On Waterlines:
Arguments for their Employment, Advice on their Generation

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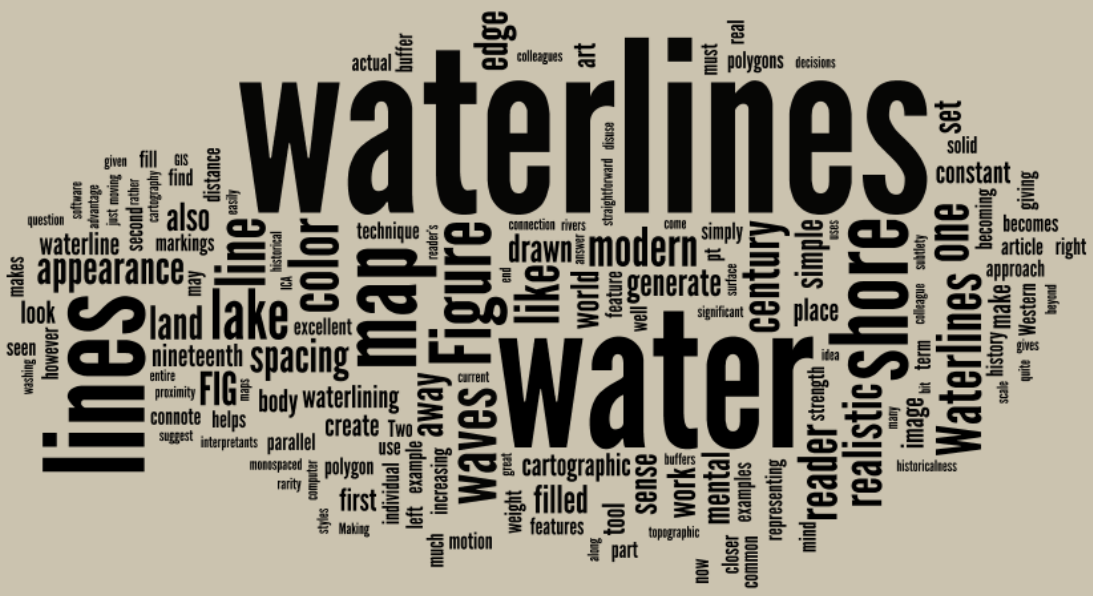

INTRODUCTION

Once a staple of Western cartographic design, waterlines have, sadly, fallen into disuse over the last century. Informal and wholly unscientific surveys of colleagues by both Christensen (2008) and myself suggest that few cartographers can even name the technique shown in Figure 1, though most would immediately recognize it.

Those thin lines emanating outward from the shore are the titular waterlines with which we will concern ourselves here. The ICA glossary (1973), one of the few modern references to the term, defines the term as *lines representing water, drawn parallel with the edge of a water feature, which decrease in proximity and strength away from that edge*. Christensen (2008), in his excellent primer on the history of waterlines, has shown that in contrast to their status today, they were once the work of well-paid specialists, important enough to consume a large share (18% by one of his estimates) of the budget for the production of European ordnance survey maps in the nineteenth century. Despite this significant expenditure, I can find no clear answer

