biological systems. The appearance of the Antarctic ozone hole was proof that increased concentrations of anthropogenic ozone depleting substances, combined with polar stratospheric clouds, had moved the Antarctic stratosphere into a new regime. Fortunately, because of the actions taken as a result of the Montreal Protocol, we appear to be on the path that will allow us to stay within this boundary. [16]

Parameter[17]	Pre-industrial value	Current Status	Proposed Boundary
Concentration of ozone (in Dobson Units)	290	283	276

Water Relationship

Reduced ozone coverage allows increased UV radiation to reach the surface of the earth. This adds additional stresses to all ecosystems, including marine and aquatic habitats.

Human Mismanagement

Emissions of effective equivalent stratospheric chlorine (EESC) resulted in 5-6% ozone loss, with non-linear chemical reactions that led to the Antarctic ozone hole. Bans on CFC production have slowed ozone depletion, but the effects persist despite changes in human behavior.[18]

Ozone-depleting substances (ODSs) were utilized because of their benefits to human activity. ODSs are useful for refrigeration, air conditioning, foams, aerosols, fire protection and solvents. As the use of recognized ODSs has decreased, substitute substances are increasingly utilized – these substitutes may be greenhouse gasses or may have other environmental or climate impacts. In addition, significant levels of ODSs remain in use in existing equipment, or are in chemical stockpiles or other storage. International regulation does not restrict the use of these 'banks' of ODSs, although national regulations may influence their use. As these sources are used or as equipment degrades or leaks, additional ODSs may be released into the atmosphere.

While the production of the most serious ODSs were phased out following the Montreal Protocol in 1987, less damaging ODSs will not be phased out until 2030, and additional substances not regulated by the Montreal Protocol have been found to destroy ozone.[19]

The effects of ODSs in the atmosphere are complicated – while a ODS might be a greenhouse gas (thus increasing radiative forcing), the thinning of stratospheric ozone decreases radiative forcing, cooling the atmosphere on a regional scale. The climate effects of these imbalanced changes are difficult to predict.[20]

---

16 Simonsen

17 Rockström

18 Molina, Mario J. (2009). Planetary boundaries: Identifying abrupt change. *Nature Reports Climate Change*, 23 September 2009. Retrieved from http://www.nature.com/climate/2009/0910/full/climate.2009.96.html

19 Environmental Protection Agency (2008). Brief questions and answers on ozone depletion. *Ozone Layer Depletion* website. Retrieved from http://www.epa.gov/ozone/science/q_a.html

20 Intergovernmental Panel on Climate Change. (2005). Summary for Policymakers and technical Summary. *Safeguarding the ozone layer and global climate system: Issues related to hydrofluorocarbons and perfluorocarbons*. Metz, B, et al (Eds.) Retrieved from http://www.ipcc.ch/pdf/special-reports/sroc/sroc_spm.pdf

Solutions

While the Montreal Protocol is considered to have been successful at limiting damage to stratospheric ozone from ODSs, there is continuing need to address ODS banks, as well as to understand and mitigate the terrestrial and atmospheric effects of ODS substitutes.

Interrelationships

ODSs and stratospheric ozone levels influence atmospheric temperature, and thus weather patterns, which impact **climate change**, **biodiversity**, and **land use**. Increased UV penetration through Earth's atmosphere has impacts on terrestrial and marine ecosystems, and thus impacts regional and global **biodiversity**.

BOUNDARY 5: OCEAN ACIDIFICATION

Around a quarter of the CO_2 humanity produces is dissolved in the oceans. Here it forms carbonic acid, altering ocean chemistry and decreasing the pH of the surface water. Increased acidity reduces the amount of available carbonate ions, an essential building block used for shell and skeleton formation in organisms such as corals, and some shellfish and plankton species. This will seriously change ocean ecology and potentially lead to drastic reductions in fish stocks. Compared to pre-industrial times, surface ocean acidity has increased by 30%.

