REJUVENATING, REVIVING AND RESTORING THE BURIED, IGNORED AND NEGLECTED 'URBAN WATER STREAMS'

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ABSTRACT

Urban Water Streams provide a wide array of benefits to communities, such as nutrient and pollution removal, groundwater recharge, and flood mitigation. Largely unnamed and mostly absent from maps, these critical small streams suffer from a lack of visibility. Being unnamed, however, doesn't lessen their importance. In fact, due to their small size and dominance within the stream network, they offer the greatest opportunity for groundwater exchange between the water and land, serving as critical connections with the terrestrial environment. Scientific research has consistently demonstrated that healthy headwater systems provide crucial downstream community benefits including clean water, flood control, and water supply, yet we routinely destroy these streams as part of the land development process.

Unplanned land development, from suburban subdivisions to urban city centers, threatens small, headwater streams and their associated ecosystems. Suburban development often channelizes or buries small streams.

Destruction of small headwater streams has already impacted many communities resulting in less reliable sources of clean water and potential for increased flooding. Cities and their residents are now reviving these once buried ecosystems and restoring them to vital community assets. The new approach of 'day lighting' streams promises to improve stream health and improve community livability as well.

Key words: *Day lighting, Urbanization, Urban Water Streams, Urban Water Management*

1 INTRODUCTION

The state of water resources in the country is perilous, but India's water crisis has been in the making for a long time.

The per capita availability of fresh water has declined sharply from 3,000 cubic metres to 1,123 cubic metres over the past 50 years. The global average is 6,000 cubic metres.

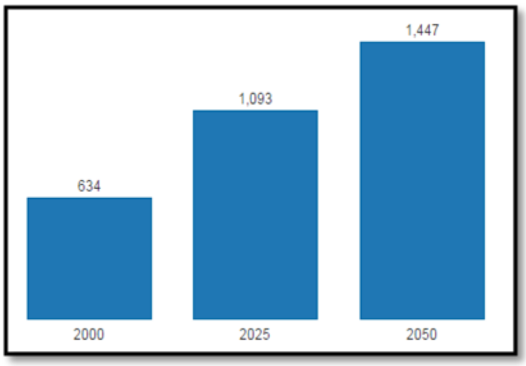

Figure 1: Growing water demand leading to growing water scarcity

(Source: Central Water Commission)

The demand supply mismatch is more severe in certain areas. In urban areas, where the demand of 135 litres per capita daily (lpcd) is more than three times the rural demand of 40 lpcd, the scarcity assumes menacing proportions. Already, Delhi and Chennai are fed with supply lines stretching hundreds of kilometres. According to projections by the UN, India's urban population is expected to rise to 50% of the total population by 2050. This would mean 840 million people in the most water-starved parts of the country compared with 320 million today. The issue of inequity in water availability has already proved to be fertile ground for several inter-state and intra-state disputes, and unless mitigating steps are taken now, these conflicts would only escalate.

By 2050, energy generation is set to assume a much larger proportion of water usage. This should further nudge India towards renewable resources since thermal power plants are highly water-intensive and currently account for maximum water usage among all industrial applications.

In order to match rapidly increasing demand, India needs to make judicious use of its two sources of fresh water — surface water and groundwater. Surface water — with rivers as its main source — is being relentlessly utilized through dams. These dams have robbed some rivers of their usual water flow, while diverting the course of others.

As much as 55% of India's total water supply comes from groundwater resources, which is also a cause of concern. Unbridled exploitation by farmers has led groundwater levels to plummet dangerously across large swathes of the countryside. Groundwater is critical to India's water security. Irrigation, of which over 60% comes from groundwater, takes up over 80% of total water usage in India. Besides, nearly 30% of urban water supply and 70% of rural water supply comes from groundwater.