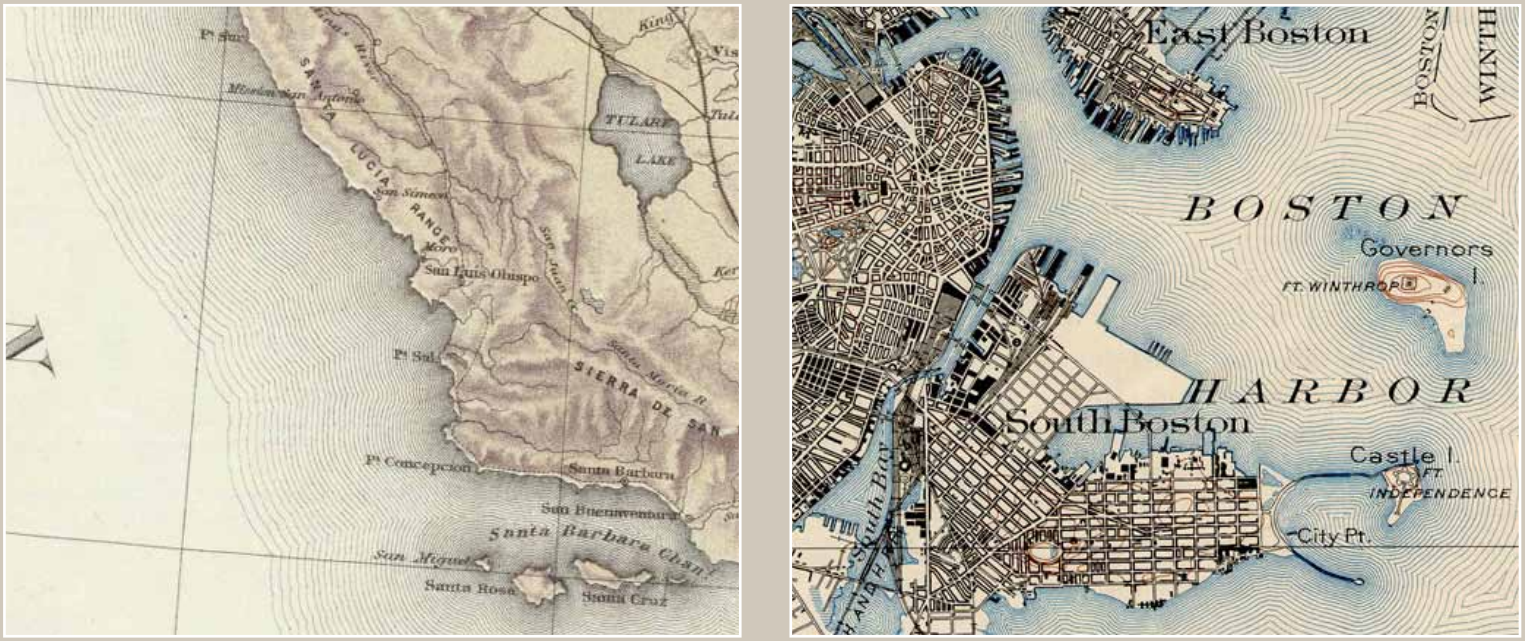

Figure 1. Two historical examples of waterlining. Left: Coast of California, from the "Geological and Topographical Atlas Accompanying the Report of the Geological Exploration of the Fortieth Parallel," 1876. Right: Boston Harbor, 1903 USGS topographic map.

in the existing literature as to why they were considered so useful as to be worthy of such funding. Certainly the cartographers of that era had reasons for spending great sums of money on waterlines, and if they were a critical budget item in the nineteenth century, I believe they must be able to provide something to the modern cartographer as well. While this article will finish up with a discussion of *how* to create them in the twenty-first century, we must first make an attempt to answer the question of *why*, which is long overdue.

THE BENEFITS OF WATERLINES

Waterlines offer an excellent way to establish figure-ground. The distinction between water and land in Figure 2 is quite plain, and yet it consists in only a few grey lines. The land and water polygons themselves are both filled white, though the waterlines can create an optical illusion that makes the water *appear* to be filled in with a darker color than the land. The subtlety and elegance with which they can divide land from sea is perhaps their greatest advantage. The series of fine lines is not very dominant, allowing the base map to settle into the background of the visual hierarchy potentially more easily than if the entire water area were filled in with a solid color. Keeping the land and water the same color also helps free up a fill color for use elsewhere on the map. In grayscale or other constrained-palette work, this can be a significant advantage.

Figure 2. A modern example of digital waterlining

Waterlines make water look more like it should. Water in the real world moves with the wind, whereas your average cyan lake polygon on a map just sits there, uncannily immune to nature. Waterlines are evocative of waves washing up on the shore, and adding them to a map restores a bit of the dynamism that

a reader would expect to see if they were out observing an actual lake[1]. This makes water features easier to interpret by giving the reader a sense of realistic motion, letting them look through the map and perceive, in their mind's eye, a moving, living lake. We also can place this argument in more technical, semiotic terms—and here I draw heavily upon MacEachren's (1995) excellent overview of the sometimes-daunting subject. Adding waterlines reduces the degree of arbitrariness of waterbody symbols, meaning simply that the symbols now look more like their real world referents. The closer our sign-vehicle (the image we've drawn of a lake on our map) visually becomes the referent (the actual lake out in the world), the more easily a map reader can make the connection and come up with the desired interpretant (the mental concept of a lake).

But using waterlines as sign-vehicles does more than simply improve our ability to plant the idea of "lake" in our readers' heads; waterlines invoke other interpretants—generate other mental images—as well. The connotations they carry will vary from reader to reader, but three common ones come to mind: art and beauty, motion, and history.

