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Pollution Mapping; or The Hide and Seek of Information

Abstract: A survey of mapping techniques used in Brownfield redevelopment reveals that there are different types of maps used to convey different types of information. These maps, more or less, accurately convey their subject of choice through different graphic devices that have direct consequences on the definition of what Brownfield Sites are, and where Brownfield Site boundaries are delineated. By applying these various map types to a polluted site their capacity to expose the realities of pollution and their capacity to conceal information is revealed within an analysis their visual language.

Have you ever sat in your car looking over a road map and wondered if a direct route represented by a light grey line would get you to your destination faster than a black line that is slightly longer but is the more conventional and recommended path of travel? As a curious individual who is often in a hurry I have taken many of these “grey lines” only to find that they involve far more twists and turns and often far more gravel than I expect my alternate road choice would have engaged in. Here in lies the crux of this paper, that relatively minimal changes in graphic language have huge implications in terms of the performance of the real life subject they represent, whether it is roadways, water courses, cities, or Brownfield sites - especially Brownfield sites. I will address the importance of maps in the Brownfield redevelopment process, and assess the differences in graphic quality and the types of maps used. Ultimately, these map types will be applied on a potential Brownfield Site in Portsmouth Virginia in order to identify their positive and negative attributes within a hypothetical context.

Importance of Pollution Mapping

There are many different types of maps and many different types of graphic devices used to convey information, but when it comes to Brownfield redevelopment these maps are important for specific attributes particularly their ability to chart the location of contamination. The reasoning behind this has to do with two primary aspects of the EPA's program, which are directly affected by the maps and graphic devices used. These attributes are what defines a Brownfield Site and what determines the edge of a Brownfield site.

A Brownfield site is a “real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant”.¹ This aspect of the EPA's definition is significant because it includes the word “potential” as a qualifier for contamination of a given location. A site does not need to be contaminated to be a Brownfield, it simply needs to be perceived as contaminated. This can include old metal smelting facilities that really are contaminated, or an abandoned lot that the local citizens have bad feelings about. In this case the definition is relevant because of how people often come to understand places – through maps.

When arriving in a new place we are bound to our vehicles or our feet and have the local road map or the Lonely Planet Guidebook open before us. As such we are bound to a map for a sense of orientation to this new and explorable arena. Furthermore, this attachment to the ability of maps to provide us orientation is not just an aspect of tourist lifestyles, it is built into our daily experience. Every time we cross an intersection painted with the words “LEFT TURN ONLY” or the infamous arrows that indicate

¹ www.epa.gov/brownfields/glossary.htm

which direction we are allowed to head. Even our street names, Ridge Street, Valley Drive, and so on, provide this sense of orientation to our experience of a place just a map would. This sense of orientation is closely related to our perception of a place because of the way we associate with these images and titles. For instance, if a street were titled Arsenic Alley we may be less inclined to let our children play there. Or if a directional arrow on the road were to fade from white to sickly green we might be more or less inclined to make that same turn.

If this example is re-applied to a map we can see the power that simple graphic manipulation has in perception of a location. On USGS maps the Ivy Landfill is defined graphically as what appears to be rough vegetation and goes without a title or text description of any sort (FIG 1). The housing images to the bottom right of the page imply the presence of a rapidly growing residential development immediately across the street from the landfill. This vegetation-like graphic would imply to the viewer that there is little more than a dense forest present on the site, an amenity to the adjacent residential development. This is similar to the graphic technique used to depict strip mining, which is nothing more than a series of aligned arcs, appearing to be small bumps, and having little to do with the reality of the geological condition (that great portions of the mountain have been removed and large quantities of streams have been filled).