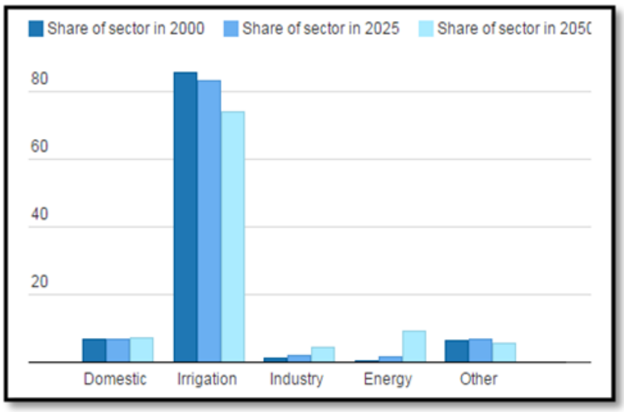

Figure 2 (left): Irrigation dominates water usage (Source: Central Water Commission)

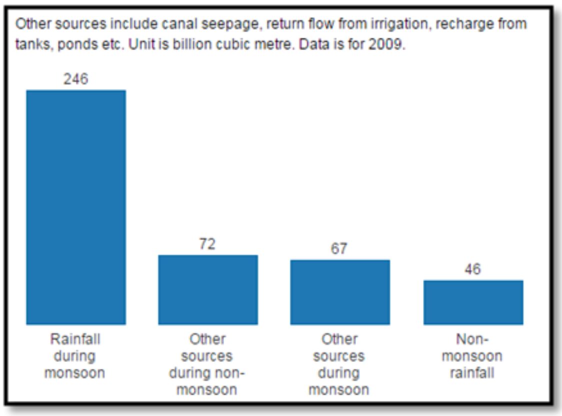

Figure 3 (right): Monsoonal rainfall is the lifeline for India's groundwater

(Source: Central Ground Water Board)

While India is blessed with some of the largest river systems in the world, a significant part of this water is rendered unavailable for use due to natural circumstances. For example, Brahmaputra has the highest total water potential of all rivers in India, but only about 4% of this can be successfully used because the mountainous terrain through which it flows makes further extraction impossible. Of the total potential of nearly 1,900 billion cubic metres (bcm) in India, only about 700 bcm can be utilized. The use of surface water is also affected by dams. With over 5,000 dams, India is behind only China and US on this count. While facilitating irrigation and electricity generation, the dams are adversely affecting water quality in the country.

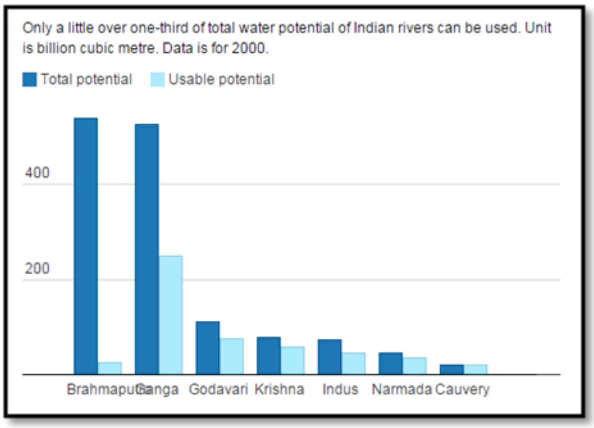

Figure 4 (left): Water-carrying potential of India's rivers (Source: Central Water Commission)

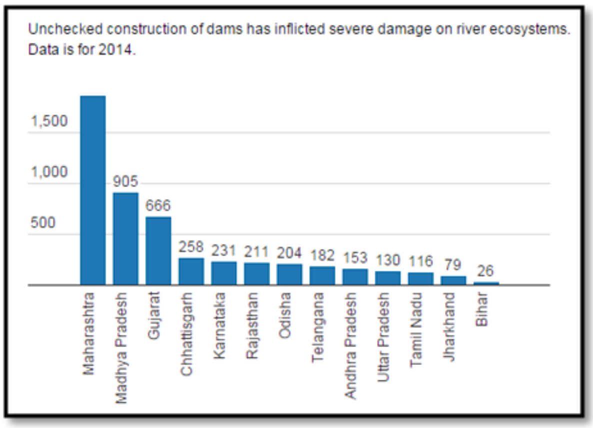

Figure 5 (right): India has the 3rd highest number of dams in the world (Source: Central Water Commission)

Several scientific studies, including one by the United Nations Environment Program in 2001, emphasize that dams have two main adverse effects on rivers. First, dams alter the chemical content and temperature of water. Water stored by dams has a temperature distinctly different from the rest of the river, and being stagnant, picks up unwanted things such as sand, besides encouraging algal bloom. Second, dams reduce the natural quantity of water flowing through downstream areas.

