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Take Me to the River: Revitalizing LA's Lost Monument

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Introduction

The tale of South Korea's Cheonggyecheon River is one to warm an urban environmentalist's heart. Cheonggyecheon runs through the center of Seoul, a bustling metropolis of ten million that has been the capital of Korea since the 14th century. The Japanese were the first to sacrifice Cheonggyecheon on the altar of urbanization, turning the River into a sewage system during their 35 year occupation between 1910 and 1945. Already thus degraded, it was easy for later administrations to eventually completely cover the river with the Cheonggye Road and Cheonggye Elevated Highway between 1958 and 1976. Cheonggyecheon became an exemplar of the expendability of urban environments in the face of modernization and economic growth, particularly the need for transportation in a quickly developing city. In the early 1990s it was discovered that extensive repair would be necessary to maintain the Highway, and with heavy political leadership of Mayoral Candidate Myung-Bak Lee, now the president of South Korea, the decision was made to restore the river rather than repair the road (Park, 2006).

Two years and $900 million later, one of the most extensive stream daylighting projects has been completed, and the River is now an 8.4 km long public recreation space. Pedestrian footpaths crisscross the narrow stream, and lush greenery lines its banks. Fish, bird, and insect species have returned in number, and children can now be seen wading and fishing in the river. Its banks are host to civic and cultural events, and have become an important public area for the surrounding community. Touted as "the most attractive cultural civic space in downtown Seoul" (Cho, 2010), the river restoration has redefined Seoul and truly succeeded in its goal of "transformation of city appearance" (Kim, 2005).

Figure 1.1: Cheonggyecheon River flows through the center of Seoul, and provides a striking juxtaposition to the high rises that surround it.

Cheonggyecheon is one of many urban rivers that have all been the foci of considerable environmental and aesthetic restoration. In the United States alone the list includes the San Antonio River, the Chicago River, Portland's Willamette River, and the Guadalupe River in San Jose, to name a few.

As with many restorations, progress on the San Antonio River has been piecemeal. The first improvement plan was submitted in 1929 as a response to a devastating flood in the fall of 1921. The primary work the most of the most recent San Antonio River Improvements Project was completed in 2002, and the San Antonio River

Walk is now a highlight of downtown, complete with access ramps, local artwork, and extensive open space. The Project is now finishing up the last of a three phase project restoring the Mission Reach section of the River to its original riparian woodland state with help from the US Army Corps of Engineers (USACE).

Figure 1.2: The San Antonio River walk offers residents and visitors a scenic chance to dip their toes in an historic river

The Willamette River, fed by melting snow from the Cascade Mountains, frequently flooded thousands of acres near the coast of Oregon and consequently by the 1950s an extensive system of dams, channels, and barriers had developed to keep the River contained. Yet flooding continued, even into the 1990s. Partly in response to this, the city of Portland has buffered the city from the River with a multipurpose river walk that features native flora, historic bridges, and floating pathways. (City of Portland, Oregon)

The Chicago River was once one of the most polluted bodies of water in the United States, a victim of Chicago's industrialization and lax sewage disposal laws. Infamously, the flow of the river was reversed to protect Lake Michigan from its harmful sludge. This began an era of change for the Chicago River, which has in recent years experienced a renaissance-like return to the waterway that it once was, and is now home to many of its original flora and fauna. ("Friends of the chicago river," 2011)

The restoration of San Jose's Guadalupe River initially aimed to preserve salmon habitat, but eventually turned into much more. The Guadalupe River Park Conservancy, is now a 3 mile ribbon of green space in the heart of Silicone Valley, and offers a Visitor and Education Center as well as a Library. Community gardens and public art invite locals and tourists to enjoy river's amenities ("The guadalupe river," 2011).

Each of these river restorations has been spurred by a number of considerations, but they all seem to have four main goals in common. Creation of public green space to further the cultural and recreational opportunities in the city is at the forefront of many of these restoration projects, with the goal of offering residents a natural space to gather in and increasing community engagement with the surrounding area.This beautification aspect of the restoration has the secondary, but no less important goal of attracting businesses and tourists to improve the economic health of the city. Environmental restoration is another common concern, as increasing environmental awareness propagates not only environmental regulation, but moreover a desire for nature in an urban setting and healthy urban ecosystems. Last but not least, flood control to prevent loss of life and destruction of property, especially in highly developed areas, is a principal component of restoration projects.

If any river needs such a multi-layered approach, it is the Los Angeles River. After a series of destructive floods between 1914 and 1938, the concretization of the newly dubbed "flood control channel" was completed in 1939. Until March of 2011, Los Angeles River was still legally inaccessible to the public without permits from both the US Army Corps of Engineers and the City of Los Angeles. Even now, a permit from the City must be obtained to enter the River channel at its two points of access–near Arroyo Seco, and an underground tunnel near 6th Street in downtown (Behrens, 2011) [1].

Figure 1.3: In the 1950s and 60s, the LA River was infamous for its crime rates, and was occasionally used for body dumps, as pictured in this crime scene photo. Photo courtesy of Los Angeles Times.

A general eyesore, the Riverbed is barren except for trash that collects along the River during rainstorms and the anemic plants that can eke out an existence on the meager layer of dirt that accumulates on the concrete. Residents who know of the River's existence often refer to it as the flood channel, or simply the ditch. For many years, the most well-known River wildlife were probably gangsters and the homeless, who used the Riverbed to congregate and hide out from the authorities. Even as recently as 2010, homeless encampments have been evicted from the Riverbed (Zavis, 2010), and crime is still a concern in many Riverside neighborhoods (Goffard, 2009). Despite its channelization, flooding is a concern every winter, and though the River has yet to overflow its banks since being channelized, a close call during the wet winter of 1980 led to the construction of additional walls along the lower reach of the River.

[1] A note to the reader: throughout this paper the references to the Los Angeles River will be signified using the proper noun, "the River", to differentiate it from rivers in general

Figure 1.4: The River provides a home for those who have none. A homeless man, pictured here, digs through scraps on the banks of the River. Photo courtesy of Los Angeles Times.

Citizen calls for a more publicly available and environmentally friendly River have occurred throughout the years, starting as early as Dana Bartlett in 1890. Community groups, minor politicians, and even urban engineers have joined the cause, each with plans for the River, ranging from turning the flash flood prone Riverbed into a playground for children (courtesy of Mr. Bartlett), to nightly streetlight cleanings (from one Mr. Robinson in 1909), to a $230 million park rehabilitation plan (developed by urban architects Olmstead and Bartholomew, this plan is still referenced by river activists). Despite their abundance, somehow none of these plans managed to garner enough support, either political or financial, to materialize into more than dreams. At least in the case of Mr. Bartlett, many of these well-intentioned plans have lacked the pragmatism that would allow them to be realized. In other cases, such as Olmstead and Bartholomew's grand River Parkway plan, the complicated political situation surrounding the management of the River, and the unwillingness of politicians and residents to allot funding for River improvement has been the main roadblock (Gumprecht, 2001). In all of these cases, plans have largely been ignored due to their lack of wider popular support or political backing.

More recently, citizen determination and activism has managed to coalesce itself into a public face for the River. Friend of the Los Angeles River (FoLAR) is a grassroots organization that has been championing the restoration of original habitat since their establishment in 1986. They have collaborated with other citizen groups including (but not limited to) the Chinese Consolidaed Benevolent Association, the Chinese American Citizens Alliance, the Alpine Neightborhood Association, the Sierra Club, Mothers of East Los Angeles, the Latino Urban Forum, and even soccer clubs (Orsi, 2004). FoLAR's most prominent successes have included projects such as the designation of Taylor Yard as a State Park and creation of a community park at Cornfield Yard. But their greatest success has most likely been placing citizen pleas for River improvement on the table as a political agenda. It was the vocal nature of these groups that made clear to city leaders that current state of the Los Angeles River is clearly insufficient to meet the needs of the communities that house it, and that there is a similarly obvious desire and momentum for change.

In response to these growing calls for change, the Ad Hoc Committee on the Los Angeles River was established by the city council in June of 2002, composed of four city council members whose districts abutted the River. In 2005, the Committee started the process of creating a comprehensive plan for the River, and began an 18-month intensive planning process, during which they met with community leaders, engineers, Public Works employees, and construction consultants. April of 2007 saw the culmination of these efforts with the publication of the finalized version of Los Angeles River Revitalization Master Plan (the LARRMP). The LARRMP, weighing in at ten chapters, is a small book, and outlines the vision, goals, and methods for revitalizing the River. Heavily influenced by its predecessor the Los Angeles River Master Plan (LARMP), the LARRMP is now considered by the city to be the plan for the Los Angeles River, and is strongly endorsed by FoLAR and other community organizations. So now the question is, can the LARRMP complete the task it was created to do?

To answer this question, we must first look at the framework within which the LARRMP must function. What are the restrictions on the LA River– environmentally, politically, and financially? When we consider the River as an urban ecosystem, what limitations do we face? And in light of these restrictions, can the current Plan succeed?

To answer this question, we first look the LA River–its history, and the features that define it. Every river is unique, and a restoration cannot be attempted without a concrete understanding of the hydromorphic, ecological, and human systems within which the River flows. Next we identify the key elements of the LARRMP, specifically its objectives, goals and methods. What is Los Angeles trying to accomplish with this restoration, and how does it intend to achieve it? Finally we consider some of the gaps and flaws in the LARRMP, and identify potential solutions, looking to both case studies of other river restorations, and research on river function, particularly within an urban setting.

Chapter 2

An Urban Ecosystem

2.1 Technical Limitations

High in the mountains, a fire had had started. Hot and fast, the local scrub–chaparral–quickly ignited and burnt off, leaving behind nothing but a light layer of waxy ash over the surrounding bare earth, a residue that creates impermeable layer on the top of the soil, making the ground essential water-resistant. The hills sides, some with slopes up to 85%, lay completely unprotected by any form of vegetation to anchor them (McPhee, 1989). Then the storms came. And kept coming. The only place for the water to go was straight down the steep mountains, racing down freshly carved gullies. As it went it picked up dirt, gravel, even boulders and fully-grown trees. While these debris flows can be lethal for the hillside communities, their destructive paths generally stop before the reach the heart of town.

Not so for the water that fuels them. Rapid rainfall swells tributary creeks and streams, and rushes, roiling, into the river, which weaves through the city, a sprawling metropolis of nearly ten million souls. Once in the river proper, water from the headlands is joined by urban runoff that has been shunted from the impenetrable roads and parking lots of the city. Carrying the pollution of over twelve million cars, this storm-fed monstrosity flows directly into the river channel. And as the stormwater runoff fills the river's meager streambed, it surges upward, relentlessly seeking escape from the concrete walls that frame it in.

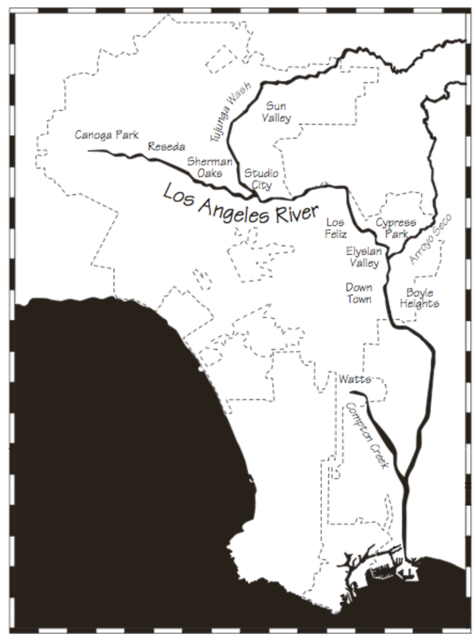


Figure 2.1: A map of the Los Angeles River and its primary tributaries

This is not a scene that many would expect to see in sunny and dry southern California, much less in urban and well-developed Los Angeles. And most of the time, they would be right. The Los Angeles River is generally placid and low-flow, described by one early LA resident as "a beautiful limpid little stream". Unfortunately, this day-to-day behavior belies the explosive danger of flood flows, which can have power like "the discharge of a bursting dam". During a flood in the 1930s, the Los Angeles River was emptying the same volume of water into Long Beach as the normal flow of the Mississippi (Gumprecht, 2001).