The ocean acidification boundary is a clear example of a boundary which, if transgressed, will involve very large change in marine ecosystems, with ramifications for the whole planet. It is also a good example of how tightly connected the boundaries are, since atmospheric CO_2 concentration is the underlying controlling variable for both the climate and the ocean acidification boundary.[21]

Parameter[22]	Pre-industrial value	Current Status	Proposed Boundary
Global mean saturation state of aragonite (a common form of calcium carbonate) in surface sea water	3.44	2.90	2.75

Water Relationship

Increased atmospheric CO_2 leads to increased CO_2 in the world's oceans. This causes the formation of more carbonic acid and hydrogen ions, thereby increasing ocean acidity. A drop in ocean pH has already occurred in the Anthropocene. At lower pH, carbonate ion concentration in ocean water also drops. A decrease in available carbonate ions inhibits shell formation in the wide variety of marine animals and plants that form shells from calcium carbonate (aragonite). As ocean CO_2 levels rise, ocean zones where shell formation becomes difficult or impossible increase, thus reducing foundational food sources and limiting creation coral, a critical ocean ecosystem.

Interrelationships

Climate change may alter ocean currents, bringing CO_2 stored in deep ocean waters to the surface, where they would release their stored CO_2 to the atmosphere, thus compounding greenhouse gas effects. Ocean **biodiversity** is dependent on shell-forming organisms at many levels. Ocean acidification puts ocean ecosystems at risk.

21 Simonsen
22 Rockström

BOUNDARY 6: GLOBAL FRESHWATER USE

The freshwater cycle is both a major prerequisite for staying within the climate boundary, and is strongly affected by climate change. Human pressure is now the dominating driving force determining the function and distribution of global freshwater systems. The effects are dramatic, including both global-scale river flow change and shifts in vapour flows from land use change. Water is becoming increasingly scarce, and by 2050 about half a billion people are likely to have moved into the water-stressed category. A water boundary related to consumptive freshwater use has been proposed to maintain the overall resilience of the Earth system and avoid crossing local and regional thresholds 'downstream´.[23]

Parameter[24]	Pre-industrial value	Current Status	Proposed Boundary
Consumption of freshwater by humans (km^3 per year)	415	2,600	4,000

Human Mismanagement

Human use of water is traditionally not separated into potable and non-potable water – therefore we use pristine water supplies for uses that do not require it. The use of water as the medium for waste disposal (in everything from toilets to factories) is inefficient, degrades water quality, and comingles usable waste products with toxics.

Separation of human settlements from water supplies, agriculture and human settlements in arid areas, and the use of water as a transport medium require massive collection and distribution systems, and remove water from natural surface and groundwater resources. Water systems within human settlement areas are typically hardened and sanitized, removing water from wetlands or other water bodies undesirable to humans. The interruption of groundwater recharge and evaporative cooling cycles in human environments has a significant impact on water cycles, changing regional temperature and precipitation patterns, as well as exacerbating flooding or droughts.

Agricultural practices fundamentally alter water cycles, redirecting water flows, irrigating arid regions, removing vast amounts of water from natural bodies. The use of water in electrical power generation (whether through hydroelectric generation or as a heat sink or waste removal medium) disrupts natural water movement and adds heat or chemical pollution to waterways. Water bodies are also polluted by air deposition from human activities.

Solutions

Human use of water should be increasingly closed-loop, whether within buildings, neighborhoods, cities or regions. Water use as a waste transport mechanism should be reconsidered – at the least water treatment systems need to be improved so that waste water is made useful for human and other uses. Agricultural practices and urban and industrial water uses must be improved to reduce our water demands. We must work to restore natural water cycles in human environments.

Interrelationships

The interruption and alternation of natural water cycles impacts weather patterns and contributes to **climate change** at local, regional, and global scales. **Biodiversity** is threatened by water scarcity, water system fragmentation, pollution, and the encroachment by invasive species. **Nitrogen/phosphorous cycle** mismanagement leads to algal blooms and eutrophication of water bodies, reducing their usefulness. Our patterns of **land use** and inefficiencies of water use in agriculture impact water availability for other uses. **Chemical pollution** threatens water sources throughout the world.

23 Simonsen
24 Rockström

BOUNDARY 7: CHANGE IN LAND USE

Land is converted to human use all over the planet. Forests, wetlands and other vegetation types are converted primarily to agricultural land. This land-use change is one driving force behind reduced biodiversity and has impacts on water flows as well as carbon and other cycles. Land cover change occurs on local and regional scales but when aggregated appears to impact the Earth System on a global scale. A major challenge with setting a land use-related boundary is to reflect not only the needed quantity of unconverted and converted land but also its function, quality and spatial distribution.[25]

Parameter[26]	Pre-industrial value	Current Status	Proposed Boundary
Percentage of global land cover converted to cropland	Low	11.7	15

Water Relationship

The conversion of land to agriculture – and the subsequent requirements for irrigation, water sequestration, the draining of wetlands and the destruction of peat bogs – has huge impacts on natural water cycles and water use in natural systems.