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Let's start with art. Waterlines can be seen as embellishments or decorations, as not strictly necessary. Their addition reminds the reader, on some mental level, of the human need to create art beyond the simple functional transmission of information. They can make a map feel more like it came from a feeling, sensate author, rather than a computer algorithm with no sense of beauty.

As addressed above, waterlines help designate bodies of water by giving them the appearance of waves. This means they also connote the abstract concept of motion. It is not just water, it is *moving* water, and the whole map now becomes subtly animated. There is a downside to this, however. The mental image of a wave-filled lake would be misleading if, for example, the real world lake in question was generally quite placid.

Finally, waterlines connote a sense of history. Waterlining appears largely in eighteenth and nineteenth century Western cartography, and any modern usage can generate, in the reader's mind, a mental connection with this historical body of work. Beyond that, they can bring to mind the various concepts that the connotation of historicalness can itself connote: authority, reverence, tradition, etc. Making use of this set of interpretants necessarily requires that waterlines not be part of current convention, and therefore helps perpetuate their rarity. I would argue that this is problematic, in that it prevents waterlines from becoming a regular part of the modern cartographer's design kit. Nonetheless, it is certainly a legitimate and powerful reason for employing them.

[1]Because of this sense of moving water, I originally called them wavelines, before learning that waterlines is preferred. I still prefer the vividness of the former term, though I am willing to capitulate to tradition.