II. STATUS OF INDIAN RIVERS

Most of the Indian rivers and their tributaries viz., Ganges, Yamuna, Godavari, Krishna, Sone, Cauvery Damodar and Brahmaputra are reported to be grossly polluted due to discharge of untreated sewage disposal and industrial effluents directly into the rivers. These wastes usually contain a wide variety of organic and inorganic pollutants including solvents, oils, grease, plastics, plasticizers, phenols, heavy metals, pesticides and suspended solids. The indiscriminate dumping and release of wastes containing the above mentioned hazardous substances into rivers might lead to environmental disturbance which could be considered as a potential source of stress to biotic community.

As for example, River Ganges alone receives sewage of 29 class I cities situated on its banks and the industrial effluents of about 300 small, medium, and big industrial units throughout its whole course of approximately 2525 kms. Identically Yamuna is another major river, has also been threatened with pollution in Delhi and Ghaziabad area. Approximately 5,15,000 kilolitres of sewage waste water is reported to be discharged in the river Yamuna daily. In addition, there are about 1,500 medium and small industrial units which also contribute huge amounts of untreated or partially treated effluent to the river Yamuna every day.

1.1 Pollution in the Ganga River

The Ganga Basin, the largest river basin of the country, houses about 40 percent of population of India. During the course of its journey, municipal sewages from 29 Class-I cities (cities with population over 1,00,000), 23 Class II cities (cities with population between 50,000 and 1,00,000) and about 48 towns, effluents from industries and polluting wastes from several other non-point sources are discharged into the river Ganga resulting in its pollution. The NRCD records, as mentioned in audit report, put the estimates of total sewage generation in towns along river Ganga and its tributaries as 5044 MLD (Million Litres per Day). According to the Central Pollution Control Board Report of 2001, the total wastewater generation on the Ganga basin is about 6440 MLD.

Many towns on the bank of the Ganga are highly industrialized. Most of the industries have inadequate effluent treatment facilities and dump their wastes directly into the river. A high concentration of tanneries in Kanpur has further aggravated the situation. Besides other chemical and textile industries, Kanpur has 151 tanneries located in a cluster at Jajmau along the southern bank of the Ganga with an estimated waste water discharge of 5.8 to 8.8 million litres per day. Out of 151 tanneries in Jajmau, 62 tanneries use exclusively the chrome tanning process, 50 tanneries use vegetable tanning processes, and 38 tanneries use both chrome and vegetable tanning. The Indian government under the Ganga Action Plan (GAP) has implemented several schemes for the abatement of pollution of the Ganga by tanneries. However, there are violations of the pollution control measures, and tannery effluents are still found in the river.

1.2 Pollution in the Yamuna River

River Yamuna is the primary source of drinking water for Delhi, the capital of India, and also for many cities, towns and villages in the neighboring states of Uttar Pradesh, Uttaranchal and Haryana. In the last few decades, however, there has been a serious concern over the deterioration in its water quality. The river has been receiving large amounts of partially treated and untreated wastewater during its course, especially between Wazirabad and Okhla, National Capital Territory (NCT) of Delhi. Pollutants flowing into the river are contributed from the waste of the cities situated along its bank.

Yamuna river water is behind death of ghariyals in the Chambal Sanctuary. Chambal lost over 100 ghariyals in the last 72 days to a mysterious toxin released, in all possibility, by its very own sanctuary – the river Yamuna

If London is famous for beauty of its river the Thames, Delhi is known for pollution of the Yamuna River. Once the lifeline of Delhi, Yamuna has now became the most polluted water resource of the country. It now looks like a sewer.

From big industries and factories to people living in big colonies, slums and rural areas, all pollute the river with impunity because of untreated water. Increasing pollution of the Yamuna has now become an international issue and a cause of concern for environmentalists.

1.3 Impact of River water pollution

The pollutants include oils, greases, plastics, plasticizers, metallic wastes, suspended solids, phenols, toxins, acids, salts, dyes, cyanides, pesticides etc. Many of these pollutants are not easily susceptible to degradation and thus cause serious pollution problems. Contamination of ground water and fish-kill episodes are the major effects of the toxic discharges from industries. Discharge of untreated sewage and industrial effluents leads to number of conspicuous effects on the river environment. The impact involves gross changes in water quality viz. reduction in dissolved oxygen and reduction in light penetration that's tends loss in self purification capability of river water. [1]

III. URBAN WATERSHED

It doesn't matter how far you live from a stream, river, or lake, you live in a watershed. Everyone resides in a watershed. A watershed is an area of land from which all water drains, running downhill, to a shared destination - a river, pond, stream, lake, or estuary. A watershed is a catchment basin that is bound by topographic features, such as ridge tops.