Separation of human settlements from water supplies, agriculture and human settlements in arid areas, and the use of water as a transport medium require massive collection and distribution systems, and remove water from natural surface and groundwater resources. Water systems within human settlement areas are typically hardened and sanitized, decreasing their usability for other species.

Human Mismanagement

Significant reduction in natural environments (caused by human land uses – whether agricultural, urban, or transportation-related) has reduced habitat for species, impacts the global carbon sequestration capacity of forests and other vegetation, decreases water and soil quality through impervious surfaces and decreased plant groundcover. Sprawling development makes inefficient use of limited land areas, as well as fostering high-energy and high-resource use lifestyles. Segregation of land uses also increases demands for transportation systems, further expanding areas of human impact on natural environments. The heat island effects of land use change impact local and global weather patterns and climate.

The conversion of land to agriculture, and the attendant stresses on natural systems, is a huge contributor to several global boundary crises. Unsustainable use of forest resources (for wood, food, and other natural resources) contribute to degradation of ecosystems.

Solutions

Improvement of systems of land use for food, fuel, and mineral production are critical to slowing destruction of natural environments. The use of plant sources for biofuel, while a positive development, can stimulate demand for agricultural land. Less land-intense sources of biofuels are an important solution.

Patterns of human settlement can be much more efficient – the Western preference for low-density suburban development, coupled with the attendant demands for transportation and utility infrastructure, is an unsustainable model for affluent societies, and new patterns should be identified before developing nations emulate our current patterns.

---

25 Simonsen
26 Rockström

Better integration of agriculture with natural environments – reintroduction of natural habitat into human-dominated environments, decreased dependence on chemical and technological solutions to food production needs.

Solutions for natural ecosystem preservation that provide local economic benefits equal to those of destructive practices must be found.

Interrelationships

Changes in land use profoundly affect anthropogenic **climate change**. Habitat reduction and human stresses on natural systems impact **biodiversity**. **Fresh water use** and disruption of natural water cycles follow most land use changes. Human development brings risks of **chemical pollution**, **atmospheric aerosol** production, and disruption of **nitrogen** and **phosphorous cycles**.

BOUNDARY 8: ATMOSPHERIC AEROSOL LOADING

This is considered a planetary boundary for two main reasons: (i) the influence of aerosols on the climate system and (ii) their adverse effects on human health at a regional and global scale. Without aerosol particles in the atmosphere, we would not have clouds. Most clouds and aerosol particles act to cool the planet by reflecting incoming sunlight back to space. Some particles (such as soot) or thin high clouds act like greenhouse gases to warm the planet. In addition, aerosols have been shown to affect monsoon circulations and global-scale circulation systems. Particles also have adverse effects on human health, causing roughly 800,000 premature deaths worldwide each year. While all of these relationships have been well established, all the causal links (especially regarding health effects) are yet to be determined. It has not yet been possible specific threshold value at which global-scale effects will occur; but aerosol loading is so central to climate and human health that it is included among the boundaries.[27]

Parameter[26]	Pre-industrial value	Current Status	Proposed Boundary
Overall particulate concentration in the atmosphere, on a regional basis		To be determined	

Human Mismanagement

While natural sources of atmospheric aerosols (primarily from volcanic eruptions and desert dust) are significant, human-made aerosols are believed to make up the majority of current aerosol levels. Human sources are primarily caused by the burning of coal and oil, although smoke (from burning of tropical forests) is also significant. The concentration of atmospheric aerosols is highest in the northern hemisphere – corresponding to higher industrial levels in the global north. Sulfate aerosols are believed to survive in the atmosphere for 3-5 days.

Human-made aerosols (and other sulfate aerosols) reflect sunlight, and thus act to cool the atmosphere on a regional level. Aerosols can also interact with cloud particles to change the size and light-absorptive levels of atmospheric clouds, which may warm or cool the local atmosphere. In addition, atmospheric aerosols that migrate into the stratosphere are chemically active and can produce chlorine, the prime contributor to ozone depletion.