Even before urbanization augmented the flow of the River, the Los Angeles River had a tendency towards violent floods. Although it spend much of the year as no more than a meandering stream that wove its way through dense growths of plants that surrounded marshes and wetlands, the River would occasionally flood spectacularly, overflowing its poorly defined streambed to swing wildly across the landscape, drastically changing its mouth from Santa Monica to its current home in Long Beach. As one researcher described it, "thickets slows and deflected the torrents, spreading them over the flatlands to sink in or work their way to the sea"– essentially, the entire lowlands was a giant flood plain. Early residents of the area, including the original Native American tribes, and then later the Spanish missionaries who came to convert them, recognized that fact, and built their homes on hillocks and other high ground that would protect them from the floods that ran rampant across the landscape (Gumprecht, 2001).

Yet nowadays, many Los Angeles residents are ignorant of the great danger that lies in the looming San Gabriel Mountains. This is despite the fact that, according to one historian, "more people have been killed in Los Angeles County in floods than by earthquakes." (Gumprecht, 2001) The reasons for flood danger are not easily apparent. It starts with the rain. Because of the way that the San Gabriel Mountains trap incoming ocean storms, the San Gabriel Mountains receive some of the heaviest precipitation

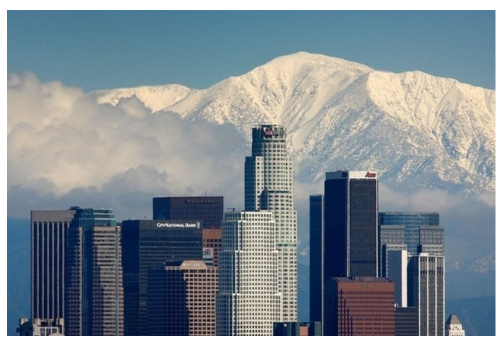


Figure 2.2: The San Gabriel Mountain are a defining feature not only of the LA skyline, but also of LA weather

in the world, with up to 7.31 inches in 24 hours, which was the highest rate recorded by the US Weather Bureau at the time (LA Times: "Thirty-seven...", 1934). The next contributors are the mountains themselves. Rising up ten thousand feet, the mountains ringing LA force the Los Angeles River to drop 795 feet over 51 miles, over 50 times steeper than the Mississippi (Gumprecht, 2001).

Next come the foothills. Sparked by the smallest flame, "the frequency and intensity of the forest fires in southern California chaparral are the greatest in the United States", and the foothills often burn clear of vegetation that may have helped rain water to absorb into the soil, or held back the avalanche of gravel that storm runoff carries to the valley floor (McPhee, 1989). Last but not least is the flood plain. Due to low flow for most of the year, the Los Angeles River cannot establish a well-defined channel to hold in its floodwaters. Before LA's flood control program, 336 square miles were subject to inundation, and one good flood could change the direction of the river's flow by 90 degrees. In 1931 "flooding became so common that schools in some parts of the valley sent children home as soon as it started to rain." In the legendary 1938 flood, 108 thousand acres were inundated, 87 people were killed, and $78 million ($888.8 million in current dollars) in damages were inflicted (Gumprecht, 2001).

After a number of half-hearted, poorly organized, and underfunded attempts to control its river, the County of Los Angeles turned to the federal government for relief. At the time, Los Angeles and Long Beach harbors were developing into hubs of international trade. Between Los Angeles city, the federal government, and private investors, over $12 million had been invested in harbor infrastructure. In fact, in 1915, one harbor proponent claimed that, nothing should “be permitted to handicap the harbor of Los Angeles County in the race for port supremacy” as it was “the single greatest asset of this country” (Orsi, 2004). Perhaps lacking the fervency, but still desirous to protect its connection to Asian markets, the federal government approved funding for flood control and turned the River over to the US Army Corps of Engineers.

The river has since been walled up. The last of the trees were removed from its bank in 1939. Concrete banks now hem in the river on 94% of its 51 miles, and for 75% of its length the bed itself has been completely concreted over. Designed to deliver water to the ocean as quickly as possible, it has famously been claimed that a drop of water falling in the San Gabriel Mountains can reach the sea in less that 60 minutes, and stormwater runoff can reach speeds of up to 45 miles per hour (Gumprecht, 2001). These concrete walls are all that hold the yearly rains at bay. Though it may be despised by environmental groups, the River channel is all that keeps Los Angeles from washing out to into the ocean every winter.

Figure 2.3: Early residents were often surprised by the power and ferocity of floods.

Thus we have a number of strictly technical limitations on any plan for the River. The concrete containment of the River cannot be removed wholesale, and the US

Army Corps of Engineers will not allow it to be removed, until there is some viable and effective plan to deal with peak flows. Since any environmental restoration project must necessarily include at least partial deconcretization of the River, essential to any meaningful restoration project must be a strategy to mitigate or absorb the extreme flows caused by the impermeability of the Los Angeles watershed.

This places a fairly serious constraint on the restoration. Changes will either have to be made across the watershed, which will be an extensive project in and of itself, or Los Angeles will have to make serious alterations in the way that runoff enters the River channel. Especially considering the heavy development that has built up along the banks of the River over the years, including crucial roadways and railroads, it will be difficult and expensive to get the riverfront land to enact the kind of changes that will be necessary.

2.2 Political Limitations

Technical limitations are not the only impediment to the progress of the River. Especially in the Los Angeles area, political considerations are of great importance. Although the principal branch of the river remains within Los Angeles County limits, only 32 miles of the River are actually in Los Angeles City. Moreover, although the US Army Corps of Engineers controls and maintains the flood-control channel, the County of Los Angeles owns the water in the river from laws stemming back to Pueblo rights in the 1800s. This means that any plans for the watershed as a whole must be coordinated through a number of political bodies–both regional and federal.

Additionally, now that the Los Angeles River has been chosen to participate in the Urban Waters Federal Partnership Program, river improvements will include more federal agencies and oversight ("Urban waters federal," 2011).

Difficulty of navigating the greater Los Angeles political system should not be taken lightly. It was political wrangling led to the US Army Corps take over of the river flood control channel in the 1900s, though on the other side of the coin, since those days political pressures exerted by citizen groups have led to the construction of a number of parks and open space areas along the river (Orsi, 2004) (Gumprecht, 2001).

2.3 Financial Limitations

One of the biggest political debates regarding the river restoration is where is the money will come from to pay for improvements. Funding has historically been a huge issue for river control, as a lack of funding was another central reason that the USACE took over control of the river, and was also the reason that much of the early 1900s flooding occurred. There is no possibility that river restoration will be inexpensive. The Cheonggyecheon restoration, which included improvements to the river itself, as well as pubic transportation to replace the removed highway, cost around $900 million to complete (Cho, 2010). Although this may be an upper bound on cost estimates for the LA River, it helps to give some understanding of the price tag that will neccessarily accompany a comprehensive restoration project. Especially since the River runs through a number of cities, the question of whom, and how, the restoration will be paid for is one of great debate.

Since many of the suggested river projects (to be discussed in the next chapter) necessitate the purchase of land along the riverbed, plans will be seriously limited by the funds available. Los Angeles City is currently funding around 50 construction projects along the river whose net value is over $650 million, and in 2004, city voters passed Prop O, a measure for clean water improvements. However, funding for improvements to the river channel itself have yet to be approved.

Since obviously some source of funding must be found, the next question is who should pay? If cost to residents is proportional to benefits received, the issue becomes quite complicated. Benefits from river improvements will include all residents of the City, but will be focused most heavily on riverside communities, which tend to be the most impoverished and therefore least able to fund such a restoration. Additionally, the Los Angeles River empties into Long Beach harbor, and so changes and improvements to the river channel will affect harbor as well. With benefits from improvement distributed along the length of the River, where should funding come from? An added complication is that restoration project also has the potential to attract tourists and businesses into the region, so another controversial question is how to split costs between businesses and citizens. Answers to these questions will not be easy, even if they can be quantified. Issues surrounding environmental justice enter the equation, as do those of social welfare. Civic groups, political factions, and community leaders each have opinions about how best to manage and improve the river, and who should benefit from these improvements.

2.4 A Human Landscape

Thus the landscape surrounding the Los Angeles River is more than simply geography. The Los Angeles River is an urban river, and so its problems, and future restoration, are ones of human scope, as well as hydrologic. As Jared Orsi asserts in his book, *Hazardous Metropolis*,

> Successful flood control requires not only measuring rainfall, debris bulk, and concrete strength, but also considering politics, economics, social relations, and cultural values–and understanding how these unquantifiable factor interact with the technical aspects of the problem

This chapter has outlined the historical aspects of the Los Angeles River that have defined its present state, and highlighted three main limitations–technical, political, and financial–that will define its future. With this context for the way that the River has and does operate within the confines of the urban ecosystem that surrounds it, it is now possible to consider the future of this ecosystem with an understanding of what options are possible given the nature of the River, and what options are not. In this light, we now direct our attention to the most recent plan for the future of the River: the Los Angeles River Revitalization Master Plan.

Chapter 3

The Los Angeles River Revitalization Master Plan

The Ad Hoc Committee on the Los Angeles River was formed in June of 2002 by Los Angeles Councilman Ed Reyes, who was joined 4 other city council members–Eric Garcetti, Wendy Greuel, Tom LaBonge and Jan Perry. The initial goal of the Committee was to "return the splendor of the River to the people of Los Angeles while maintaining flood protection and safety"– an attractive sounding if vague goal. What eventually came out of the Committee was the Los Angeles River Revitalization Master Plan. Initially merely a framework outlining some hopes and goals for the River, the plan went through an 18 month planning process that produced a 20-year blueprint for the development and management of the Los Angeles River. As of April 2007, the plan was officially adopted by the City of Los Angeles, and has since been endorsed by Friends of the Los Angeles River(FoLAR), the preeminent LA River activist group, as well. The following summary of the LARRMP is based on the Ad Hoc Committee's final published Master Plan (Los Angeles Ad Hoc Committee on the Los Angeles River, 2007) [1] .

3.1 Motivation

In the Plan, the committee outlines a number of impetuses for the restoration and renovation of the LA River. The first, which seems to be the primary motivating ideas is that "open space ... is necessary for human health and well being". Although Los Angeles is home to a number of parks, including Griffith Park, the largest urban wilderness preserve in the nation, the city suffers from a general dearth of open space. According to the numbers cited in the report, there are some neighborhoods with as little as 0.7 acres of open space per 1000 people. Lack of open space has been "directly correlated with the public health epidemics of obesity and diabetes". Trees and other greenery have also been found to reduce air pollutants and greenhouse gases, which in turn affect childhood asthma and other respiratory health issues. Last but not least, green spaces have been shown to build a sense of community, and are correlated with better community health, including lower crime and increased civic involvement (Ch2, 2).