A watershed has three primary functions:

First, it captures water from the atmosphere. Ideally, all moisture received from the atmosphere, whether in liquid or solid form, has the maximum opportunity to enter the ground where it falls. The water infiltrates the soil and percolates downward. Several factors affect the infiltration rate, including soil type, topography, climate, and vegetative cover. Percolation is also aided by the activity of burrowing animals, insects, and earthworms.

Second, a watershed stores rainwater once it filters through the soil. Once the watershed's soils are saturated, water will either percolate deeper, or runoff the surface. This can result in freshwater aquifers and springs. The type and amount of vegetation, and the plant community structure, can greatly affect the storage capacity in any one watershed. The root mass associated with healthy vegetative cover keeps soil more permeable and allows the moisture to percolate deep into the soil for storage. Vegetation in the riparian zone affects both the quantity and quality of water moving through the soil.

Finally, water moves through the soil to seeps and springs, and is ultimately released into streams, rivers, and the ocean. Slow release rates are preferable to rapid release rates, which result in short and severe peaks instream flow. Storm events which generate large amounts of run-off can lead to flooding, soil erosion and siltation of streams.

Ultimately, the moisture will return to the atmosphere by way of evaporation. The hydrologic cycle (the capture, storage, release, and eventual evaporation of water) forms the basis of watershed function.

A watershed should be managed as a single unit. Each small piece of the landscape has an important role in the overall health of the watershed. Paying attention primarily to the riparian zone, an area critical to a watershed's release function, will not make up for lack of attention to the watershed's uplands. They play an equally important role in the watershed, the capture and storage of moisture. It is seamless management of the entire watershed, and an understanding of the hydrologic process, that ensures watershed health.

IV. EFFECTS OF URBANIZATION

Almost eighty percent of our country's population resides in metropolitan areas. Many city residents think of natural areas in a wilderness context. However, as cities spread outward, more and more streams, especially small creeks feeding directly into lowland rivers, are transformed into urban streams. These natural areas are perhaps the most neglected watercourses.

An urban creek may experience many things on its journey from its headwaters in the upper watershed to its mouth at the confluence of a larger creek, stream, or river. It may pass through a park or residential area in one reach, then flow past a shopping mall or industrial park the next. In a small, steep, wooded canyon behind a residential area, it may become a convenient place to dump grass clippings or garbage. It may pass through vacant lots, becoming lost among the discarded appliances, shopping carts, and tires. It may follow-through an over-fertilized golf course. It may flow for long distances inside a culvert underground. It may receive storm water run-off from oily roads, parking lots, and factory drainage ditches. Uninformed neighbors may even dump used motor oil or antifreeze into storm drains that empty directly into the stream.

There are countless threats to water quality and habitat due to urbanization. The urban environment contributes 11.8% of nonpoint source pollution into the nation's waters. Impacts result from residential, transportation, commercial and industrial land uses. Specific impacts include toxic substances that enter the food chain, petroleum products that are harmful to plants, fish, and wildlife; excessive nutrients that increase algal blooms; and a reduction of water quality.

New development Run-off from developing areas creates problems regarding both water quality and quantity. Earth moving during construction contributes sediment to the run-off. Construction alone contributes 3.3% of the nation's nonpoint source water pollution.

Once buildings and pavements are introduced, less water is able to penetrate the soil to be filtered of contaminants such as automobile by-products, pesticides, fertilizers, and excess sediment. Not only is the land less able to filter such contaminants, but increasing numbers of people produce a greater pollutant load.

The clearing of vegetation decreases a watershed's capacity to capture moisture, increasing the amount run-off. The loss of vegetation also destabilizes stream banks vegetation and reduces the shade produced by the canopy.

1.4 Impervious Surfaces

As a watershed area becomes more populated, natural surfaces, that absorb water and recharge ground water supplies, are covered with hard, impervious surfaces (streets, sidewalks, rooftops, driveways, and parking lots). Conversion from predominantly vegetated land use to urban uses may result in tremendous reductions in watershed's absorption capacity.

1.5 Flash Flooding

The traditional approach to run-off has been to remove it as quickly as possible from developed areas. The cumulative result of such changes throughout the watershed is an increase in the volume of run-off to streams, wetlands, and rivers. The increased volumes of run-off also travel more quickly to surface waters, which in turn produce higher peak flows and velocities. Flooding may occur as flows exceed natural, designed, or available system capacities, threatening homes and businesses located along the stream.