The combination of overall global warming with localized or regional atmospheric cooling is predicted to cause climate and weather system disruptions, although the nature and scope of these disruptions is not yet predictable.

Atmospheric aerosols in the lower atmosphere are a major source of smog and reduced air quality. This impacts human and environmental health and the local climate, as well as altering the amount (and spectrum) of sunlight that reaches the Earth's surface.[28]

Solutions

There is a considerable amount of current research on the causes and effects of atmospheric aerosols. However, beyond overall energy efficiency, reduction in pollution, lifestyle changes, and the move to non-fossil fuel sources of energy, specific solutions to problems caused by atmospheric aerosols have not been identified.

Interrelationships

Atmospheric aerosols can contribute to **ozone depletion**, and act as local or regional contributors to **climate change**, primarily in creating imbalances between warming and cooling zones. Atmospheric aerosols also affect air quality, which may impact **biodiversity** and **fresh water** sources.

Land use patterns effect how much oil and coal is burned, thus how much atmospheric pollution is created. The burning of forest cover for the conversion of land to agriculture is also a major source of aerosols.

27 Simonsen

28 NASA Langley Research Center (1996). Atmospheric aerosols: What are they are why are they so important? *NASA Facts* FS-1996-08-11-LaRC. Retrieved from http://www.nasa.gov/centers/langley/pdf/70811main_FS-1996-08-11-LaRC.pdf

BOUNDARY 9: CHEMICAL POLLUTION

Emissions of persistent toxic compounds such as metals, various organic compounds and radionuclides, represent some of the key human-driven changes to the planetary environment. There are a number of examples of additive and synergic effects from these compounds. These effects are potentially irreversible. Of most concern are the effects of reduced fertility and especially the potential of permanent genetic damage. As an example, organism uptake and accumulation to sub-lethal levels increasingly cause a dramatic reduction of marine mammal and bird populations. At present, we are unable to quantify this boundary; however, it is nonetheless considered sufficiently well defined to be on the list.[29]

Parameter[26]	Pre-industrial value	Current Status	Proposed Boundary
Amount emitted into - or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals, and nuclear waste in - the global environment; or the effects on ecosystem and functioning of Earth system thereof		To be determined	

Water Relationship

Existing wastewater treatment facilities are unable to remove many chemical and pharmaceutical compounds that are now entering wastewater streams. These chemicals significantly impact aquatic species and habitats. Air deposition of pollutants into water systems also strongly impacts these ecosystems.

Human Mismanagement

We continue to have insufficient understanding and regulation of the impacts of chemical pollution on people, animals, and environments. Our waste treatment systems are currently incapable of removing many chemical pollutants from the waste stream.

Modern societies are very dependent on chemical solutions to problems, but pollution remains externalized in many industrial and economic processes. Governments are often reluctant to require full responsibility for pollution.

Solutions

Reductions in overuse of chemicals would reduce their entry into air and water, as would improvements to our waste treatment and recycling systems. A better understanding of the effects of various chemical compounds would allow us to properly regulate those that impact human and ecosystem health.

Interrelationships

Land use patterns, and the increase of agriculture and industrial uses, increase the number of sources and overall quantity of chemical pollution. **Freshwater** systems are impacted by chemical pollutants in wastewater and from air deposition. **Biodiversity** is threatened by the fertility and genetic damage effects of chemical pollution. Chemical pollutants in the atmosphere may contribute to **climate change** and **ozone depletion**. Many chemical pollutants can act as **aerosols** in the atmosphere.