If these graphic tools are modified we confront questions regarding the implications of a change in this practice. For instance, what if the USGS map showed how much toxic material was hidden below what they imply is a roughly vegetated surface? A simple change in color could be sufficient to change perception on the map (FIG 2). Or if a standardized symbology is desired, the “Mr. Yuck” icon has much more

direct inferences for the subterranean contents. Either way these changes get more to the point of suggesting that there is an undesirable attribute to the location, and that the trend in housing development previously suggested in the bottom right corner would be dramatically affected. In effect map symbology has the capacity to determine what is and what is not a Brownfield Site.

The second aspect of the EPA's Brownfield Program that calls for the necessity of pollution mapping is how the boundaries of a Brownfield site are determined. The Superfund Site in Coeur D'Alene Idaho set the precedent for this definition strategy where in 1983 a 21 square mile area was listed on the National Priority List (NPL) as the Bunker Hill Mining and Metallurgical Complex (FIG 3; refer to the small rectilinear area around Smeltersville and Kellogg). However, after beginning the assessment process the EPA discovered that the initial area of coverage was woefully inadequate if it sought to address the entirety of the polluted area. The reality was that a much larger polluted area was present and because of the initial site definition many potentially responsible parties (PRPs) were legally exempt from required participation. Ultimately this led to the redefinition of a Superfund / Brownfield Site under EPA standards.²

The new definition of Brownfield had to do with the issue at hand – the reality of contamination. Instead of defining a fixed boundary as in the first rectilinear definition, the new definition of site boundary allowed for a flexible edge condition. It did this by suggesting that a Brownfield site is not defined by the property line of a parcel whose primary occupants were polluting industries, or by a more generic district that seems to include a number of potentially responsible parties. Rather, the new definition of

²www.epa.gov/superfund/reports/pdfs/coeur/ch1.pdf+Coeur+D%27Alene+Superfund+Site+History&hl=en

Brownfield Site Boundaries was simply determined by the presence of pollution. This led to a re-identification of a 1,500 square mile area that has been contaminated by the mining and metallurgical industries³. This new definition is captured on a map (FIG 3, refer to the larger organic shape that encompasses the previous rectilinear box) that describes the difference that the proper mapping of pollution can mean – 1,479 square miles.

Pollution Map Types

Many different types of maps have been used in the Brownfield redevelopment process. Ironically no maps are required by the EPA at any step of the process, rather they are left up to consultants whose job it is to position the site for redevelopment. From the most primitive maps used in the earliest days of the Brownfields program to the highly articulate maps of contemporary three dimensional computer graphics, there is a huge amount of breadth to the field. What is important for the sake of this paper is that they each have positive and negative attributes that make them more or less appropriate for the use at hand and operationally their ultimate goal to “do no harm”⁴ or convey as much information as is possible without confusing the issue or concealing important information within the graphic language.

The most basic form of pollution mapping is a type of suggestive map that isn't positive of the location of pollution one way or another (FIG 4). Some of these maps reference the Sanborn Fire Insurance Maps from the late 1800s to the mid 1900s, and some of them are simply a scribble that recalls a historic state of affairs. In these cases

³ ibid

⁴ Tufte1990 p.81

the maps are not precise, but they are in some sense accurate meaning that these maps cannot hope to quantify that there is a hypothetical 4,376.5538 gallons of petroleum that has spilled in a given location, but they can effectively suggest that there is the presence of contamination and its location is in the northeast corner of the lot. Of course this data is often dependent on the reliability information source whether it is a person telling a story or an image that allows us to interpolate the location of an underground storage tank (UST).

Also included in the graphic repertoire are pollution maps that have to do with the marking of samples. These maps are not necessarily maps of pollution but are indispensable in the process of Brownfield Redevelopment. They show the locations of every surface or sub-surface sample that has been taken for a site suspected of being polluted (FIG 5) and, with an ancillary data sheet, list the findings of every sample. The conflation of marks made across a sampled site reveal the rigor of the sampling and suggesting a sampling methodology. Sites that come with pre-existing knowledge of pollution can be sampled in a more direct manner beginning with the known contaminated area and working out. While those that have no pre-existing data need to be tested in a meticulous and systematic manner that spans the entire parcel in a regularized grid. The sampling process is an absolute necessity, as the depth of knowledge gleaned directly relates to the number and frequency of samples. It is this process informs all future work on a contaminated site.