1.6 Stream Alteration

Streams also suffer consequences from changes in peak water volumes and flows. Streams are always in a process of change, but human actions can accelerate the rate of change. As development in the watershed occurs, the flows associated with storm events increase. The stream low flow channel will erode to accommodate the increased flows becoming wider or deeper.

1.7 Run off Pollution

Storm induced urban run-off carries pollutants from roadways, yards, parking lots, storage areas, and flows directly into streams via storm drains and ditches. Up to ninety percent of the atmospheric pollutants, deposited on impervious surfaces, are delivered to receiving streams.

1.8 Bank Erosion

Run-off can erode land and carry sediment into streams. Erosion reduces the value of property, and the resultant sediment loads streams, degrading the stream's water quality, fish habitat, and diversity of macro-invertibrate. Larger sediment particles may clog spawning gravels. Sediments also reduce the hydraulic effectiveness of the surface water system as they settle into ditches, creek beds, and culverts.

1.9 Pollution (Point and Non Point Source)

Pollutants such as oil, gas, fertilizers, and pesticides carried with run-off can adversely affect fish, wildlife, plants, and may impact drinking water supply. Pollutants that originate from one source, like a sewage treatment plant, are known as point source pollutants. Point source pollution is regulated at the local, state, and federal level. Some examples of point source pollution include municipal, industrial, and commercial wastewater discharge; combined sanitary sewage and stormwater overflows; discharges from confined animal feedlot operations; and urban storm sewer discharges.

Pollutants that originate from diffuse sources are known as nonpoint source pollutants. Nonpoint sources are the most significant source of water pollution. Some examples of nonpoint source pollution include sedimentation from logging operations; chemicals and fertilizers from agricultural operations; oil, toxic chemicals, and heavy metals from commercial and industrial operations. Cumulative effects from residential activities are also significant nonpoint source pollutants, including household chemicals, paints and solvents; fertilizers, pesticides and herbicides used on gardens and lawns; nutrients and fecal matter from septic systems and domestic animals; and metals and toxins from wash water, oil, antifreeze, transmission and brake fluids; and fuel from automobile maintenance.[2]

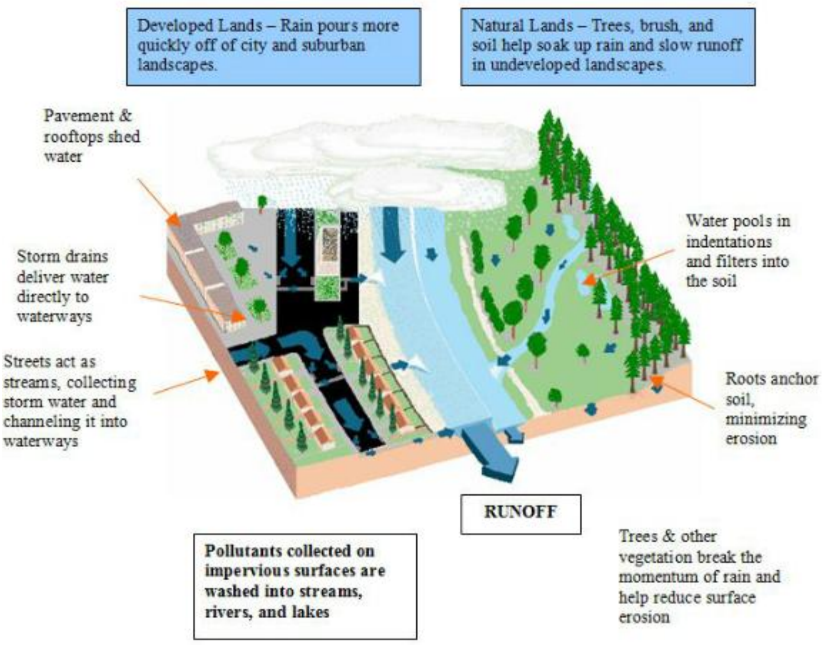

Figure 6: Natural Lands v/s Developed Lands

V. WATERSHED MANAGEMENT

Watershed residents can be the "watchdogs" of the watershed, reporting occurrences of flooding, contamination, and illegal dumping. Residents are also in the best position to act as stewards of their watershed; they can help monitor water quality and enhance wildlife habitat. At the national level, citizens can establish groups to protect and restore watersheds.