29 Simonsen

WEBSITES

Solutions: For A Sustainable And Desirable Future
http://www.thesolutionsjournal.com/

PanArchy
http://www.panarchy.org/

Blue Planet Project
http://www.blueplanetproject.net/

Our Water Commons: Shared Lifeline, Not Commodity
http://ourwatercommons.org/

The Ecosystem Services Partnership
http://www.es-partnership.org/

America's Great Waters Coalition
http://online.nwf.org/site/PageServer?pagename=GreatWaters_MainPage

BOOKS

Supply-Side Sustainability
Timothy F. H. Allen, Joseph A. Tainter, and Thomas W. Hoekstra
Columbia University Press: 2003

Toward a Unified Ecology
Timothy F.H. Allen and Thomas W. Hoekstra
Columbia University Press: 1992

Worldchanging : a user's guide for the 21st century
Edited by Alex Steffen ; foreword by Al Gore ; design by Stagmeister Inc.
Harry N. Abrams, Inc.: 2006

Design like you give a damn : architectural responses to humanitarian crisis
Edited by Architecture for Humanity
Metropolis Books: 2006

Blessed unrest : how the largest movement in the world came into being, and why no one saw it coming
Paul Hawken
Viking: 2007

Biomimicry : innovation inspired by nature
Janine M. Benyus
Harper Perennial: 2002

Fragile Dominion: Complexity and the Commons
Simon Levin
Basic Books: 2000

The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability
David Waltner-Toews, James J. Kay, Nina-Marie E. Lister
Columbia University Press: 2008

Dirt: The Erosion of Civilizations
David R. Montgomery
University of California Press: 2008

Sustainable Urbanism: Urban Design With Nature
Douglas Farr
Wiley: 2007

EcoCities: Rebuilding Cities in Balance with Nature
Richard Register
New Society Publishers: 2006

Cities as Sustainable Ecosystems: Principles and Practices
Peter Newman and Isabella Jennings
Island Press: 2008

BIBLIOGRAPHY

Attached Articles:

Nelson, V. 21ST Century Water Management: Restoring the Commons.

Roberts, L. Planetary boundaries Workshop – Discussion draft.

Additional Reading:

These articles were prepared as background materials for workshop participants.

Berry, W. and Jackson, W. (2009, January 4). A 50-Year Farm Bill. Retrieved from http://www.nytimes.com

Biello, D. (2009, September 23). Grappling with the Anthropocene: Scientists Identify Safe Limits for Human Impacts on Planet. Scientific American. Downloaded from http://www.scientificamerican.com

Cullen, P. (1990). The turbulent boundary between water science and water management. Freshwater Biology. Volume 24:1. 201-209. http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2427.1990.tb00319.x/abstract

Diamond, J. (2009, December 5). Will Big Business Save the Earth? The New York Times. Retrieved from http://www.nytimes.com

Gelber, B. (2009, November 17). Ben Franklin on Global Warming. The New York Times. Retrieved from http://www.nytimes.com

Janssen, M. et. al. (2006). Toward a Network Perspective of the Study of Resilience in Social-Ecological Systems. Retrieved from http://www.ecologyandsociety.org

Jennings, I. and Newman, P. (2008, January 31). Cities as Sustainable Ecosystems. Island Press. pp. 92-142.

Jong, M. & Begawan, B. (2009, October 7). Incorporating nature in city designs for sustainability. The Brunei Times. Retrieved from http://news.brunei.fm/2009/10/07/incorporating-nature-in-city-designs-for-sustainability/

Kirschenmann, F. (2005, October 8). Spirituality in Agriculture. Retrieved from http://www.leopold.iastate.edu

Levin, S. (2000, June). Fragile Dominion: Complexity and the Commons. Basic Books. pp. 195-206.

Moddemeyer, S. Sustainable Infrastructure in Seattle: Leveraging Capital for Sustainable Outcomes. Retrieved from http://www.collinswoerman.com

Rockstrom, J. et. al. (2009, September 24). A safe operating space for humanity. Nature. Retrieved from http://www.nature.com

Rottle, N. Open Space Seattle 2100. Powerpoint Presentation. Retrieved from http://depts.washington.edu/open2100/OpenSpaceSeattle2100Public.pps

Solomon, S. (2010). Water: The Epic Struggle for Wealth, Power and Civilization. Harper Collins. pp. 1-5.

Speth, J. (2008, September 17). Global Warming and Modern Capitalism. Retrieved from http://www.thenation.com

Speth, J. (2008). The Bridge at the Edge of the World: Capitalism, the Environment, and Crossing from Crisis to Sustainability. Yale University Press. pp. 217-237.

Steffen, A. (2009, November 1). The Revolution Will Not Be Hand-Made: A Quick Sunday-Morning Rant. Retrieved from http://www.worldchanging.com

The Baltimore Charter for Sustainable Water Systems. Retrieved from http://sustainablewaterforum.org