Strategies & Technologies to Address Litter within Integrated Urban Water Management

(Source: C. Marulanda)

Urban Water System

- In urban areas, rain and storm water enter drainage systems en route to rivers, bays, and oceans.
- Litter can clog drainage systems and impair water and waterways limiting reuse by downstream users.

Photo: Melbourne Water
https://www.melbournewater.com.au/getinvolved/education/Pages/Urban-water-cycle.aspx

https://www.melbournewater.com.au/whatwedo/manageflooding/Pages/Drainage-system.aspx

Sources of Urban Litter in Drainage Systems

Urban litter found in drainage systems can come from a variety of sources and take many forms

Domestic litter

Construction materials

Vegetative Litter

Other large litter

Economic Costs of Urban Litter on Drainage Systems

- Aesthetics (beaches, urban parks, etc.)

  Increase in visitations at beach
  - eliminating litter: 211%
  - eliminating parking fees: 51%

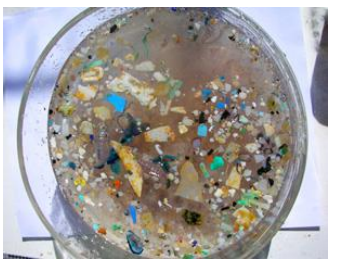
- Health hazards (e.g. rats in canals filled with garbage)
- Effects on water quality and ecosystem
- Flooding due to interference with workings of drainage system

- Costs for cleanup

  Costs for Long Beach California (2011)
  $2.2 million a year

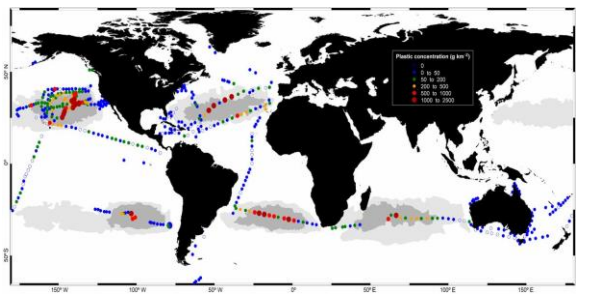
Global mpacts of Urban Litter on Drainage Systems-
Growing Concern over Global Accumulation

- Oceans are dynamic systems, with currents that coupled with wind and the earth's rotation, create "gyres"
- The gyres form slow rotating whirlpools in which plastic trash from drainage systems ultimately accumulate



(5gyres.org)

Concentration of Plastic Debris in Surface Waters



Andrés Cózar et al. PNAS 2014;111:10239-10244

Density of plastic is higher than density of marine debris. There's growing evidence. Severe challenges with cleanup and global issue.

Concentrations of plastic debris in surface waters of the global ocean. Colored circles indicate mass concentrations (legend on top right). The map shows average concentrations in 442 sites (1,127 surface net tows). Gray areas indicate the accumulation zones predicted by a global surface circulation model (6). Dark and light gray represent inner and outer accumulation zones, respectively; white areas are predicted as nonaccumulation zones. Data sources are described in *SI Appendix*, Table S1. Plastic concentrations along the Malaspina circumnavigation and a latitudinal gradient are graphed in *SI Appendix*, Figs. S4 and S5.

Impacts of Urban Litter on Drainage Systems-
A Little Goes a Long Way

- Melbourne Australia
  - <1% of total waste generation
  - 60,000 tons per year
- South Africa
  - 2% of total waste generation
  - 780,000 tons per year

~5-10 tons

< 1 ton

<< 1 ton

Bottle of a certain height and then estimated from size. Compare litter in all of Australia and all of South Africa - represent a small percentage of the total litter. A little goes a long way small volumes represented in the photos.

Factors Affecting Litter Composition & Quantity
Community characteristics

- Type of development
  - Commercial and industrial areas tend to produce higher litter loads than residential areas
- Density of development
  - Higher densities often generate higher litter loads
- Consumption habits of community
  - Access to consumer products affects generation of litter from products or containers
- Existence of litter intensive activities (ie, special events, tourism and construction activities).