When beginning to define one's watershed, it is helpful to:

- Identify watershed boundaries;
- Identify water bodies showing visible signs of point or nonpoint source pollution (erosion, siltation, etc.);
- Identify water bodies and aquifers or recharge zones
- Identify current land uses in the watershed

Identify critical areas

Two types of critical areas occur in every watershed: areas adjacent to or near the water body and areas that may contribute large amounts or high concentrations of pollutants to the watershed irrespective of their location. The following critical areas should be considered:

- Areas adjacent to a water body
- Areas within 1/4 mile of a water body
- Areas that contain direct discharges to a water body (pipes, ditches, tanks)
- Areas that have intense land use patterns
- Areas that are used for higher-risk purposes
- Geologically vulnerable areas (unstable soils, steep slopes, etc...)[3]

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VI. CASE STUDIES

1.10 Rejuvenation of Arvari River

Arvari, a small river in the Alwar district of Rajasthan state was revived after years of drought had caused it to become a monsoon drain.

The river had disappeared in 1940s, and was revived in 1997 through the efforts of TBS.

Tarun Bharat Sangh (TBS) is a non-governmental organization in Rajasthan. It is directed by Rajendra Singh (Waterman of India) and best known for doing ecological research and land development to provide clean water to people.

First, a small Johad was constructed in a village Bhaota and to this date, there are 375 Rain Water Harvesting Structures in its catchment area.

Due to increased recharge & controlled discharge river "ARVARI" is now perennial.

1.11 Daylighting Saw Mill River, Yonkers, New York

Daylighting is a potential tool to restore small streams and community benefits in urbanized areas.

Daylighting projects expose some or all of a previously covered river, stream, or stormwater drainage. Daylighting exists in several forms including:

- **Natural restoration** – restoring a stream to natural stream conditions;
- **Architectural restoration** – restoring a stream to open air, flowing water but within a constructed channel; or
- **Cultural restoration** – celebration of a buried stream through markers or public art used to inform the public of the historic stream path, although the stream remains buried.

Although all of these types of daylighting have potential benefits, natural restoration will be most effective overall for flood mitigation, water quality, and stormwater control.

The Saw Mill River, which flows through Westchester County before emptying into the Hudson River in Yonkers, was buried in the 1920's in response to Yonkers' development and rapidly expanding population. Through the 1990's, pollution levels in the Saw Mill River were high due in part to its industrial past, rampant illegal dumping, and sewage overflows during flooding events.

Research conducted by U.S. Geological Survey found the stream contained the highest concentration of metals from all sites measured in the National Water Quality Assessment Program. Yonkers received $250,000 from the U.S. EPA Brownfield Program to daylight the river and redevelop an associated downtown brownfield site.

- The Saw Mill River daylighting project was initiated in December 2010 in Yonkers, New York. The project created 13,775 square feet of aquatic habitat.
- Plantings were also made along the floodplain and within the stream to attract insects beneficial to the American eel and various Hudson River fish.
- The daylighting of Saw Mill River was the centerpiece of revitalizing the space for hosting outdoor ecological workshops and musical performances as well as a providing a reading area and wireless internet, all of which incentivize residents to come downtown.
- The daylighting project has also sparked a downtown revitalization project with plans for a new minor league ballpark and new housing and retail development.

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- The daylighting was completed in December 2011 with a cost of $19 million. A natural river now parallels an old underground Army Corps of Engineers flume; the existing flume serves as an overflow channel to protect downtown from flooding.

Before proceeding with a daylighting project, however, cities should think about how best to engage the community. Many citizens likely have no knowledge that buried streams even exist in the area. Proper communication and education will ensure more meaningful results. Public interest can be enhanced by creating disappearing stream maps, which indicate paths of buried streams, as well as locations of remaining open space. Cities such as Oakland, California; Baltimore, Maryland; and Portland, Oregon, have prepared buried stream maps used for restoration, protection, and education efforts. These maps give citizens a sense of where streams exist within the community while emphasizing the sense of place within a watershed. Interest and approval are also peaked when citizens are involved from the beginning rather than as an afterthought.[4]