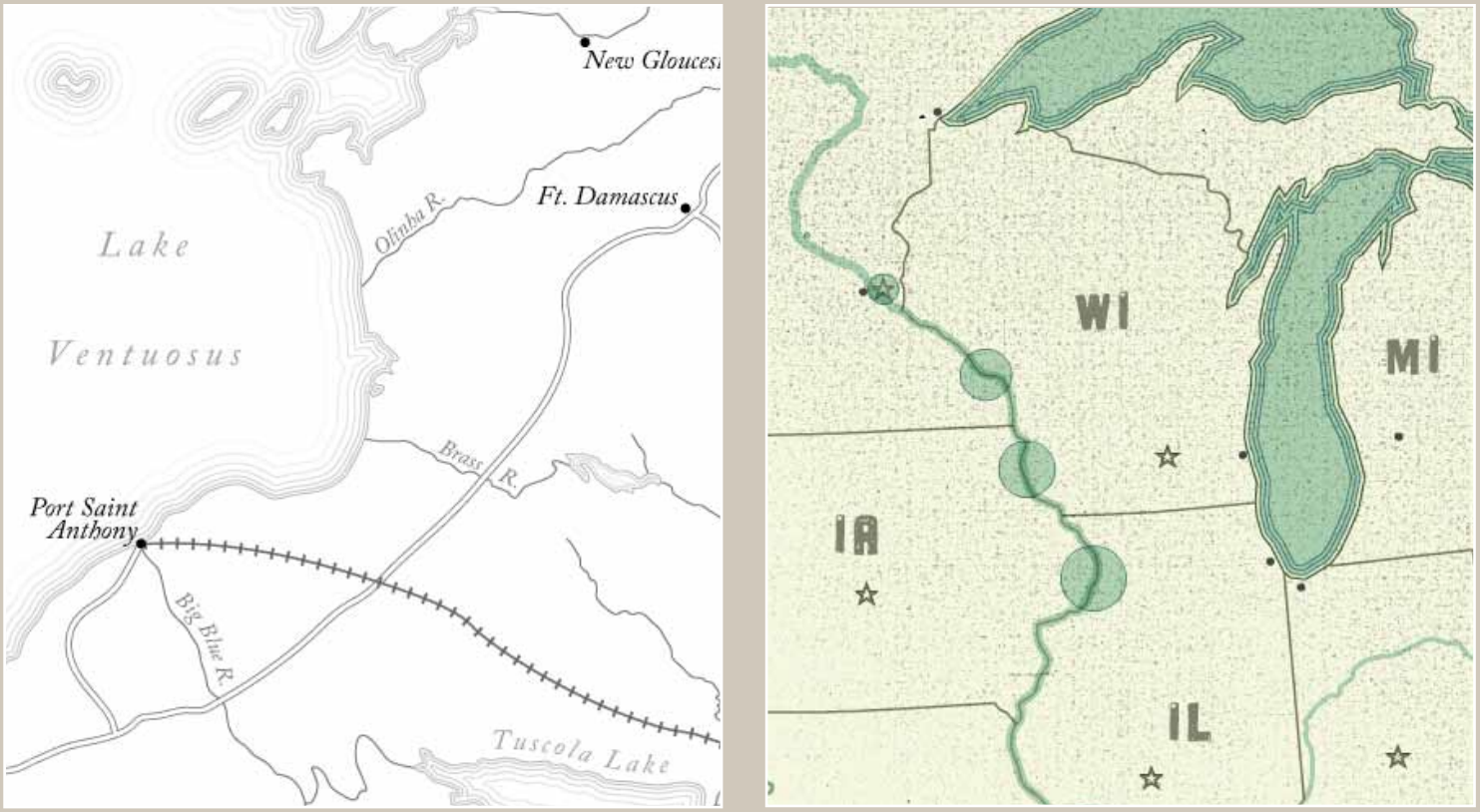


Figure 3. Two modern examples of waterlining. The map on the left is patterned after Victorian styles, while the one on the right, provided by colleague Tim Wallace, uses waterlines as part of a neo-historical, pop art letterpress aesthetic.

GENERATING WATERLINES

Creating waterlines is a relatively simple process. Most GIS packages contain a tool to calculate buffers around polygons; buffers are simply new polygons whose outer edges are a set, constant distance away from the original polygon, following its contours. This is exactly what a waterline is—a line which keeps a constant spacing from the shore, running parallel to it. Repeated applications of a buffer tool (or the Offset Path tool in Adobe Illustrator, which functions much like a GIS buffer tool), then, is all that is needed to generate a series of waterlines. Buckley and Barnes (2005a and 2005b) and Buckley (2009) have detailed how to use the buffering tools in ArcGIS to generate various styles of water markings, including waterlines.

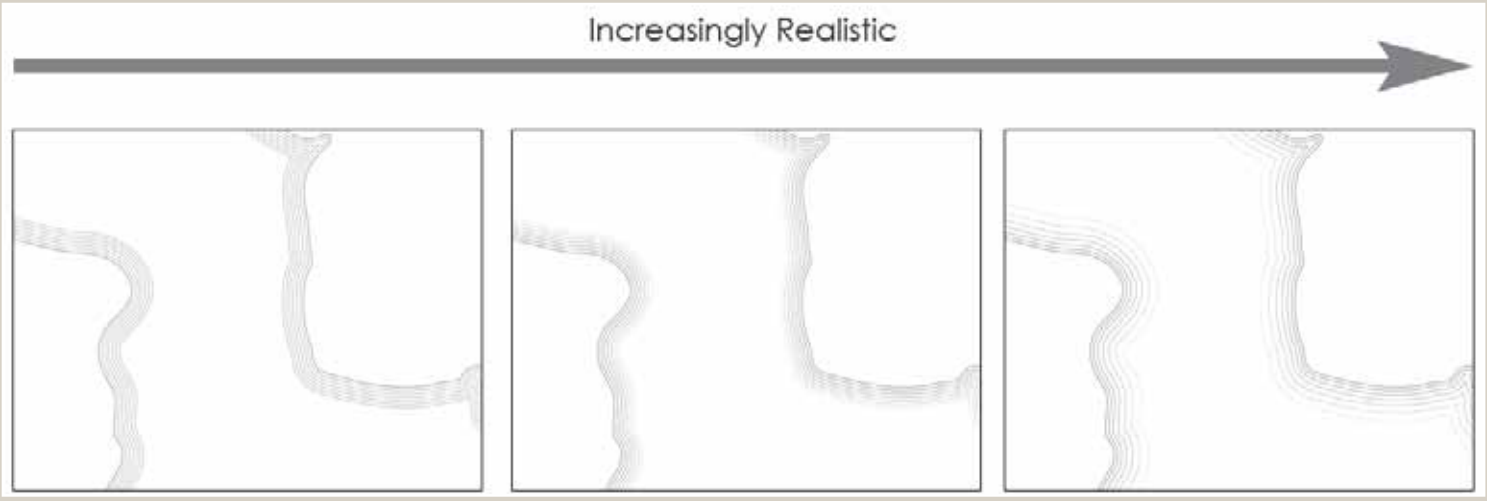
Regardless of which software is used to generate the lines, some smoothing and manual cleanup may be required, as some software packages can give the lines too jagged an appearance. An application of human judgment is necessary to round out the sometimes harsh mathematics of the computer (Figure 4).

Figure 4. Smoothing out digitally generated waterlines. The sharp corners on the left image have been manually adjusted on the right image.