The River project is hoped to be "a springboard for the greater success of the City itself". Similar to the way that the Cheonggyecheon River restoration transformed Seoul, it is hoped that restoring the Los Angeles River will be transformative for the

[1] For the reader's convenience, all specific citations referencing the LARRMP are denoted with a parenthetical indicating the chapter and page of the reference.

city as a whole, and that the restoration will be a guiding light for city improvement projects yet to come –"great and transformative change may not be accomplished in one lifetime, yet it must remain in the minds of the people who will carry in forward" (Ch 2, 3).

Civic pride is another clear driver. The LARRMP claims that a "great city" is one that "offer[s] productive conditions for business, culture and leisure", and moreover that "a great city should also be a healthy place without environmental hazards" (Ch2, 3). The potential of a restored River to attract tourists and international acclaim, which has happened of other successfully restored urban rivers, is not explicitly mentioned, but was certainly in the mind of politicians writing about the criteria for a great city.

Figure 3.1: The logo and motto of the LARRMP give an indication of the civic pride that motivate the restoration. Courtesy of the LARRMP Homepage

The LARRMP's self-stated main principles are to (1) revitalize the River, (2) green the neighborhoods, (3) capture community opportunities, and (4) create value. These motivations as stated are fairly vague, but each has a core concept behind it. For each of these main principles, we want to gain a better understanding of what these slightly vague motivations mean in the context of the river. Next, we will identify the specific goals and tasks that the LARRMP suggests to realize these objectives. Finally, we will look at the particular methods that are suggested to accomplish each goal.

3.2 Revitalize the River

The river revitalization aspect of the plan is the core of the project, and essentially desires to give citizens access to a "naturalized" River. To that end, the main objective is the restoration of the River's ecological and hydrological functions. The Plan hopes to achieve this "through creation of a continuous riparian habitat corridor". While the plan itself states that complete restoration is "not likely feasible given flood control requirements" it does hope for "[naturalization] in significant stretches." (ch 2, 5) However, this is in no way a simple or straightforward task. The LARRMP lays out three main prerequisites for the restoration of a riparian ecosystem, one of which it classifies as a precondition, while the other two are short-term goals.

Enhanced flood storage is identified as the primary precondition to begin the revitalization process. The main goal of flood storage is to decrease flow at all points along the river to "sub-critical" (less that 12 feet per second) speeds. It is believed that maximum speeds of 12 ft/sec will allow for the "maintenance and reestablishment of vegetation." Unfortunately, there are not many options to decrease flow speed. Flow speed is determined by the amount of water passing through the channel (discharge) and the cross-sectional area of the channel, i.e., the amount of space that the discharge has to pass through (Mount, 1995). Thus to decrease flow speed, either the channel needs to increase in size, or the amount of discharge must

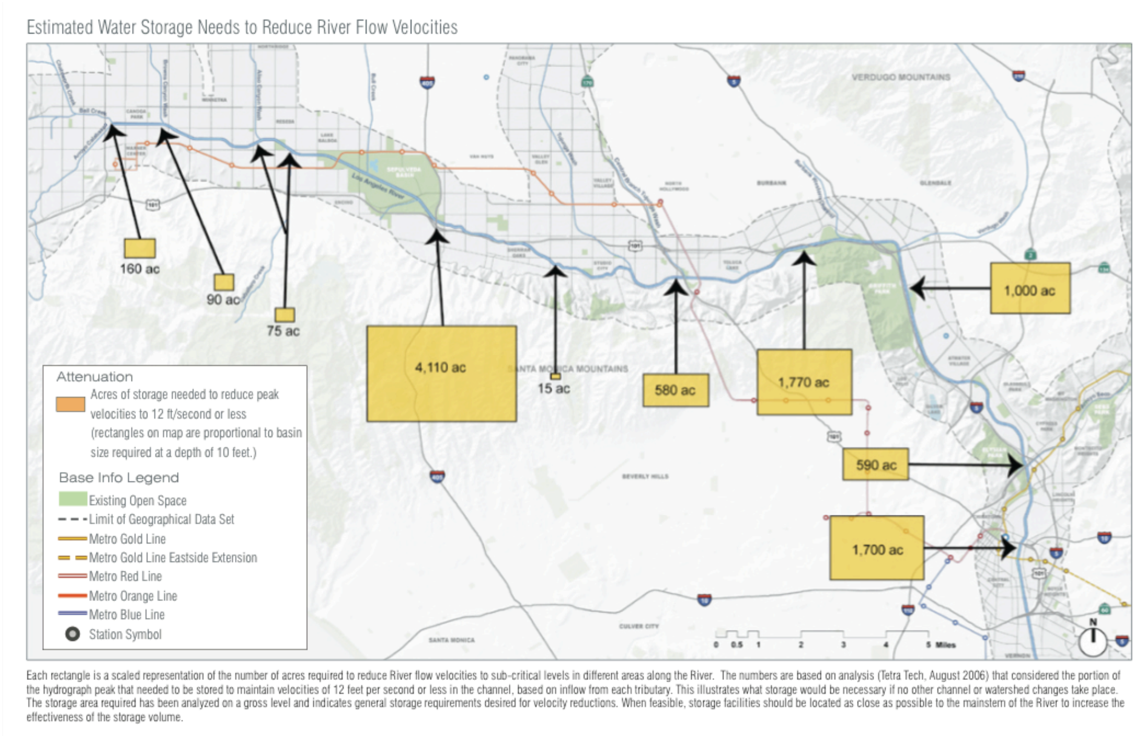


Figure 3.2: From the LARRMP: "Each rectangle is a scaled representation of the number of acres required to reduce River flow velocities to sub-critical levels in different areas along the River. The numbers are based on analysis (Tetra Tech, August 2006) that considered the portion of the hydrograph peak that needed to be stored to maintain velocities of 12 feet per second or less in the channel, based on the inflow from each tributary. This illustrates what storage would be necessary if no other channel or watershed changes take place"

decrease. In fact, to have the amount of decrease planned, it is likely that both will have to occur. To achieve these goals, the Plan looks almost exclusively at options both for off-channel storage. The Committee has made estimates for the acres of off-River storage that will be necessary to reduce flow speed to the desired level (figure 3.2). It is unclear whether off channel storage is intended to take the form wetlands, which is an area intensive solution, or storage tanks, which is cost intensive, or some utilization of natural aquifers. The amount of land needed is considerable, and finding the funding for such purchases will be a long-term project in its own right. However, especially considering the dearth of water in southern California, such costs could be offset through the use of stored water for irrigation or other uses.

The second option to reduce flow speed is to increase the channel's cross-sectional area, i.e., widening the channel to "create public open areas that effectively recreate the floodplain" (Ch4, p 9). Given the constraints of the concrete Riverbed, this is not at all viable as a short-term option. However, in the long-term as land is purchased along the River this plan may come back on the table. This option is the most expensive, since it will involve the purchase of land area adjacent to the River to essentially recreate the its historic flood plain. The plan suggests that "land acquisition could represent one component of a long-range strategy for restoring functional habitat within the Los Angeles River", which will take advantage of acquisition opportunities as they arise.

3.2.1 Short-Term Goals

The LARRMP outlines a couple of short term goals, which are defined by their ability to be enacted with limited funding, and the necessity of their completion for later objectives. The two primary short-term goals for the River are to improve water quality and provide safe public access to the River.

Water Quality

Water quality along many stretches of the Los Angeles River is infamous, so much so that it led one river adventurer to quip, “You think we’ll turn into a Teenage Mutant Ninja Turtle if the water touches us?” (Medina, 2011). All jokes aside, even the LARRMP recognizes the dire straights of River water water quality. According to facts cited in the report, a monitoring of bacteria levels in the River found that, “established standards were exceeded in between 44 and 100-percent of the test results”. Even more concerning, the standards themselves “were as much as 25 times the allowable limit set by the Department of Health Services” (Ch3, 8).

Improving water quality is important not only because it clears the way to accomplish some of the long-term goals (specifically, ecological restoration), but also because it will increase the appeal of the river to citizens. There are few people who want to spend their free time walking along the banks of a polluted, disease-ridden, trash-filled river, and if residents do not take advantage of the river, what is the purpose of restoring it? As will be seen in a number of the LARRMP’s goals, increasing the River’s appeal to citizens is a common theme.

Another reason for water quality improvements was the EPA’s designation of the Los Angeles River as a “navigable waterway” in the summer of 2010, following a highly publicized kayak down the River. This was a major victory for environmentalists, as navigability is one of the main criteria to place the River under the protections of the Clean Water. With this recent development, the LA River must meet new pollution standards and water quality goals, which specify a certain total maximum daily load (TMDL) for bacteria, trash, nutrient and metal particulate levels (Sahagun, 2010) (Hall, Linton, Tsong & Link). The eventual goal is to return the River to a fishable and swimmable body of water.

The LARRMP outlines a number of plans for improving water quality. Throughout, one important theme in these plans is that "the River cannot and should not be expected to be the treatment location 'of last resort' "–essentially, the River cannot be depended on to be the sole solution for water quality. A considerable amount of the planned contaminant reductions will have to occur upstream, either in tributary streams or even at contaminant sites themselves.

One option for water quality improvement is trash catchments, which will function similarly to the debris basins used in the foothills (McPhee, 2004), (Gumprecht, 2001), catching trash before it can enter the river. According to the Plan, implementation of 10,000 of such catch basins has already been planned to target areas with high trash generation (Ch3, 8). It is hoped that reducing trash levels in the River will also help control bacterial levels in the river, as "bacteria and viruses are often found in urban runoff and have been linked to the presence of trash". It is uncertain how well these trash catchments will function to control the debris produced during high flow events, since the LA River has historically been able to move sizable "trash", including a Jacuzzi and numerous shopping carts (Orsi, 2004). It is also unclear how these catchment basins will cope with the possibility of trash plugging the water outflow and causing potentially disastrous backflow and flooding.

A second strategy for water filtration is wetlands, which can double both as storm water runoff treatment area and a high flow storage area. Wetlands have also been shown to be an effective means of absorption for nutrient runoff. The difficulty with wetlands is that they have high land requirements, and will need installation and maintenance until a functional ecosystem has developed (Platt, 1994).

Water-treatment terraces are a second option that the LARRMP asserts should be fairly easy to implement. These terraces would treat runoff after it has left the storm drain, but before it reaches the river, and can be used to deal with any number of pollutants. Though they are referenced throughout the LARRMP's outline for water quality improvement, no clear explanation is given for what water-treatment terraces are, or how exactly they would function. However, it appears that construction of water-treatment terraces is closely tied to daylighting streams and storm drains (i.e. bringing water systems which had previously been contained in pipes to the surface) because daylighted streams would then be able to be treated through these terraces. From this it is inferred that treatment terraces would act in a manner similar to treatment wetlands, but would be targeted towards River tributary inflow. According to the report, terraces "are most effective during very low-flow conditions," specifically from .5 to .75 inches of rain, which unfortunately means that they will be less helpful in dealing with the peak-flow runoff that composes much of the inflow to the River.

Public Access

Creating public access is one of the least expensive and time intensive aspects of the project, but it is simultaneously one of the most important. Getting residents access to the River is crucial for increasing public awareness, access, and enjoyment of the amenities it offers, and to garner support for restoration projects. To create green space and help make the river accessible to the public, it is hoped to start with "pocket parks" which are small green areas that can be constructed next to the river on land that the city already owns. Some such parks have already been completed, most of which are in the Elysian Valley, including Steelhead, Osos, Egret, Rattlesnake, and Marsh Parks. Plans for future pocket parks include playgrounds and urban plazas, and could hopefully be connected by bike trails or walking paths. Terrace parks are another aspect of this plan, and would be placed at the 50-year flood level, which would allow visitors to be closer to the river while still providing sufficient protection from regular flooding and "an acceptable level of maintenance risk from washout" (Ch4, 11).