(Rocinha, Brazil; Source: Tuesday_Morning)

This section provides a basic background of what affects this.

Factors Affecting Litter Composition & Quantity:
Relationship to solid waste and cleansing services

No services

Drainage system functions as disposal facility

Inefficient Services

Drainage system is a substitute for cleansing and collection

Efficient services

Drainage system is depository for litter.

Volume of litter in drainage system y-axis

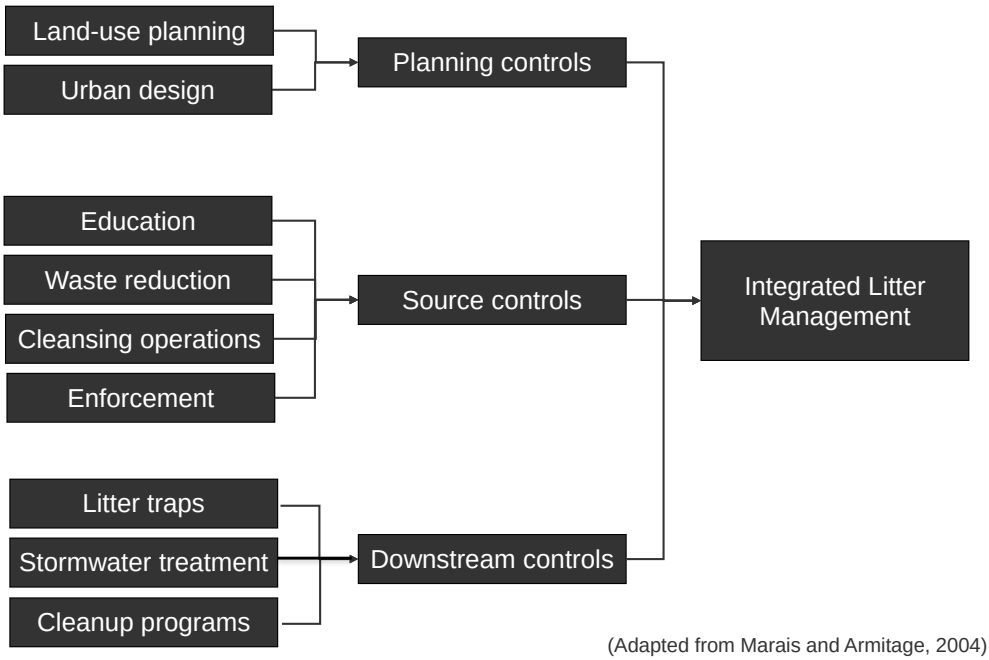
X-axis is degree of efficiency in services

Factors Affecting Litter Composition & Quantity
Climate and Catchment Characteristics

- Rainfall pattern
  - Litter will build in catchment until removed by cleanup operations or swept into drains by rain
  - Dry spells give greater opportunity to remove litter, but also result in heavy concentrations of litter sent down stormwater systems with first rains - “first flush”

- Type of vegetation in catchment area: Deciduous trees can interfere with drainage systems by contributing to litter collected in traps

Solving the Problem- Integrated Litter Management Strategy



(Adapted from Marais and Armitage, 2004)

Planning Controls

- Integrated planning of urban development and water services includes:
  - Protection of water quality and water resources, and
  - Controls that restrict litter-generating activities to areas where they can be effectively controlled and potential impacts can be reduced.
- Examples include
  - Preserving elements of natural stormwater system such as natural channels, wetlands, and riparian vegetation
  - Locating litter-generating activities in areas where it is easier to contain and control accumulation
  - Requiring pollution control measures as part of development activities