DESIGN DECISIONS

Making the waterlines themselves is quick and straightforward. There is, however, a great deal of room for fine-tuning; decisions must be made concerning the number of lines, their spacing, their weight, and their color. These decisions determine whether the waterlines feel more like a cartographic symbol for water, or like actual water. At the realistic end of the scale, the symbol becomes transparent, leaving the reader seeing waves more than they see lines representing waves (see Figure 5). Where along the spectrum a set of waterline markings lies will be very much based on the needs and aesthetics of each individual cartographic work; very realistic waterlines would clash with the purposefully rough appearance of the right-hand map in Figure 3, for example. What are offered here are points to consider when designing, rather than a set of rules.

Figure 5. Waterlines becoming more realistic in appearance. First a color gradient is added, and then the line spacing is changed from monospaced to one of increasing steps.



Victorian waterlines frequently filled the entire water body, as seen in Figure 1 above. This approach, however, minimizes their advantages over giving a solid fill color to water features. It reduces their subtlety and makes it more difficult to place other map features on the water. It also pushes them away from the realistic end of the scale; the water feature looks more like it is filled with a symbolic texture and less like it has surface waves. Confining waterlines to areas near the shore eliminates these difficulties. How much of a water body is covered by waterlines depends on how many lines are drawn, and how far apart they are spaced.

There are two main options for determining the spacing between individual waterlines: the interval between each line can be constant, or it can increase with distance from the shore (compare the second and third examples in Figure 5). The uniformity of monospaced lines gives them a more stylized appearance, while the increasingly spaced lines suggest a more realistic scene of waves being compressed as they approach the barrier of the shore. A personal rule of thumb for the latter, which gives an aesthetically pleasing result, is to keep increasing the waterline spacing by a factor of 1.3 as they move away from the shore. That is to say, if the first line is drawn 2pt from the shore, the second line would be 2.6pt (1.3 * 2) from the first, and the third would be 3.38pt (1.3 * 2.6) from the second, and so on. The distance between the shore and the first line is one of the more critical factors. The smaller it is, either for monospace or increasingly-spaced lines, the closer all of the lines will be to the shore, and the sharper the edge between water and land will be (see Figure 6).

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Finally, the line weight and color of each individual waterline can be held constant, or it can follow along a gradient. Revisiting the ICA glossary's (1973) definition, we find that they describe waterlines as *lines representing water, drawn parallel with the edge of a water feature, which decrease in proximity and strength away from that edge*. The term "strength" is a bit ambiguous, but it suggests lines becoming fainter or thinner (or both) as they move away from the shore. Doing so lends the waterlines a more realistic appearance; stronger lines reflect the reality of surface waves increasing in height as they approach the shallow water of the shore. It also helps create a smooth transition between the waterlines and the open area in the center of the water body.

Figure 6 – Each of these two sets of waterlines uses the same line weight, color, and line spacing rate. The one on the left has a harder edge because it starts closer to the shore than the one on the right, leading to a more compact set of lines.

RIVERS

Though it was common practice to do so in the nineteenth century, I believe it is advisable to leave waterlines off of rivers. As said, the lines resemble waves washing up on the shore, but waves do not generally begin in the center of a river and push against the banks[2]. Waterlining rivers creates a cognitive mismatch, detracting from the sense of reality that the technique can convey by directly conflicting with the reader's knowledge of how the world works. That being said, a simple, solid fill polygon for a stream may likewise look out of place when compared with the more detailed treatment given to waterbodies. A different marking device, analogous to waterlines and conveying a sense of linear flow, is needed. The choice and application of such a technique is beyond the boundaries of this essay, but may be addressed in a future one.

FINAL THOUGHTS

Once the painstaking task of highly specialized engravers, waterlining is now simple and straightforward with current software tools. Its rarity in modern work is as lamentable as it is perplexing, given the elegance and clarity that it imbues. This article is written with the hope that an iconic element of Western cartography for over a century will be revived from disuse and find its place once again in our common lexicon.

ACKNOWLEDGMENTS

Two years ago, I had no idea what waterlines were, until my colleague Daniel Reynolds pointed them out on an old USGS topographic map and suggested that I add some to a piece I was working on. A year later, after drawing them on several maps, I still knew nothing about their history, or even what they were called. Fortunately, Paulo Raposo at Penn State knew of Christensen's 2008 paper and sent me a copy, which helped put me on the track to writing this article. I am as well indebted to my many talented colleagues in the UW—Madison Geography Department, with whom it is my good fortune to interact daily, and who have always patiently listened when I wanted to talk about the esoteric subject of cartographic water markings.

[2]My colleague Ben Coakley first alerted me to this problem while reviewing a map in which I had waterlined the Mississippi River.

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