Other recommendations related to public access include the establishment of some kind of flood warning system, which is of particular concern given the LA River's tendency towards flash floods. Plans to improve resident enjoyment of the River also include the installation of inflatable rubber dams, which would allow for temporary, selective, "ponding areas". It is also hoped that the City's River-wide improvement will "encourage spontaneous, community-driven projects" similar to the pocket parks (Ch4, 17).

3.2.2 Long-Term Goals

The restoration of the River, while depending on these two crucial preliminary steps, has even more intermediate and long-term goals. In order to restore the River's ecosystem functionality, a riparian corridor will have to be established. This means creating habitat along the entire length of the river, which will require the purchase of riverside land, and the removal of significant portions of concrete. Additionally, to encourage the return of native flora and fauna it is recommended that the River habitat be connected to preexisting wildlife areas.

The River revitalization effort has the hallmarks of a plan that will be difficult to implement over the short-, or even medium-term. Even the preliminary step of slowing flow speed relies on the slow process of purchasing land for peak flow storage. Since the rest of the restoration plan relies on this step, one of the issues that we will look at later will be finding ways to put the restoration on a faster track. Although it is true that this project cannot be accomplished in a day, it will also be difficult to ever achieve anything if progress is not started now.

3.3 Green the Neighborhoods

The next main goal of the Plan is to use the River revitalization as a springboard to create a greener Los Angeles, focused along a “River Greenway” that would connect to other parks and public spaces in the surrounding neighborhood. There are four primary aspects to this plan.

The first is land acquisition. The basis of any park system is the purchase of open space upon which to base the system. The second task is to create non-motorized routes from neighborhoods to the parks and the River. More than 70% of LA residence lack safe, walkable access to parks or other green space within a quarter mile of their homes. It is hoped that continued development of bikable and walkable roadways will provide “a new and safe means of commuter travel”.

The third goal is to improve existing open space areas. This includes naturalization such as daylighting streams (bringing underground or piped streams back into a natural streambed), and increasing natural landscaping. The last task is to increase a sense of culture and community in riverside neighborhoods. Specifically, the Plan aims to “encourage local and diverse character within the River Corridor,” including increasing public art that celebrates cultural history (Ch5, 3).

3.4 Capture Community Opportunities

The Plan also calls for using the restored River as a center for community life. This hopes to increase residents’ engagement in civic events, and increase appreciation of cultural heritage. Although plans for community development must inherently be developed in a neighborhood-by-neighborhood basis, the LARRMP identifies “Opportunity Areas,” which it uses to highlight “potential approaches to and solutions for common conditions that exist along the River” (Ch6, 3). The Plan looks specifically at Canoga Park, River Glen, Taylor Yard, the Chinatown-Cornfields Area, and the Downtown Industrial Area, and fifteen more adjunct areas. This section offers little new as far as revitalization ideas, but primarily shows how the already outlined plans could be implemented in these particular neighborhoods. Because of the specific nature of these plans, a comprehensive review is not germane to the overall review of the LARRMP, and is therefore omitted.

3.5 Create Value

This objective is focused mostly on economic costs and benefits stemming from the restoration and associated development, whether they are strictly monetary, or come in the form of improved amenities for communities. More specifically, the LARRMP calculates benefits in four 'Opportunity Areas': Canoga Park, River Glen, Chinatown-Cornfields and the Downtown Industrial Area, and uses these for extrapolations to the rest of the city. Within these areas the Plan considers three options: (1) existing condition, (2) moderate economic development, and (3) major economic development. It should be noted that public workshops with residents found a preference for the third option in each of the four Opportunity Areas.

From the moderate development, it is expected that $2.9 billion in new development would create 52,000 short-term jobs and 10,500 permanent jobs, with tax revenue of $167 million per year during development and $90 million per year afterwards. Major economic development of $5.7 billion is expected to produce 104,000 short-term jobs and 19,000 permanent jobs, with an associated increase of $331 million in tax revenue during construction and $168 million thereafter (Ch7, 13). As a conclusion to these analyses, the report claims that "every dollar invested by the public is expected to lead to four dollars of subsequent private investment" (Ch7, 31).

As a point of comparison for the aforementioned benefits, the River Revitalization webpage asserts that the San Antonio Riverwalk has been the catalyst of over $2.8 billion in tourism for the City of San Antonio, and the Brush Creek Cultural Corridor in Kansas City has generated more than $750 million in new development (City of

Los Angeles, 2011). While these economic benefits from these restorations may be on the high end of the spectrum, they do provide some sense of scale for the economic effects of the revitalization.

All told, the economic benefits from the River restoration are worth billions in the long-term, but will require a substantial input up front. With an obvious bias, the LARRMP highlights the benefits of the Restoration, while glossing over a number of economic costs, such as loss of industrial land, gentrification, lack of affordable housing, and potential impacts on railroad operations. Undoubtedly, these issues and others will need to be flushed out more fully before the Plan can go into effect.

Chapter 4

Critical Analysis of LARRMP

Los Angeles is an urban ecosystem; it is defined by the political, social, and geographic characteristics of the landscape. The Los Angeles River is a part of that ecosystem, and any changes to it must fit within that landscape. Chapter 2 outlined three major limitations on a river restoration project, while chapter 3 ran through the primary aspects of the LARRMP. From these it now becomes possible to analyze the plans of the LARRMP in the context of that ecosystem. In this chapter, it is hoped that we can finally answer the question laid down in the introduction: Can the LARRMP achieve its stated goals given the restrictions placed on the River?

4.1 Political

The Los Angeles River Revitalization Master Plan was formulated primarily by politicians; their influence is evident throughout. The development stage of the Plan included a number of community workshops, offering residents the chance to learn about the plan and voice their opinion on various aspects. The Plan itself is very careful to avoid jurisdiction related conflicts by means of a three-tiered management system, that clearly divides river control between city, county, and federal bureaus, and also lays out a management mechanism for the revitalization itself. It is equally adept at fitting itself within the current bureaucratic structure of the Department of Public Works and current improvement plans already in place throughout the watershed, in particular the city's Integrated Resources Plan and the county's Integrated Regional Water Management Plan. As a precursor to larger efforts, small projects like the Los Angeles River Emergency Response Signage System have already been completed in partnership with county, state and federal agencies (Ch1, 8).

Yet in its attempt to avoid upsetting the system, the plan similarly manages to avoid answering many of the tough questions that lie at the heart of the restoration effort. The Los Angeles River passes through some of the poorest areas in the city, particularly the southern cities of Compton and Downey. In these areas, there is little to no land currently allotted for open space, and the purchase of land for this purpose will most likely be difficult, as these areas are also some of the most highly developed.

However, there are no clear strategies for these areas. In regions where removal of concrete walls might be problematic, "the Plan advocated drawing on existing City precedents for greening freeway retaining and sound walls with hanging vines" (Ch4,17). In other words the current suggestion offers merely the aesthetic of "put up vines" to cover concrete walls. These are the poorest neighborhoods that will be the most difficult to help, for which the Plan is purports to do the most. The fact

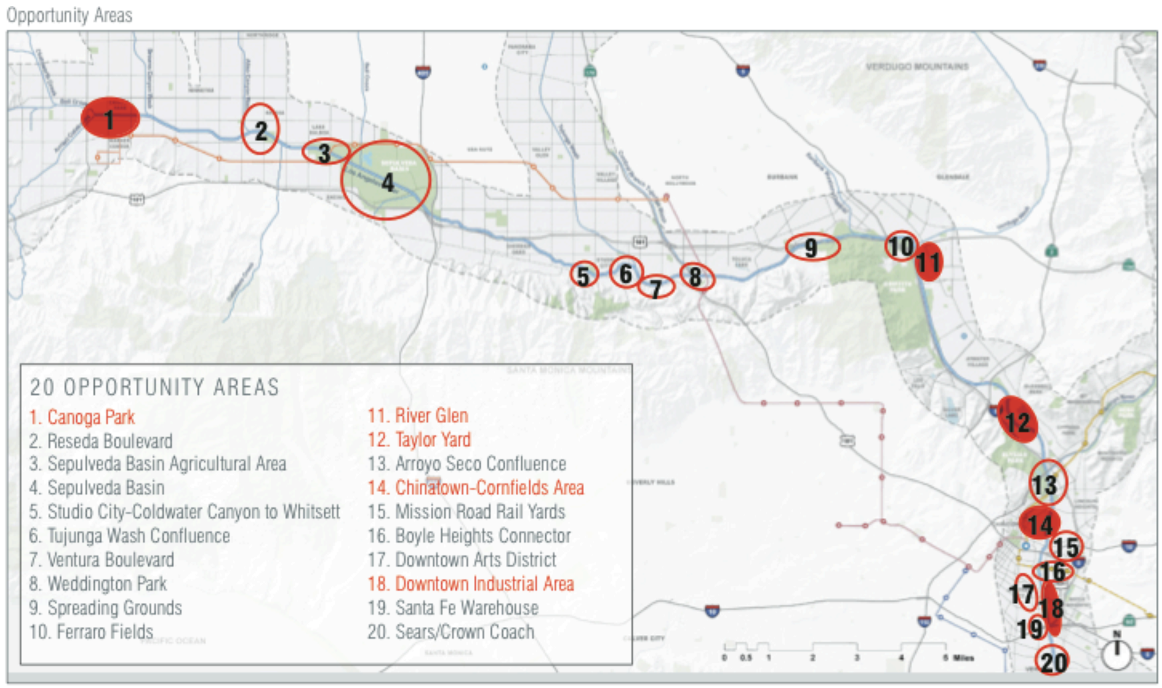


Figure 4.1: The predominance of 'Opportunity Areas' in South LA can be seen on this map

that the Plan blatantly ignores the hard problems associated with the restoration project has disturbing implications for the project as a whole. Moreover, it implies a willingness to sacrifice the needs of the communities for a political agenda. While sometimes it becomes necessary to compromise certain aspects for the overall success, the fact that these issues did not even make it onto the table is troubling, and raises prickly issues of environmental justice.

The LARRMP has the support of FoLAR, which will most likely help it to gain the community popularity it needs, should a decision ever come to the ballot. Even more strongly in its favor on that front, the Plan does target a number of neighborhoods that are in dire need of revitalization, giving special focus to South LA in its section on community opportunities (see figure 4.1) . Given the planned expenditures for these neighborhoods, it is unlikely that voters in these areas will oppose the Plan, and so the Plan is well prepared in that way.

4.2 Financial

On the financial front, the Plan appears to be similarly well armed. If anything, the LARRMP's section on economic benefits of the restoration underestimates the total benefits associated with the plan. Although the strictly economic outcomes are well-documented–the number of jobs created, millions in tax revenue earned, etc– the Plan does not take into consideration a number of factors, including quality of life and health benefits resultant from urban greening.

Although the motivations for the Plan do recognize the health benefits associated with urban revitalization, this is not taken into account during economic calculations. Besides the impacts on obesity and diabetes mentioned in chapter 3, the presence of trees has been found to reduce air pollution associated with childhood asthma, respiratory failure, and lung diseases. The value attached to these improvements was not quantified in the report, but given that about 1 in 15 Californians suffer from asthma, the benefits of air pollution reduction, both in quality of life and in dollar value, would be difficult to overstate (Recent Research Findings, 2004).