Source Controls – Educational Campaigns

- Educational campaigns increase public awareness of urban litter and improve public response to the problem
- Campaigns inform citizens how streets, drainage systems, rivers, and oceans are interconnected and how daily activities affect stormwater quality
- Their purpose is to inform and motivate households, commerce, industry, local government and law enforcement

https://nuhduttyupjamaica.org/nduj_garbage_3-1-2/
Nuh Dutty Up Jamaica is a public education campaign that aims to improve citizens knowledge about the impact of poorly handled waste on public health and the environment, while encouraging personal responsibility for the generation and disposal of waste. Nuh Dutty Up Jamaica, launched in February 2015, is one component of the Clean Coasts Project, led by the Jamaica Environment Trust (JET) with the support of the Tourism Enhancement Fund (TEF) and the Wisynco Group.

https://nuhduttyupjamaica.files.wordpress.com/2015/06/nuh-dutty-up-jamaica-talking-points.pdf

Source Controls - Waste Reduction

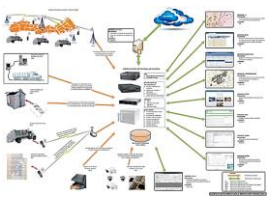
- Commerce and industry are ultimate source of litter:
  - Directly through generation
  - Indirectly through products that are sold
  - Indirectly through packaging
- Waste reduction efforts should focus on wastes that significantly affect a drainage system
- Bag or foam bans
- Fees for single use bags.
- Pollution taxes.
- Deposits for containers.

Styrofoam Ban, Sibu Municipal Council

Can your butts – from City of Long Beach
http://www.litterfreelb.org/home/butts_pilot_program.htm

Source Controls - Cleansing Operations Options

- Waste collection coverage and optimization
  - Collection coverage and frequency.
  - Optimization to ensure frequency meets volume
  - Specialized services (events, bulky waste)



- Containerization:
  - Household containers
  - Communal containers

Source: bcn.cat

- Better placement and design of public litter bins

Guayaquil, Ecuador (Source: C. Clark)

Source Controls - Street Sweeping Options

- Street cleaning coverage and optimization
  - Collection coverage and frequency.
  - Specialized services (historic areas, mechanical cleaning)
- Adjusting service to address litter in drainage:
  - Effectiveness requires street sweeping to be more frequent than significant rainfall events (>10mm)
  - Seasonal variation may require altering sweeping frequency during the year
  - Training of street sweepers (cleaning under vehicles, avoiding sweeping into drains).


(India)


gton, DC)


Mexico City

Another type of cleansing operation. Not swept into drains.

Source Controls - Enforcement Mechanisms

- Local authorities often have more pressing demands than enforcement of anti-litter legislation
- However, enforcement can create effective incentives for reducing litter
- Examples of cost effective litter enforcement include:
  - Cameras to capture litterers in the act
  - Volunteer litter patrols can take responsibility for cleaning neighborhoods
  - Website for shaming or reporting litterers
  - Publication of "pollution hot-lines" where telephone access is available can aid reporting of offenders

(Environmental Wardens, Jamaica)

(Leicester UK)

http://stpetersnm.com/litter_louts.html
http://www.newtownabbey.gov.uk/contactus/reportlittering.asp

According to the State of Washington Department of Ecology, while many support the use of enforcement, studies show that few jurisdictions are able to enforce littering laws effectively for two reasons:

(1) Lack of personnel available for such a low priority issue, and (2) The fact that it is difficult to "catch" offenders in the act.

Downstream Controls

- Physical barriers and removal mechanisms to prevent litter from clogging the drainage system and affecting the environment
- Effective controls as part of an IUWM approach enable use or reuse for various purposes downstream
- For combined sewer systems removal can be achieved at the wastewater treatment plant
- For separated sewer systems, litter must be trapped and removed along the sewer system prior to discharging to waterway

http://www.sweetwaterwetlands.org/about_us

Sweetwater Wetlands Park is a man-made wetland habitat of more than 125 acres. The park has several miles of trails and is teeming with plants and animals. It was designed to trap litter and debris at a sediment basin, and then improve water quality by filtering out pollution and nutrients though the wetlands. The park provides several environmental benefits, such as:

- Restoring the natural water flow to more than 1,300 acres of formerly drained wetlands in Paynes Prairie.
- Protecting and improving water quality in the Alachua Sink and the Floridan aquifer.
- Increasing the amount of conservation lands within Paynes Prairie Preserve State Park.