From an effective field of samples a third type of map can be generated sometimes referred to as a Gaussian Distribution⁵, which identify intensities of

⁵ mathworld.wolfram.com/GaussianDistribution.html

contamination. Ranging from non-toxic contents to apexes that imply lethal amounts of toxins, these maps identify a full range of site conditions (FIG 6). Although such maps can clearly relay large quantities of information, these maps can still be further developed. This can be seen in the map on the bottom right that suggests that contamination intensity is measured in the fields of background color, and contamination content is measured by each of the separate pie charts that float on top of the rainbow beyond. This map type allows an interpretation that pollution intensity, understood as potential harm, and its location is of secondary importance to more detailed and more poignant subjects such as pollution content.

Three-dimensional modeling technology has recently allowed a series of new map types. Although these maps can be based on information that is gathered through high and low altitude imagery such as Aviris⁶, an advanced spectroscopy technique, they are more often based on conventional sampling techniques similar to the other previously mentioned map types. These maps begin to identify not only the planimetric location of a type of pollution but also the sectional location as well. Together these two qualities can be used to plot a three dimensional realm that the contaminants occupy (FIG 7). With enough sampling or enough pre-existing information this type of mapping can also begin to integrate pollution location with local geology as in the image on the bottom right, which suggests that there is a link between the land and the location of the contaminant. These maps are identifying pollution as a three-dimensional spatial entity and are providing a range of new information that can be used in the remediation process.

⁶ speclab.cr.usgs.gov/earth.studies/Utah-1/park_cityAV5.html

The maps used in the process of Brownfield Remediation are many and diverse. They each have their own positive and negative attributes and can be used to many a different end. However this is exactly the issue at hand – these maps can be used for nearly anything and without the proper attention they could be used for the wrong thing, inadvertently hiding the reality of the contamination in a given situation.

Pollution Mapping Case Study

In Portsmouth Virginia, on the north side of town there is a substantial piece of land owned by Earl Industries with 22 acres of it undeveloped and existing today as a predominantly level green lot with tremendous amounts of shoreline on Scott's Creek (FIG 8). This piece of land is prone for development as it already has the necessary infrastructure, it is in a prime location near the Mid-Town Tunnel and could potentially rent for \$3.15 – \$13.20 per square foot (industrial - commercial)⁷ and could sell for over \$14.3 million if developed into single family homes⁸ that matching the residential quality of neighborhoods immediately to the south. This makes the site perfect except that it is contaminated. Created out of fill material that had high levels of arsenic, and adjacent to petroleum spill site (west end) and a storage yard for solvents and fuels (east end). The following discussion applies the previously discussed map types to this site in Portsmouth in an effort to uncover the implications of different kinds of pollution mapping graphics.⁹

⁷ www.portsmouthvaed.com/PDFs/2004-2005%2520EDFactsbroch.pdf+Cost+per+acre,+riverfront+property+Portsmouth+VA&hl=en

⁸ www.city-data.com/city/Portsmouth-Virginia.html - the average home price of \$81,500 on 1/8 an acre over 22 available acres

⁹ Given minimal sampling to date the map contents are largely hypothetical. What is relevant is that each map type is used regularly in Brownfield redevelopment.

If we are to work under the assumption that the property in question is polluted the simplest of maps can be made (FIG 9). This map shows that the entire piece of property has the presence of some form of contaminant, as implied by the red tone. This map is the easiest to draw and can be understood as a stereotype, or “a negative or limiting preconceived belief.”¹⁰ This idea relates closely to the earlier discussion about the potential presence of contamination, and this map implies that we are sure that the piece of property is polluted in the most absolute sense. What this map does not imply is that there is any variation in the pollution, whether it is type or degree or even location. In the context of this survey this will be considered the most basic amount of information that a pollution map can contain, all future maps being built up in layers of information from this point.