As residents have already indicated strong support for a River and economic development plan that requires higher spending by the city, it seems likely that the plan will be able to obtain the funding necessary to begin the Restoration. As previously mentioned, residents showed their willingness to put their money where their mouths were with the passage of Prop O in 2004, which provided $650 million for clean water initiatives. Unfortunately for future developments, voters may be less enthusiastic to approve big spending plans given the current economic recession. As always with economic issues, it is difficult to predict what the future holds, and thus how lavish voters will feel when next at the ballot box, but it does seems safe to say that voters have shown a readiness cough up the finding that will be necessary to make the LARRMP a reality.

4.3 Technical

Unfortunately, the one area that the LARRMP seems to fall short is the most important –the River restoration itself. Perhaps to keep from boring its readers, the LARRMP shies away from going into the nitty-gritty details of how, exactly, it plans to transform a concrete channel into an aesthetically pleasing river promenade that still manages to protect Los Angeles from yearly floods. Regrettably, the core of the Los Angeles River revitalization is the technical part–how can we open up the river to restoration without compromising the integrity of flood protection? Without this restoration, any kind of greening projects are trivial, and all the community and civic projects that rely on the river as a backbone for activism and change will remain incomplete. Although the LARRMP recognizes the importance of the restoration project, it does not anywhere explicitly state how crucial the restoration of the River is for all other aspects of the Plan most certainly does not seem to make it the principal component of the revitalization. Because of this, there are many parts of the restoration that are not well developed, and some critical parts that are under-acknowledged. Most importantly, the Plan does not acknowledge that in order to ecologically restore the Los Angeles River, Los Angeles will have to rethink the way that it interacts its river, and its flood protection system. This is not an easy task, but next chapter endeavors to offer some insight on how to negotiate the need for flood control with the desire for a more natural river system.

Chapter 5

Ecology Versus Flood Control

There are a number of critical changes that are necessary for the rehabilitation of the LA River, but the problem that seems to have the potential to be the most costly, divisive, and long-term is that of the deconcretization of the riverbed and subsequent ecological restoration. Because this aspect of restoration ties in closely with flood control issues, river hydromorphology, groundwater use, the riparian ecosystem, and even the political infrastructure there does not appear to be a quick or simple solution. There is a need for fundamental change in the channel flow of the river, and much of this chapter is focused on potential solutions, both those offered by the LARRMP and those successfully employed on other rivers.

The first step in flood control is to recognize "that complete protection from flooding is impossible and that some risk has to be accepted"(Nienhuis, 93). Although is politically unpopular to acknowledge the potential failure of flood protection, it allows the most important question in the development of a flood system which is, what is acceptable flood risk? The flood protection created by the USACE was originally intended to provide 100-year flood protection, but after an especially wet winter in 1980, flood protection was recalculated. For about half of the length of the River, the desired 100-year protection was not provided, and for a number of miles protection was only at the 50-year level. Some sections only had 25-year protection. It was this recalculation that caused FEMA to designate 82-square miles a “flood-hazard zone,” necessitating higher flood insurance. Although improvements were quickly made to the river, it was calculated that these higher insurance rates would have cost 177,000 jobs and $30 billion in economic productivity. Even more, with flood protection as it was, a 100-year flood would cause $2.3 billion in damage to the area, and completely inundate an area that is home to 500,000 people (Gumprecht, 2001).

With these facts in mind, it seems reasonable to insist upon 100-year flood protection for the full length of the River. In fact, 100-year protection seems to be an international standard for flood control and risk management. Many countries, including the UK, Germany, Spain, France, Canada, and New Zealand (not to mention the US) all use the area affected by a 100-year flood as a representation of the flood hazard and as the basis for flood mitigation (Begum, 2007).

5.1 Meandering Streams

Having decided that the restored River should provide 100-year flood protection, the next question becomes what is the best way to remodel the River to do this. When searching for the best” solution that balances ecology and flood needs, factors such as cost, engineering simplicity, time to completion, flood protection, and ecosystem verisimilitude should all be taken into consideration. Since the LARRMP asserts that the long-term goal of the Plan is the restoration of a functional urban riparian ecosystem, it seems that in the long-range vision of the plan should weight the last two of these factors most heavily. Given these seemingly dichotomous goals, current studies of river systems and flood control suggest that a meandering stream offers the best compromise between the two.

It should be noted that a meandering stream is in direct opposition with the USACE's current management protocol, which relies on the swift flow of water to the ocean, even to the extent of clearing vegetation and sediment from the Riverbed before expected high flows. Clearly, this is not a strategy that can be maintained in concordance with ecological restoration.

Figure 5.1: The red on the map represent the areas in danger of inundation in the event of a 100-year flood

A complete 'restoration', i.e. return of the LA River to its original state, is not a viable option, as explained in the first chapter. Although the LA River was originally a braided stream, this is a less predent option as compared to a meandering stream, primarily for flood control reasons. Meandering streams are much more stable than braided ones, although they seem to provide similar ecological services (Schumm, 1985). Increased bed stability means the River will be more likely to carve a consistent and reliable channel, which will help to contain it during high flow events. Moreover, it has been found that "single-thread" channels (as opposed to braided channels) will "reduce flood damage and be less likely to acquire large sediment loads" (Schumm, 1985). A meandering stream can be created using "training banks" which help to direct the river's flow and give the river sinuosity. Among the other benefits already mentioned, construction of the river's meander will allow engineers to have more direct control over the shape of the river, which may reduce the required floodplain area.

On the other end of the spectrum, a meandering stream is preferable to a less sinuous riverbed for mostly ecological reasons. Though a pair of European river restoration specialists note that " 'naturalness' has become an important element of the enhancement ethos," implying that the desire to return a stream to its "natural" state is nothing more than an environmentalist's idealistic desire for a "pure" natural space (Nienhuis, 2001), it has been seen that using a landscape's original biome as a template for improvements is crucial for the restoration of the full suite of ecosystem services. Due to the complexity of riparian ecosystems and science's incomplete understanding of their mechanisms, the most effective restoration of a degraded ecosystem is to return it to its original natural state (Palmer, 2008). Thus a meandering stream is the best compromise between river stability for flood control, and hydrologic authenticity for ecological success.

5.2 Hydrologic Restoration

River studies also contend that the first task of an ecological revitalization project should be to reconstruct a reasonable facsimile of the river's original abiotic hydrological system. This is predominantly because the hydraulics lay the groundwork for species introduction. "First comes the physical habitat, and then the species will follow"–the ecological rehabilitation process, even for vegetation, cannot be started until organisms have a habitat (Neinhuis, 2001). Following an "if you build it, they will come" approach, restoration of abiotic systems is very much a precursor to ecological restoration. Particularly for vegetation, a meandering stream will slow flow velocities and allow plants to take root. Habitat construction is equally, if not more important for animal species as well. In fact, one study on Japanese rivers, which are hydrologically similar to Los Angeles, asserts that the restoration of macroinvertebrates relies on the creation of "stable substrates"–rocks, wood, and other debris that are stable for most river flow velocities (Nakano, 2009). Macroinvertebrates, which include shellfish, snails, worms, and insect larvae, are the basis of many river food chains and will be crucial for the introduction and maintenance of fish and waterfowl populations.

Additionally, a well-established river habitat will increase the likelihood of successful reestablishment for species that have become locally extinct or endangered and will need human help with reintroduction. Japan experienced some success on this front, realizing in the 1990s that the price for flood protection had been the loss of many of its natural spaces. It was as this time that Japan started considering more natural ways of managing its hydrological systems, and since then numerous river, wetlands, and lake restorations have been started. One of more successful lake restorations relied on the use of natural seed banks cut from offshore bottom sediments. This use of preexisting sod expedited the recovery of many locally extinct plant species, as well as general vegetation growth. Among the components considered essential to the success of the restoration were the initial repair of the slope, alignment, and location of the bank of the lake (Nakamura, 2006).

5.3 A Bed for the River

If a meandering stream is the best option for restoration, the next question is how to achieve this for the Los Angeles River. The LARRMP already identifies many of the needed hydrologic prerequisites for River, the first of which is slowing peak flow. The Plan recognizes the importance of reduced flow velocities, yet the only real solution suggested is the creation of off-channel flood storage to hold excess water volume produced during peak flows.

The Plan also recognizes the importance of purchasing land along the River to expand the floodplain, which will be vital for the construction of stream meander, as well as providing flood space for peak flow. In some parts of Europe, particularly the Netherlands, Germany, and Belgium, the current strategy for managing floods is to allow the rivers to take more physical space"– in other words, to widen riverbeds and essentially allow rivers to flood–just not into human settlements. This policy is definitely the most technically simplistic, though not necessarily the most cost-effective. (Neinhuis, 95)

The LARRMP presents estimates of 150 to 250 additional feet of River width in northern areas, to as much as 600 additional feet on coastal end of the River (Ch 4, 9). Although this is obviously an expensive effort, it is not unheard of, even in Los Angeles. In the 1930s, when flood protection projects were in their infancy, the County and the federal government were beginning their collaboration on the current flood channel, As a part of the arrangement, the City was required to purchase all of the land needed for the joint project. In a hearing with Congress, H. G. Legg, chairman of the Board of Supervisor's Flood Control Committee complained, "It has been a tremendously expensive thing to go down the channels and buy rights-of-way, widening the channel." (Gumprecht, 210) Nevertheless, given their options, the County managed to find the funding to make the purchases, and found it in a reasonably short period of time.

Understandably, the City is trying to make the purchases a more long-term project this time, due primarily to cost constraints. Stretching over a longer time scale will reduce costs, since the City will be able to buy land as it become available, rather than paying a premium to convince land-owners to sell. However, especially since land is being purchased in a piecemeal fashion, it becomes increasingly important which parcels are purchased immediately, and which are bought farther down the line. If the purchase of one area will allow for the slowing of flow velocities to the point where vegetation can be reintroduced to the River, it would seem that this would have a higher priority than the purchase of an area for a pocket park or for extending bike routes. Yet there does not seem to be any kind of clear methodology for obtaining land, or at least none is outlined in the published Plan. Considering the necessity of riverside real estate for most of the LARRMP's projects, one of the first tasks of the executors of the Plan must be to locate funding to expand the area available for the river and then begin identifying the most optimal areas for purchase. Although the Plan accepts that these efforts will be difficult and most likely must happen when opportunity arises, this is the basis for all other river work and thus is time sensitive.

5.4 The Little Stream that Could

One of the principal reasons that the Los Angeles River today so little resembles the "limpid stream" that it once was, is the destruction of its home. Though it may seem maudlin to bemoan the loss of a riverbed, this is what has fundamentally changed the Los Angeles River from a river to a flood channel. Though it must be done with care to prevent the flooding that once terrorized the city, by giving the River back its bed, and restoring its hydrologic flow, there is hope for River to once again amble across the landscape, providing a home to fish and fowl. Though the LARRMP does provide possibilities available to achieve this end, there is a final option that the LARRMP skirts away from addressing, but which has enormous potential for hydrologic restoration. This holdout is action at the watershed level for the river.

Chapter 6

Watershed Restoration

A watershed, or drainage basin, is the area of land whose precipitation empties into a certain body of water, usually a stream or river. One of the primary contributors to flooding in a metropolitan setting is watershed urbanization. Watershed "urbanization" is a measure of how much of the ground has been covered by impermeable surfaces, or surfaces that do not absorb water, and is a direct result of increased population and building density associated with urban areas (Sheng, 2009). It is widely understood that urbanization increases peak flow and flooding by preventing precipitation from infiltrating into the ground, which increases runoff into storm drains and streams.