Downstream Controls - Catchpits

Downstream Controls - Litter Traps

(Source: J. Seltzer)

(Source: Ar[illegible]ge 2008)

(Source: Dredging systems)

Downstream Controls - Cleanup Measures

- Where planning controls, source controls, and other downstream controls have failed, cleanup efforts can directly remove litter from the environment
- Such efforts include:
  - Canal or drain cleaning
  - Beach or river cleanups
  - Direct removal from waterways via skimmer boats


(United Marine International)


(Afroz Shah via Twitter)

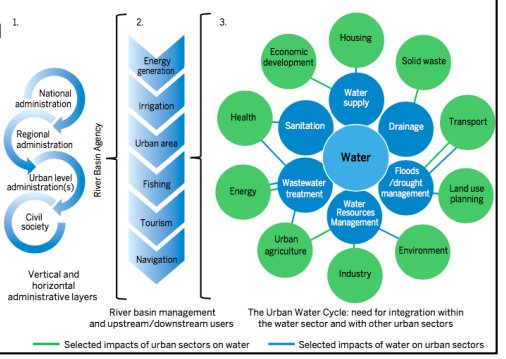

(Source: C. Marulanda)

Update with Afroz Shah pictures from Mumbai's Versova Beach – 21 month cleanup effort of 2.5 km of beach with 5.3 million kilograms of trash.

http://www.huffingtonpost.in/2016/09/13/this-mumbai-man-gave-versova-beach-a-makeover-by-cleaning-it-of_a_21470874/

Identifying Your Strategy: What is the goal?

- **How is uncontrolled litter impacting the urban environment and broader watershed?**
- **What negative effects does the community want to prevent?**
  - Flooding, aesthetics, environment, health, infrastructure functions
  - Are there upstream contributions?
  - Are there downstream complica



Understanding the Setting: Existing Management Profile

What are the major sources of garbage entering the system?

Types of activities: Is it residential, commercial, tourism, industrial or informal communities.

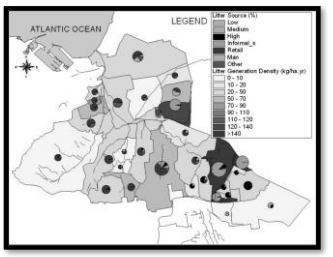
Is it specific types of waste: Is it construction debris, yard waste, plastic packaging or industrial waste?

What areas of the city: Are there certain geographic districts or populations?

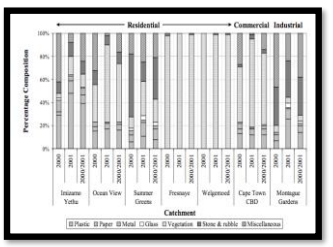
What are the reasons: dumping, inefficient collection or littering?

South Africa

Litter Generation



Litter Composition



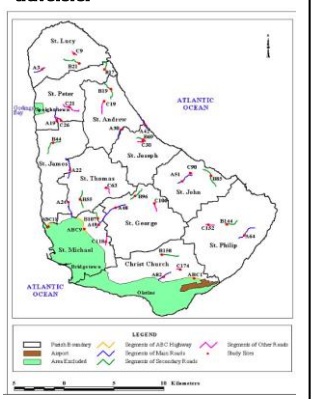
(Wise and Armitage 2004).

Barbados

Predominantly non-biodegradable plastic and paper.