As previously discussed, the first real stage in mapping pollution has to do with rigorous sampling. In this case (FIG 10) each mark defines the center point of an area of approximately 25,000 square feet or just over 1/2 an acre. The irony of which is that this seems a large area for a single sample to account for but is considerably smaller than most sampling budgets would ever permit. What this map does accomplish is that it suggests an extremely thorough testing where each row and column of test sites would have been carefully tabulated in an external data sheet with each of their attributes plotted for review. By showing such an even and ubiquitous grid of test plots any anomalies can be analyzed in context with the readings from adjacent test sites offering the opportunity to reduce error in the readings.

¹⁰ www.nationaltcc.org/tcc/

From a complete testing, a more accurate map of pollution locations can be generated (FIG 11). This map, while better describing the presence of contamination, uses a graphic device from the map of test plots, the raster cell¹¹. The information that is conveyed in this map comes in the same form that the information was gathered, that is a sample cell that sized in response to the frequency of the test pits. This results in a static map that is characterized by a series of cells similar to raster information from other computer graphics operations. However like the first map (FIG 9) this map is also at fault for lacking any specificity in pollution type or degree. And what information was gained, greater specificity in terms of contaminant location, ends at the edge of the sample area. Given that the pollution in this scenario encounters the edge of the test area, a greater sample area is needed for a complete assessment of the situation (refer to Coeur D'Alene ID).

Using the information from the numerous test sites a more detailed map can be generated with regards to pollution intensity (FIG 12). Such a map shows where the most concentrated pollutants are and places them in context of areas with little or no pollution. Although this is a fairly conventional mapping type it begins to address significant issues with regard to defining the edges of this area as Brownfield Site. Knowing that part of the site is more contaminated than the rest brings up the question how polluted does a location have to be in order to be a Brownfield Site? If the definition simply requires the presence of contamination then this map is useless for site definition and earlier maps can be referred to (FIG 9, FIG 11). If pollution levels that are not harmful affect a majority of the site, and only a portion of land is severely contaminated, this map redefines the

¹¹ www.css.cornell.edu/courses/420/lecture12.ppt+raster+analysis&hl=en

Brownfield Site as only being a portion of the original parcel. This is good for developers and given that remediation methods rely on accurate pollution intensity and location information this map can play an important role in informing the process of healing a site. However, it does imply that the edge of a Brownfield site may be predicated on a less quantifiable issue, which is how “bad” is it? Who is to determine the degree to which a contaminant's presence implies Brownfield status, and just how is this standard determined? This map, like the last (FIG 11), shows intense contamination at the edge of the sampling area, particularly in the southwest corner, begging for additional testing.

The next map in the series (FIG 13) breaks up pollution intensity into different kinds of pollution, suggesting the locations of different pollution types. This map gives each type of contaminant its own domain suggesting that they have originated from different sources and result in different intensities. The fault of this map is that it also implies that each type of pollution is an isolated event and that it could occur in a vacuum, existing without the presence of the other adjacent contaminants. This can best be seen around the purple cells, representing volatile organic compounds (VOCs), where cells of red, representing arsenic, occupy every piece of its tested circumference. The purple makes no recognition of the red within its own domain. Ultimately, this identifies this map as a lie by trying to present static, absolute entities in terms of pollution location.