The Los Angeles River watershed in particular suffers from extreme urbanization, which has increased drastically over the years. Urbanization of the watershed increased from 19.3% to 44.0% from 1947 to 1979, and has only increased since the 70s (Orsi, 1994). According to figures cited in the LARRMP, "only 13 percent of

Figure 6.1: The major watershed of the Greater Los Angeles Area are pictured here

the land area remains as open space" in the low Los Angeles watershed (Ch3, 19). Impermeable surfaces now cover as much as 66% of ground surface in some parts of the county (Sheng, 2009). These changes have had a proportional effect on runoff, which increased by 25% in the years from 1940 to 1980 (Orsi, 2004). River flow has similarly been affected, and one inch of rain in 1966-79 produced 58% more runoff in the River than it had in 1949-65 (Gumprecht, 2001).

Understandably, this has meant increased flood danger in many parts of Los Angeles. The winter of 1980 was a particularly wet one, and in February debris from a high flow was found on the top of Long Beach levees. The walls constraining in the River no longer provided 100-year flood protection. In fact, in some areas they don't even provide 50-year flood protection. Of greater concern, 100-year flood estimates have been increasingly shown to be inaccurate for current River flows. Even worse, they have been shown to have no useful information about a river's likelihood of flooding. In light of these facts and continuing development of the watershed, the LA River still has the potential to flood, even despite the many precautions that have already been taken to keep it in its banks

In short, is evident that the watershed is of paramount importance when considering the future of the LA River. The watershed *is* the River, and any changes that are made to the watershed will have a measurable effect on the River. This is acknowledged by LARRMP itself, which states that "the perspective taken by this Plan is that the River cannot–and should not–be expected to be the sole means for addressing flood damage reduction and water quality challenges in the larger watershed." Unfortunately, the LAARMP has simultaneously decided that changes at the watershed level are outside of its scope, stating that "the Plan reinforces and relies upon other City and County watershed planning initiatives," rather than making a statement about watershed health and what it means for this Plan, and the River as a whole. What this implicitly denies is that watershed health is a fulcrum upon which the success of the River restoration hinges. Accordingly, we assert that the principal component missing from the LARRMP is a plan for of comprehensive watershed action to restore river health via Los Angeles area watershed.

6.1 A watershed for the River

What does it mean to talk about watershed health? When talking about the health of a stream or river, we refer to the pollution levels of its waters, its viability as a habitat, and its biological diversity. Watershed health encompasses all of these, but moreover desires to include a functioning, sustainable hydrological system that manages the water and water transport within a watershed in a manner conducive to stream and river health.

As previously mentioned, the LARRMP relies on the slowing of flow velocities to 12 mph along the length of the River as a precursor to other restoration actions. The currently suggested method to achieve this goal is to provide off-channel water storage. Given the estimates in the Plan, this will be a land intensive, and thus high cost endeavor (see figure 3.2), which may delay the project for years in a search for funding and low cost real estate.

Another obvious solution that is not discussed at much length is reduction of inflow to the River. The LARRMP recognizes the importance of inflow reduction, mentioning "reducing impervious surfaces, or using BMPs to capture, treat, and infiltrate storm runoff". The Plan also cites other city proposals (specifically Integrated Resources Plan (IRP) and the Integrated Regional Water Management Plan (IRWMP)) which have goals of "reducing runoff by 50 percent (IRP)" and "reducing and reusing up to 90 percent of storm runoff from developed areas (IRWMP)" (Ch3, 9).

In terms of Los Angeles River, meaningful inflow reduction plans will involve finding ways to decrease runoff, or intercept runoff before it reaches the River, thus decreasing peak flows, and the volume of water that must be stored. This is where watershed management comes in. Increasing infiltration and capture of runoff has the potential for substantial reduction of inflow to the River. As previously stated, Sheng and Wilson's recent study of the Los Angeles watershed indicates that in some areas, runoff has increased by 66%, which is in accordance with estimates of runoff production in other cities (Ferguson, 2005). Given these numbers, there is a potential for a reduction of almost 40% of current runoff volume in some areas. While this magnitude of reduction may not be possible in all areas, it gives some sense of the potential benefits of implementing watershed management change.

While headwaters are highly influential on the River flow, they are equally important for outflow to the ocean. The Los Angeles River empties into Long Beach Harbor, the second busiest seaport in the nation, moving more cargo and containers move through than any other United States Port. This trade totals more that $140 billion in net value, and is related to nearly 1.4 million jobs (Port of Long Beach, 2011). Long Beach Harbor is an important hub not only for California, but also internationally, and will not allow River modifications to jeopardize its future. Sediment build-up can be a serious concern for the port, and the Los Angeles River carries in most of the deposited sediment. In one flood, the River dumped three million cubic yards of silt into Long Beach and Los Angeles Harbor, grounding an ocean-bound steamer. Before the concretization of the river, the Harbor had to be dredged regularly. incurring costs up to

Japan, whose steep and tectonically active mountains also produce high volumes of sediment flow, has also learned the importance of headwater management for riparian and coastal ecosystems. Some fishing villages have programs for reseeding forests to reduce sediment flow and runoff, which eventually make their way to ocean fisheries. This initiative, called "The Forest is the Sweetheart of the Sea", has been implemented throughout Japan, and is used with headwater catchments to conserve space downstream and reduce flood flow. However, one of the challenges with which Japan still struggles is the difficulty of finding ways for downstream communities to sufficiently compensate upstream communities for their conservation efforts.

6.1.1 Some Solutions

Yet despite the clear impact of watershed urbanization, the LARRMP explicitly states that "it is beyond the scope of the Plan to provide detailed solutions to watershed-wide issues," though this seems to be more of a statement about social issues such as industrial land use and affordable housing (Ch2, p 9). Although the City is limited to enacting change within the geographic confines of the City of Los Angeles, such changes still have the potential for measurable benefits for residents and the River project.

In order to have the desired impact, all of the watershed that feeds the River will need to undergo improvements, but just as the River project is hoped to be a trendsetter for future parks and greening works, so too can the city of Los Angeles be an inspiration to surrounding cities for watershed health. So how can we improve watershed health within the confines of the City of Los Angeles? In fact, efforts have already started.

As of September 2011, the Los Angeles City Council unanimously passed a Low Impact Development Ordinance, which mandates that 100% of rainwater from storms producing precipitation $\frac{3}{4}$ of an inch or less be captured and either infiltrated or used on-site. This ordinance will apply for any construction where more than 500 ft of "hardscape" is added, and will include residential, as well as commercial and industrial developments (City of los angeles stormwater program, 2011). Although it may seem demanding to force single-family residences to install catchments for rainwater, this process has already begun in the Santa Monica Watershed.

In 2009, Santa Monica started the Rain Harvest Rebate Program, and began subsidizing the purchase of rain barrels and cisterns for Santa Monica city residents. A rain barrel is a water storage device that can be installed beneath a gutter to catch precipitation runoff. Enticing residents with the promise of "a little excitement [in] your life and landscape" and "money in your pocket", Santa Monica's program is still in effect today, and allows residents to sign up online for their rebate. This project has helped protect the Santa Monica Bay from runoff, and reduced the use of drinking water, since residents can use captured water for gardening and agricultural needs (City of Santa Monica, 2011).

Figure 6.2: A rain barrel, similar to the ones subsidized by the City of Santa Monica

This program is eminently employable in Los Angeles. Rain barrels can come in sizes as small as 30 gallons for well under $100, or as large as 75 to 80 gallons at prices ranging between $150 and $250. Many fit comfortably at the bottom of most gutter spouts, and can be found in decorative forms. Santa Monica is currently offering rebates of up to $200 per barrel, though they originally started by only offering $100 rebates. Cisterns, which are a more serious investment, can hold hundreds to a few thousands of gallons of water are funded as well (City of Santa Monica, 2011) . Culver City has also begun implementing a similar rainwater harvesting" program, which has already filled all available spots (Santa Monica Bay Restoration Commission). Judging from this popularity, a similar program could easily and profitably be implemented in Los Angeles, and would fit well within the scope of the $650 million raised by Prop O for clean water and storm water cleanup.

These efforts are a good start, and will help to reduce runoff for low flow events. Unfortunately, they will not be able to have the magnitude of impact necessary to decrease flow velocities resulting from storm events. For larger scale precipitation, a larger scale of water capture is necessary. One increasingly popular option is to take advantage of natural infiltration. This has potential especially in the Los Angeles area due to the plentitude of natural aquifers for water storage.

6.1.2 Aquifers

An aquifer is "a zone or strata of saturated sediment beneath the surface of the earth," and one or more aquifers bounded by non-porous rock forms a groundwater basin. Southern California in particular is rich in natural basins, with around 450 spread throughout the state. It is estimated that these basins have a capacity of approximately 143 million acre-feet, triple the volume of surface reservoirs (Blomquist, 13).

The importance of groundwater reservoirs in California cannot be overstated.

It is estimated that it would cost $28 million per year to import surface water to replace groundwater usage for coastal LA County. Even more importantly, it is estimated that the value of basins for their storage capacity may outweigh that of their water resources, especially considering that groundwater basins are cheaper and more effective than both manmade and natural aboveground storage, in their water retention, maintenance costs, space efficiency, and ecosystem compatibility (Blomquist, 13).

Groundwater is a crucial resource in California, and serves two-thirds of California residents, as well as providing one-third of all water used in southern California. Although there is no comprehensive management program for groundwater in California, some basins have been managed locally, apparently to great success. Management of groundwater basins consists primarily of preventing overdraw of the basin (essentially drying it out), which can result in aquifer shrinkage or destruction if it occurs long-term. The generally considered “annual safe yield” of a groundwater basin is equal to the long-term average annual natural replenishment (Blomquist, 13).

This becomes of particular concern in urban areas reliant on groundwater due to the low rate of natural replenishment caused by impermeable surfaces. In particular, groundwater provides about 90% of water supply for the over one million residents of San Gabriel Valley. Due to the limited area available for percolation in urban areas, Blomquist suggests that, “it may become necessary to identify particularly good recharge zones in urbanizing areas and protect them and thereby ensure that water continues to be supplied to the underlying groundwater basin” (Blomquist, 1992).

The inclusion of natural aquifers into a comprehensive watershed management plan could be instrumental in for cost reduction. By directing excess runoff into groundwater basins, the City could reduce the necessary acreage of off-channel water storage and consequently land-purchasing costs. Moreover, the increased consideration and replenishment of natural aquifers could help to defray some costs by increasing the sustainable yield from natural aquifers, decreasing the necessity of imported water. So, the question becomes, how do we increase infiltration, particularly in areas that will feed into groundwater basins?

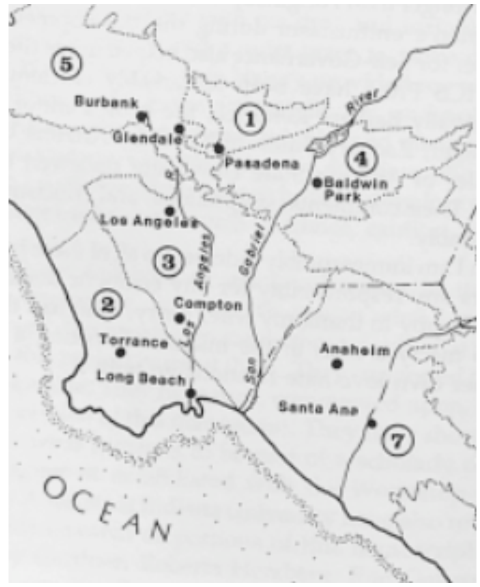


Figure 6.3: Pictured are the primary groundwater basins that underlie the LA Area: 1) Raymond Basin 2) West Basin 3) Central Basin 4) Main San Gabriel Basin Photo taken from *Dividing the Waters*

There are four groundwater basins that underlie most of the LA Area, and in particular the parts that feed into the Los Angeles River watershed. The Raymond Basin, the West Basin, and the Central Basin lie under the river proper, while parts of the Main San Gabriel Basin are within the Los Angeles River watershed. It is beyond the scope of this paper and the ability of the author to pinpoint specific areas that are particularly apt for infiltration. Rather, we identify some methods to encourage infiltration in general, and discuss their potential for implementation in the context of the River restoration plan.