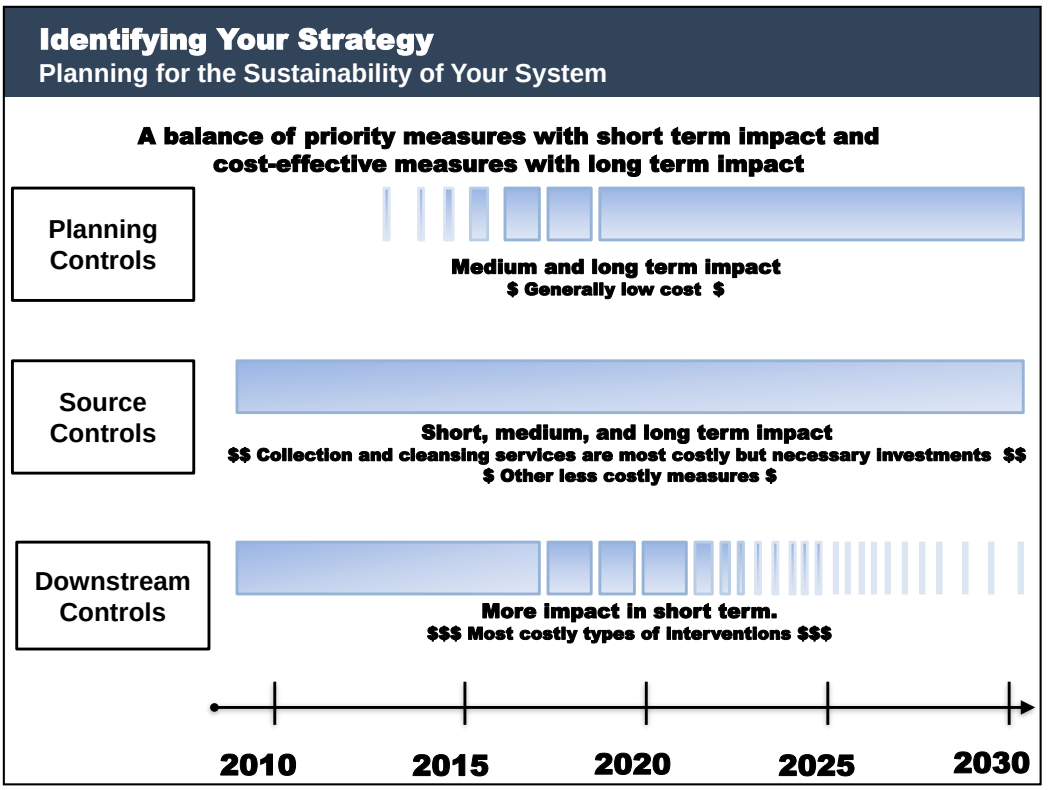
- **Plastic 59% by count, 13% by weight**
- **Paper 22% by count, 12% by weight**

Most common source is waste from food and beverages consumed by travelers.



At times I think (at least in our projects) the solution to the problem has been generically and conveniently identified as "better solid waste management" when in fact there are many solid waste interventions that have a marginal or no impact on garbage in drainage systems and some systems (Buenos Aires for example) that have 100% collection yet have a massive waste problem with their drainage system. On the other side there are places like Haiti that because of the absence of an operating solid waste management system the drainage system is the disposal system and therefore collection is the issue. My feeling is some more thought into this, teasing out the various situations and when it is SWM that matters, vs when litter management matters and when both matter might be useful to the discussion.

Surveys can be done - example of South Africa.



Balancing short term impact and cost-effective measures with long term impact

Other Key Issues

Identifying and Designing Cost-Effective and Functional Strategies

- **Rainfall patterns:** Many interventions are dependent on storm frequency and strength and will need to be catered to the program
- **Catering awareness campaigns and community involvement:** Ensuring awareness targets a communities concerns about litter and their incentives for involvement
- **Developing functional structural measures:** Careful choice and design of litter traps and other structural mechanisms will help ensure they are both effective and can be easily maintained
  - Detailed hydrologic analysis, costing, and pilot trials are often needed
- **Institutional capacity and mandates:** Effective measures will rely on a variety of agencies including drainage, solid waste, environment with NGOs effectively implementing programs
  - Proper mandate and capacity for each agency is necessary to effectively implement a given measure

Assessing the feasibility of the options in the table it's important to consider these additional factors.