Using organic forms and physical transparency in a map can illustrate the same contents with powerful implications. By abandoning the raster cells for amorphous forms the static read is transformed into something much more “fluid” and dynamic (FIG 14). Even if the organic zone of pollution depicts an identical amount of area as the pollution

zone from the raster cell map it implies a quality of movement to the contaminant that was not previously present. The dynamic nature of this graphic comes closer to a describing the reality of a polluted site – the contaminant is mobile and this is quality is directly related to its host medium. This, in turn, identifies the boundary of the site as one in flux. The additional graphic device of overlapping of transparent layers also has powerful implications. Because this graphic tool requires a discriminating eye for any quantifiable read it is most effective as a device meant to qualify the observer's experience. This means that is difficult to perceive that the VOCs are shown with 30% transparency and the Petroleum is shown with 42% transparency suggesting a respective 30% and 42% proportional content relative to the over all contamination (including arsenic) for given points on the map. Rather, the use of transparency is used to suggest an extremely layered system of contamination, but not a precisely measured one, that is not present in any previous map. Although this map suggests limits to the manner in which information is conveyed it is absolutely essential to the consultants who need to specify certain remediation techniques relevant to different types of toxins and their different intensities. This map takes advantage of graphic transparency and interpolated form to convey considerable complexity in the situation.

By translating the forms of each type of pollution into a three-dimensional body, an entirely new understanding of the Brownfield site can be generated. Although crude by standards of modern pollution mapping, the accompanying image of pollution as its own spatial entity (FIG 15) has powerful implications in for Brownfield site delineation. The simple layering of pollution on or within certain media suggests where it might rest relative to the surface of the ground plane. For example the arsenic contamination on the

Earl Industries property is from fill that was likely brought from another industrial site and has saturated the ground. Because arsenic is a heavy metal it has settled out into the sediment and limitedly occupies the water of Scott's Creek immediately south. This is in contrast to the VOCs on the eastern end of the property that contaminate the surface of the materials storage yard and volatilize when exposed to air, and in contrast yet again to the petroleum that is in the soil and on the water at the western end of the site. Each of these toxins has its own realm within the environment. Given the EPA's definition of a Brownfield Site, the implications of this is that an entire Brownfield Site can now be identified as a subterranean body, potentially having minimal contact with the surface – a radical departure from conventional planimetric site definitions. A good example would be the emptying of oil drums into a sinkhole, where there is minimal surface contamination but potentially massive pollution of aquifers.

The idea that pollution is dynamic causes problems for something static such as a map. A map's graphics can imply that contamination has the tendency to move, but it is uncommon to have sampling on a regular interval and rare to have a map that is regularly updated. Only with the advent of the Internet and digital sampling (particularly for water quality) has this become a readily available option. The importance of this is that the maps we are using, even if they are static and two-dimensional, need to suggest that contamination does move, that the landscape is dynamic.¹² These maps need to chart the way toxic materials can migrate and the ways in which we can be exposed to them (FIG 16). By showing that VOCs volatilize and move with the air, or arsenic has laden the soils and is beginning to slowly move with the water as sediment, or petroleum is moving very

¹² Corner p. 21

quickly in water bodies, the definition of a Brownfield Site is up for grabs suggesting that given a certain environment the edge of a contaminated site is anything but definable.

Pollution Mapping Conclusions

Three primary observations can be drawn out this process of survey and analysis:

1) Because of the public's ready digestion of graphic images, and because of the necessity of precise spatial information in the remediation process, pollution mapping is the key to the Brownfield redevelopment process. Without proper mapping (and by deference without proper sampling) the process of redeveloping a contaminated site could easily be bogged down in the overwhelming amount of information necessary for a project's completion.

2) Pollution mapping technology has begun to out pace our ability to deal with contaminated sites by adding a spatial identity to contamination that was not conceived of during the EPA's formulation of Brownfield site definitions. New techniques in three-dimensional mapping have the potential to transform the Brownfield real estate market.

3) Because of the dynamic nature of the landscape, and therefore the pollution in it, pollution mapping needs to be more preformative¹³ and reflect the movement, exposure, area of effect, and opportunities for remediation in the surrounding landscape. Such maps embody greater accuracy and increase level of information sharing.

Bibliography;

¹³ Corner p. 36

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