6.1.3 Infiltration

It is similarly beyond the scope of this paper to identify and evaluate the spectrum of infiltration enhancement options. However, there are a couple of strategies that have been successfully implemented in t he Los Angeles area, or that are particularly relevant.

Rain Gardens

The first of these is rain gardens. A rain garden is a depressed area, often planted, that allows for infiltration of surface runoff. Rain gardens are commonly recommended as a best management practice (BMP) and in fact have been installed along the top of the Ballona Creek channel (Creek Freak). Judging by their popularity on the internet and in newspaper or magazine articles rain gardens are one of the most common methods of runoff control partially due to their low installation cost, high efficiency, and simplicity of construction ("Everything you want to know about rain gardens and how easy they are to install in your yard, school, place of faith, government building or business"

Figure 6.4: Rain Gardens, recently installed atop Ballona Creek, during a rainstorm. Photo courtesy of LACreekFreak.wordpress.com

proclaims raingardennetwork.com).

Rain gardens have been shown to increase runoff absorption, and have some limited potential to reduce pollution, particularly that of organic compounds such as the herbicide atrazine and common ammonia-nitrogen or phosphorous fertilizer (Dietz and Clausen, 2005), (Yang, 2010). Unfortunately, there is limited research about the effectiveness of rain gardens as compared to a normal permeable surface in terms of absorption rate and filtration. Some studies seem to indicate that absorption potential is heavily dependent on soil type and saturation level (Shuster, 2007) . Nevertheless, they do offer an inexpensive and effective option for runoff reduction, and can be implemented in small areas, and in both residential and commercial areas.

Bioswales

Another popular option for runoff control is swales, or more particularly, bioswales. Swales in general are low-lying moist or marshy tracts of land, and are particularly useful for aiding in infiltration by slowing or capturing runoff. Bioswales, on the other hand, are man-made swales used for encouraging infiltration and filtering detritus and pollution from water runoff. Bioswales are most commonly implemented around parking lots or roads to filter out car related pollution from water, and have been

Figure 6.5: Bioswales capture and retain water for infiltration. Photo taken from Council for Watershed Health

found to reduce suspended heavy metals by up to 80- or 90-percent(Blecken, 2009). Similar to rain gardens, bioswales incorporate plants, and in fact higher levels of vegetation have actually been found to reduce overflow frequency (Mazer, 2001).

Though a bit more advanced than rain gardens, bioswales are similarly low tech and easy to install. Partially for this reason, they have recently been implemented in Malaysia to reduce flash floods, river pollution, and water scarcity. Called the "Bio-Ecological Drainage System (BIOECODS)", a combination of swales, biological water detention storages, and dry ponds are all used to create a sustainable drainage system that filters water through a series of natural treatment areas to control pollution. A similar effort has been built here in Los Angeles on one block of Elmer Avenue in Los Angeles.

Figure 6.6: Elmer Avenue Bioswales aid in the infiltration of runoff while improving the aesthetic and walkability of the neighborhood. Photo taken from Council for Watershed Health

Built as a collaboration of the Council for Watershed Health, TreePeople, and the City of Los Angeles, the Elmer Avenue Retrofit was designed to manage water from 37 acres of residential land. This project relies on bioswales in front of residential lots and infiltration galleries under the street to "reduce flooding, improve water quality, and recharge local groundwater supplies" ("Council for watershed," 2011). The monitoring program implemented after this project's completion has shown reduced concentrations of lead, copper, and suspended solids, which is in keeping with other research. One aspect of the monitoring program that was not included in other studies was the relationship that residents had with the completed project. Surveys showed an almost overwhelming increase in residents' awareness of watershed related issues, and empowerment about their ability to act meaningfully to help solve these problems (Belden and Morris, 2011). This shows a powerful ability to impact not only the health of the watershed itself, but almost more importantly, residents' level of concern for and awareness about the watershed. Especially since historically many of the calls for change and improvement for the River have been grassroots efforts, this is crucial for building support for future efforts, especially among poorer communities. Though this project was fairly extensive and would be expensive to implement across the board, similar projects without the infiltration galleries could be constructed at a fairly low cost around the city.

Porous Pavement

Porous pavement is another increasingly utilized option for runoff control. Porous pavement is exactly what it sounds like–pavement for roads, streets and parking lots, be it concrete or cement, that allows water and air infiltrate through to the ground beneath. The basic difference between porous and impermeable or dense pavement is that porous pavement has "void space", or holes, which allow the transport of water and air. Besides encouraging runoff absorption, porous pavements also help to filter heavy metals and biodegrade pollutants (Legret and Colandini, 1999), while offering a number of other benefits, such as cooling urban heat islands, reducing driving noise, and helping to maintain healthy rooting habitat for trees and other vegetation (Ferguson, 2005).

A porous pavement is generally constructed in two levels–the surface layer, which must be made of relatively more expensive material to withstand wear and tear while still permitting infiltration, and the base course, which is composed of relatively less expensive material to support the porous surface layer. Porous pavements require very little maintenance, though some flushing is necessary to keep void space clear of debris. In fact, the biggest concern associated with porous pavement, is that they can sometimes be damaged by sudden freezes, which is a non-issue in Los Angeles. As far as cost, installation porous pavement is more expensive than that of traditional impervious pavement, but in most cases costs are outweighed by reduced runoff management costs, especially considering modern environmental standards (Ferguson, 2005).

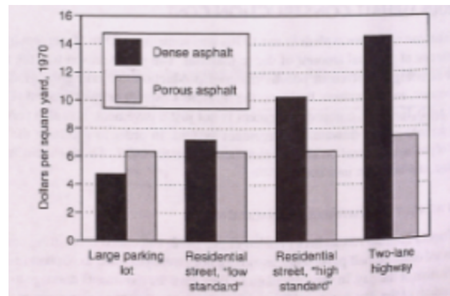


Figure 6.7: The cost of porous asphalt as compared to dense asphalt for a number of different quality levels. Photo taken from *Porous Pavements* by B Ferguson.

In the context of infiltration plans mentioned thus far, porous pavement is the most expensive to implement in pre-existing structures. However, especially in light of Los Angeles's recent LID ordinance about runoff infiltration and capture, porous pavement could actually be a cost saving mechanism for future construction projects.

6.2 Conclusions about watershed action

This overview of watershed action, necessarily brief given the limitations of this paper, presentss the tip of the iceberg as far as available strategies to reduce runoff and pollution at a grassroots level. The methods outlined are, on the whole, eminently affordable, especially considering the budget of a businesses or the City of Los Angeles. Rain gardens and bioswales are even possible for implementation, both financially and in terms of construction, by individual citizens.

Individually, each of these actions has the potential to make a measurable change in runoff volume, especially during low flow events, but together they can be combined to create a considerable arsenal with which to combat urbanization induced peak flood flows. Possibly equally important, they aid in the process of water filtration and purification to improve water quality in streams and creeks that feed the River. Already identified by the LARRMP as a prerequisite to the reintroduction of a functioning River ecoysestem, water quality is also a concern due to EPA standards.

Another similarly important externality from this type of work is resident engagement in watershed issues. Working at the watershed level will rely on resident help and import, and will begin the important process of engaging residents actively in the restoration. As shown in the Elmer Avenue Retrofit, these projects have the potential to raise citizen awareness. Resident activism and awareness was a crucial goal in the Elmer Avenue Retrofit. A major part of the renovation was teaching residents how to care for the bioswales along their street, which in turn helped to educate residents about watershed issues and ways to conserve water.

In these benefits as with many things, “It is not possible to draw a boundary around a freshwater system” (Nienhuis and Leuven, 2001). The many issues surrounding watershed care all relate to and feed off of each other, and while focus may be on one of those issues, actions to improve watershed health will invariably aid with other problems. So it is with the challenges faced by the LA River. The problems that must be overcome to restore the River are numerous, but as solutions develop it can be seen that watershed solutions help with pollution related difficulties, and open new avenues to address preexisting social problems. Thus as this project moves forward, we keep in mind the holistic view that will make this restoration a success.

Chapter 7

Conclusion

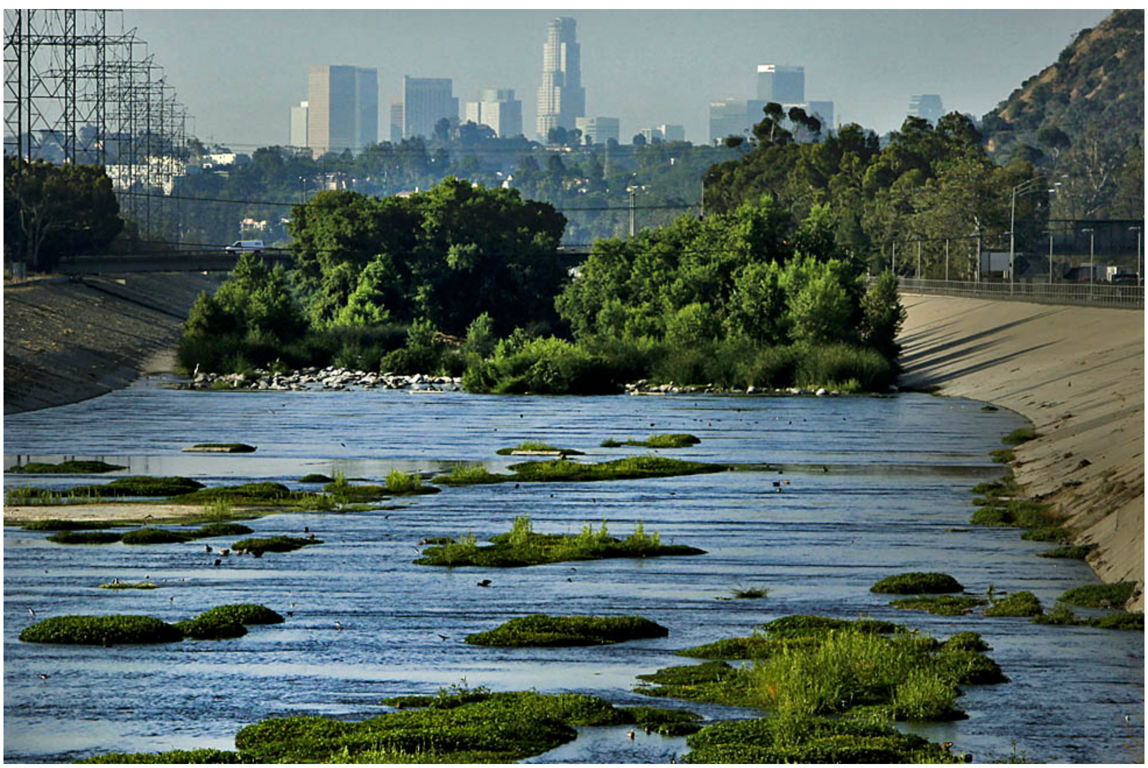
It has been asserted that, "flood hazard is largely of human origin" (Nienhuis and Leuven, 2001). Nowhere is this truer than in Los Angeles. Though flooding is an inherent aspect of the Mediterranean climate and rugged landscape that define southern California, the dangers to humans and manmade structures associated with flooding are due solely to human action. The root of Los Angeles's flood problems comes from the decision to build a city in the center of a flood plain, and flood danger has only increased as population has grown and continued development has urbanized the watershed. Though this danger may currently be conquered, it makes no promise of remaining vanquished.

