Visualizing Water Pollution Data Using Beck-Style Flow Path Maps
Submission for the Visualizing Nutrients Challenge — June 2015

Beck-Style Flow Path Maps: The Visualizing Nutrients Challenge seeks "compelling, innovative, and comprehensible visualizations that inform individuals and communities on nutrient pollution [nitrogen and phosphorus] and inspire them to take actions …." In this submission, we propose a novel way to represent water pollution data which we believe will be useful to policy-makers, informative to citizens, attractive to writers and editors, and motivating to public and private donors.

We propose to represent flow paths in river systems on maps created in the style of the urban transit diagrams pioneered by Harry Beck [1] in the 1930s for the London Underground (see Figure 1, PDF attached). Our maps are a modern, urban portrayal of river systems, putting the natural world into a more constructed, engineered visual language that will resonate with a technology-minded audience. Most importantly, the geography is intentionally distorted *to clarify relationships between communities*. Once the maps are created, nutrient pollution data are represented through colored bands, making it easy to see levels at different locations. Viewers can also observe how pollution may be flowing from upstream to downstream communities, and eventually to bays, lakes, and oceans where rivers terminate.

The Water Quality Portal [2] includes locations in the eastern United States of testing sites where nutrients are measured (see Figure 2, PDF attached). We can see that states such as South Carolina, Connecticut, and Arkansas are well-covered by testing sites. However, for this proposal, we chose to create maps for the Susquehanna River valley and the Potomac River valley, because both watersheds have implications for several states and the Chesapeake Bay.

Telling A Story: The Susquehanna and Potomac River Valleys: Attached to this written description are several Beck-style flow path maps created using the total nitrogen and phosphorus data available on the Water Quality Portal [2], as well as the Chesapeake Bay Program Water Quality Data Hub [3]. On the maps (PDF attached), nutrient levels are indicated for locations where one or more measurements occurred for the time period indicated. The maps provide a visualization of aggregated data from different decades, and they reflect both good and bad news for these two key waterways that flow into Chesapeake Bay.

The good news from the maps is that progress has been made to decrease nutrient pollution in these two river systems. This can be seen by placing maps of different time periods side-by-side, or by considering the two Potomac maps (with gray backgrounds) that present changes in total nitrogen and phosphorus readings over a generation. These maps demonstrate that efforts by governments and by private organizations to decrease nutrient pollution are making a difference, and the clear representation of these successes may help spur further action.

However, there is a lot more work to be done. New concerns about water pollution have arisen in the past few weeks in Pennsylvania, after the discovery of a cancerous fish near Duncannon, where the Juniata River flows into the Susquehanna [4]. Through the 2010s maps, we can quickly see high levels of both nutrients measured at nearby upstream Newport. Is there a connection? We can also see how different nutrient levels blend as water flows towards Chesapeake Bay, as low levels measured in the west branch of the river mix with higher levels from the main branch and the Juniata.

Based on these maps, recommendations can be made: for instance, as there are so many locations with no data, funding for a regular program of testing at all locations on the map should be a higher priority.

Also, the EPA should redouble its efforts to encourage states to define acceptable levels of nutrient concentration. For the current state of this work, see [5].

Potential Benefits of Beck-Style Flow Path Maps: We believe these maps are visually appealing, engaging, and meaningful, and will be attractive to editors of regional magazines (e.g. *Philadelphia Magazine*, *Portland Monthly*) and local newspapers, as they commission stories about water pollution affecting their regions. In particular, the maps can be incorporated into online articles, blogs, and social media. This method of representing geospatial information has been implemented on a number of subjects and has proven to be popular (see [6] for an example).

We believe that the information on the maps will spur new intra- and interstate cooperation between communities that are on the same flow path "subway line", by clearly conveying the relationship between upstream and downstream communities when it comes to water pollution. This outcome supports the President's Climate Data Initiative [7].

We envision donors (private and public) being called to action by the information on the maps. The maps may encourage new resources to remediate environmental damage, or to create demonstration projects where regular measurements of nutrient levels are made at all "stops" on a "subway line". Online maps of updated and longitudinal data can be made available. In addition, we anticipate that Beck-style flow path maps could become a standard for data visualization of scientific publications on water quality, including government reports.

Finally, the purpose of maps (and other infographics) is to distill the complexity of the world down into a meaningful caricature. Our maps, like the subway diagrams they draw upon, intentionally simplify complex systems to allow fast, easy communication of the big picture: the spatial relationship between nutrient measurements and the communities affected by the nearby rivers. More traditional, less-stylized maps, while geospatially accurate, do not always show these complexities clearly, and can distract from what is important. Also, the techniques to develop these maps is scale-independent, and with sufficient effort, scalable Beck-style flow path maps could be created and made publically available. Maps of this type, or maps that are animated to show changes over time, would be excellent for viewing on portable devices like tablets and smartphones.

References

[1] "Harry Beck's London", BBC London, accessed May 24, 2015 at URL http://goo.gl/aFwTWf
[2] National Water Information System (NWIS), EPA STOrage and RETrieval (STORET), and the USDA ARS Sustaining The Earth's Watersheds - Agricultural Research Database System (STEWARDS) data available on the World Wide Web (USGS/EPA/NWQMC Water Quality Portal), accessed May 24, 2015, at URL http://waterqualitydata.us/
[3] The Chesapeake Bay Program Water Quality Data Hub, accessed May 24, 2015, at URL http://data.chesapeakebay.net/WaterQuality
[4] "A Fish With Cancer Raises Questions About Health Of Susquehanna River", accessed May 24, 2015 at URL goo.gl/f9qVKm.
[5] "State Development of Numeric Criteria for Nitrogen and Phosphorus Pollution", U.S. EPA, accessed May 24, 2015 at http://cfpub.epa.gov/wqsits/nnc-development/
[6] "U.S. Interstates As A Subway Map", accessed May 24, 2015 at URL visual.ly/us-interstates-subway-map.
[7] "Fact Sheet: The President's Climate Data Initiative: Empowering America's Communities to Prepare for the Effects of Climate Change", the White House (Washington, DC), accessed May 24, 2015 at URL https://goo.gl/ulQw0R