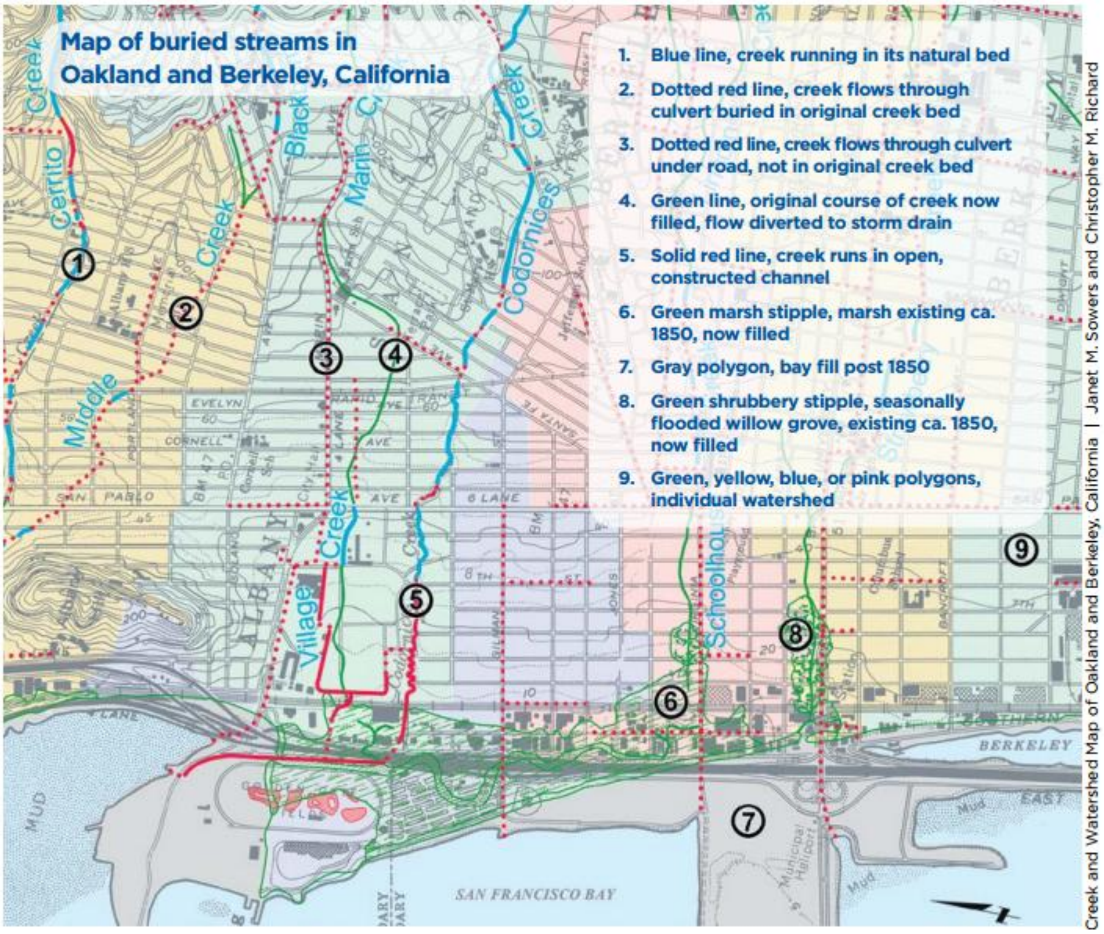

Figure 7: Creek and Watershed Map of Oakland and Berkeley, California

VII. CONCLUSION

Urban areas need a better approach towards urban planning where the land use planning is integrated with other inter related factors such as, watershed planning, storm water management, rainwater harvesting, environmental impact assessment, etc.

Till now, urban planners have mostly ignored our mother nature while assigning land uses to vacant undeveloped land parcels. Planners have just considered land while planning and not, water; there are numerous order, major and minor streams that flow naturally until there is no development over and around them. Once any human settlement occurs, all these natural streams are buried totally, blocked at various places or neglected and left for pollution and encroachments by humans.

Once these natural streams are blocked, various adverse effects like, water logging, flash flooding, water pollution, ground water depletion, etc. happen of which some are long lasting and can even be irreversible in future. And thus, all the natural drainage channels in the form of streams need to be first of all, restored wherever possible, then automatically there appears the scope to revive and rejuvenate not only the streams but even the surroundings. The areas around such revived streams also get upgraded in terms of land values, land beautification, air quality, increased ground water table, improved ground water quality, etc.

We all live in some or the other natural Watershed until we make changes to the natural topography and thus, it is very important to give due consideration to the natural setting before making any alteration in the natural area or before turning any area from undeveloped to developed or rural to urban.

LIST OF FIGURES

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