With the uncertain future of climate change and its implications on global weather patterns looming on the horizon, the actions taken now to ensure flood safety and protection become even more imperative. The Los Angeles River Revitalization Master Plan offers a future for the Los Angeles River that to controls and minimizes these human made dangers, while encouraging personal contact with this river that once nurtured the city. Well-rounded in its construction, the vision and ideals of the LARRMP have been written not only by the City Councilmembers who hatched it, but the engineers, community members, economists, and activists who all took part in its formation. Yes, the plan offer by the LARRMP is imperfect. But it is the best hope that the Los Angeles River has yet seen. And it is also continuing to evolve to meet changing needs of the community.

An early resident of Los Angeles one remarked that, "it would be expensive and difficult, if not impossible, over to make the river a thing of beautybut it is not necessary to have it be so ugly and unsanitary" (Gumprecht, 2001). While this may be a bit pessimistic, its pragmatism very accurately encapsulates the approach needed for the LA River. This River will never be the lush, winding flows of the East coast. It will never be the fat and lazy stream that Huck Finn paddled. It will never be anything but what it is, impulsive and volatile, breathtaking, and sometimes terrifying, and accepting that is the first step towards creating a place for the Los Angeles River within our city.

Though the essential nature of the Los Angeles River may be as implacable and its banks are pliant, the City and its inhabitants have been given an opportunity, not to start anew, but to move forward in their relationship with the River. It cannot be said more aptly that Dallman and Piechota do in their introduction to *Stormwater: Asset not Liability*: "We have acknowledged the great engineering feats that have tamed the occasion wild and raging storms that have done so much damage to lives and property in the past. And we have acknowledged that thinking and policies must change over time."

Searching for balanced perspective of the new and the old, Orsi offers up this advice on the Los Angeles River: "The solution to the flood-control problem, then, is not to fire the engineers, rip up the concrete, and let the rivers do what they will" (Orsi,181). Nor can we, as residents of Los Angeles, in any good conscience permit such potential to remain incarcerated. Instead, Orsi suggests, the solution"is to make flood control more ecological". This is not an easy solution. In fact, it may be the hardest of all roads to walk, for it will require intensive care and the continued dedication of residents to push for the herculean changes that must be made. This path will no doubt be fraught with potentially costly mistakes, as the City learns a new way to manage its River.



A US Army Corps Engineer once said of deconcretizing the river, "We cannot permit ourselves to yield to an emotional impulse that would make their cure the central purpose of our society. Nor is there any reason we should feel guilty about the alteration which we have to make in the natural environment as we meet our water-related needs." (Orsi, 2004). Hear, hear. The city has spoken. Our water related needs are now needs for parks and green spaces, for a river that is welcoming to humans, not just restricting floods. No, we cannot let dreams for a riverside playground blind us to the violent and unpredictable nature of the Los Angeles River. But neither can we let it scare us from the River's potential as a focus of economic growth, community activism, environmental learning, and urban restoration.

Bibliography

[1] Behrens, Z. (2011, Mar 04). L.a. river: Tour operators gain access, recreational zones identified. *KCET*. Retrieved from `http://www.kcet.org/updaily/socal_focus/environment/30872-la-river-ad-hoc-committee-mtg.html`

[2] Begum, S. (2007). *Flood risk management in europe: innovation in policy and practice*. Springer.

[3] Blecken, G. T., Zinger, Y., Deletic, A., Fletcher, T. D., &Viklander, M. (2009b). Influence of intermittent wettingand drying conditions on heavy metal removal by stormwaterbiofilters. Water Research, 43(18), 45904598

[4] Blomquist, W. (1992). *Dividing the Waters: Governing Groundwater in Southern California*. University of California Press.

[5] Brater , EF, and Suresh Sangal. "Effects of Urbanization on Peak Flows." Effects of Watershed Changes on Streamflow. University of Texas Press , 1970 Print.

[6] Cho, M. (2010). The politics of urban nature restoration: The case of cheonggyecheon restoration is seoul, korea. *IDPR*, 32(2), 145-164.

[7] City of Los Angeles. (2011, Oct 24). *City of los angeles stormwater program.* Retrieved from http://www.lastormwater.org

[8] City of Los Angeles. (2011). *Frequently asked questions.* Retrieved from http://www.lariver.org/faq.htm

[9] City of Portland, Oregon. (n.d.). *Portland parks & recreation.* Retrieved from http://www.portlandonline.com/

[10] City of Santa Monica. (2011, Nov 17). *Office of sustainability and the environment.* Retrieved from http://www.smgov.net/

[11] *Council for watershed health.* (2011). Retrieved from http://watershedhealth.org/

[12] Dallman, S., & Piechota, T. (2000). *Stormwater: Asset not liability.* (1 ed., Vol. 1). Los Angeles: The Los Angeles & San Gabriel Rivers Watershed Council

[13] Dietz, M., & Clausen, J. (2005). A field evaluation of rain garden flow and pollutant treatment. *Water, Air, and Soil Pollution, 167*, 123-138.

[14] Hall, J., Linton, J., Tsong, J., & Link, J. *L.A. Creek Freak*. Retrieved from http://lacreekfreak.wordpress.com/

[15] Hundley, Norris. *The Great Thirst*. Berkeley: University of California Press, 2001. Print. Kil-Dong, Park. Seoul. Seoul Metropolitan Government.Cheonggyecheon Restoration Project. Seoul: Print.

[16] Ferguson, B. (2005). *Porous pavements: Integrative studies in water management and land development.* CRC Press.

[17] *Friends of the chicago river.* (2011). Retrieved from `http://www.chicagoriver.org/`

[18] *Friends of the los angeles river.* (2011). Retrieved from `folar.org`

[19] Goffard, C. (2009, Nov 24). Fear sets up camp on a stretch of the l.a. river. *Los Angeles Times*. Retrieved from `http://articles.latimes.com/2009/nov/24/local/la-me-river-killings24-2009nov24`

[20] Gottlieb, Robert. *Reinventing Los Angeles : Nature and Community in the Global City*. Cambridge, MA, USA: MIT Press, 2007. p 130.

[21] *The guadalupe river park conservency*. (2011). Retrieved from `http://www.grpg.org`

[22] Gumprecht, Blake. *The Los Angeles River: Its Life, Death, and Possible Rebirth.* Baltimore: The Johns Hopkins University Press, 2001. Print.

[23] Kim, N. (2005). Ecological restoration and revegetation works in korea. *Landscape Ecology Engineering*, 77(1), 77-83.

[24] Legret, M., & Colandini, V. (1999). Effects of a porous pavement with reservoir structure on runoff water: Water quality and fate of heavy metals. *Water Science Technology*, 39(2), 111-117.

[25] Los Angeles Ad Hoc Committee on the Los Angeles River. City of Los Angeles Department of Public Works, Los Angeles Ad Hoc Committee on the Los Angeles River. (2007). *The los angeles river revitalization master plan*. Retrieved from website: `http://www.lariver.org/5.1a_download_publications_LARRMP.htm`

[26] Mazer, G., Booth, D., & Ewing, K. (2001) Limitations to vegetation establishment and growth in biofiltration swales. *Ecological Engineering*, 17 (4), 429-443, Available at: `http://www.sciencedirect.com/science/article/pii/S0925857400001737`

[27] McPhee, John. *The Control of Nature*. Harper Collins, 1989. Print.

[28] Medina, J. (2011, Aug 25). Los angeles river tries on new role, as waterway. New York Times. Retrieved from `http://www.nytimes.com/2011/08/26/us/26river.html?_r=1`

[29] "Mission Reach." San Antonio River Improvement Project. San Antonio River Authority, 2011. Web. 15 Oct 2011. Retrieved from `http://www.sanantonioriver.org/mission_reach/ecosystem_restoration.php`.

[30] Mount, Jeffrey. *California Rivers and Streams: The Conflict Between Fluvial Process and Land Use*. Berkeley: University of California Press, 1995. Print.

[31] Nakamura, K., Tockner, K., & Amano, H. (2006). "River and Wetland Restoration: Lessons from Japan." *BioScience*, 56 (5) 419-429. Web. 15 Oct. 2011.

[32] Nakano, D. (2008). River restoration for macroinvertebrate communities in lowland rivers: insights from restorations of the shibetsu river, north japan. *Landscape Ecology Engineering*, (4), 63-68.

[33] Nienhuis, P., & Leuven, R. (2001). River restoration and ood protection: controversy or synergism?. *Hydrobiologia*, 444, 85-99.

[34] Palmer, Margaret A, and Solange Filoso. (2009) "Restoration of Ecosystem Services for Environmental Markets." *ScienceMag*. 325.: 575-576. Web. 15 Oct. 2011.

[35] Park, K. Seoul Metropolitan Government, (2006). *Cheonggyecheon restoration project.* Seoul:

[36] Paul, M., & Meyer, J. (2001). Streams in the urban landscape. *Annual Review Ecological Systems*, 32, 333-65.

[37] Platt, Rutherford H, Rowan A Gowntree, and Pamela C Muick. Ed. The Ecological City: Preserving and Restoring Urban Biodiversity. University of Massachusetts Press, 1994. Print.

[38] Port of Long Beach. (2011). *Facts at a glance.* Retrieved from `http://www.polb.com`

[39] Price, J (2008). "Remaking american environmentalism: On the banks of the l.a. river, *Environmental History* (13) 536-55.

[40] Orsi, J. (2004). *Hazardous metropolis: flooding and urban ecology in los angeles.* University of California Press.

[41] Recent Research Findings: Health Effects of Particulate Matter and Ozone Air Pollution, California Air Resources Board, January 2004

[42] Sahagun, L. (2010, July 08). L.a.'s river clears hurdle. *Los Angeles Times.* Retrieved from `http://articles.latimes.com/2010/jul/08/local/la-me-Compton-Creek-20100708`

[43] Santa Monica Bay Restoration Commission. *Culver city rainwater harvesting program.* Retrieved from `http://ballonawatershed.org/`

[44] Schumm, S. (1985). Pattern of alluvial rivers. Annual Review Earth Planet, 13, 5-27.

[45] Sheng, J., & Wilson, J. (2009). Watershed urbanization and changing ood behavior across the los angeles metropolitan region. *Natural Hazards*, (48), 41-57.

[46] Shuster, W. D., R. Gehring, and J. Gerken (2007) ."Prospects for enhanced groundwater recharge via infiltration of urban storm water runoff: A case study." *Journal Of Soil & Water Conservation* 62, (3), 129-137.

[47] "Thirty-seven on death list in record 8.27-inch deluge: Upward of Thirty-five Injured During Downpour, Thousands of Men Put to Work Removing Wreckage Left in Wake of Torrents, Los Angeles Times, January 2, 1934, p. 1. Available at: `http://pqasb.pqarchiver.com/latimes/access/3931148`

[48] *Urban waters federal partnership.* (2011, Nov 23). Retrieved from `http://www.urbanwaters.gov/`

[49] Yang, H., McCoy, E., Grewal, P., & Dick, W. (2010) Dissolved nutrients and atrazine removal by column-scale monophasic and biphasic rain garden model systems. *Chemosphere*, 80, (8),929-934. Available at `http://www.sciencedirect.com/science/article/pii/S0045653510005977`

[50] Zavis, A. (2010, Dec 14). Homeless encampment along l.a. river broken up. Los Angeles Times. Retrieved from `http://articles.latimes.com/2010/dec/14/local/la-me-homeless-20101214` 5