Triple Bottom Line Analysis of Philadelphia's CSO Program

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What I Will Talk About

- Triple Bottom Line (TBL) Analysis
- Philadelphia Water Department's (PWD's) Combined Sewer Overflow (CSO) control program
- Methodology and assumptions
- Results
- Examples from other communities

TBL: The Economics of Sustainability

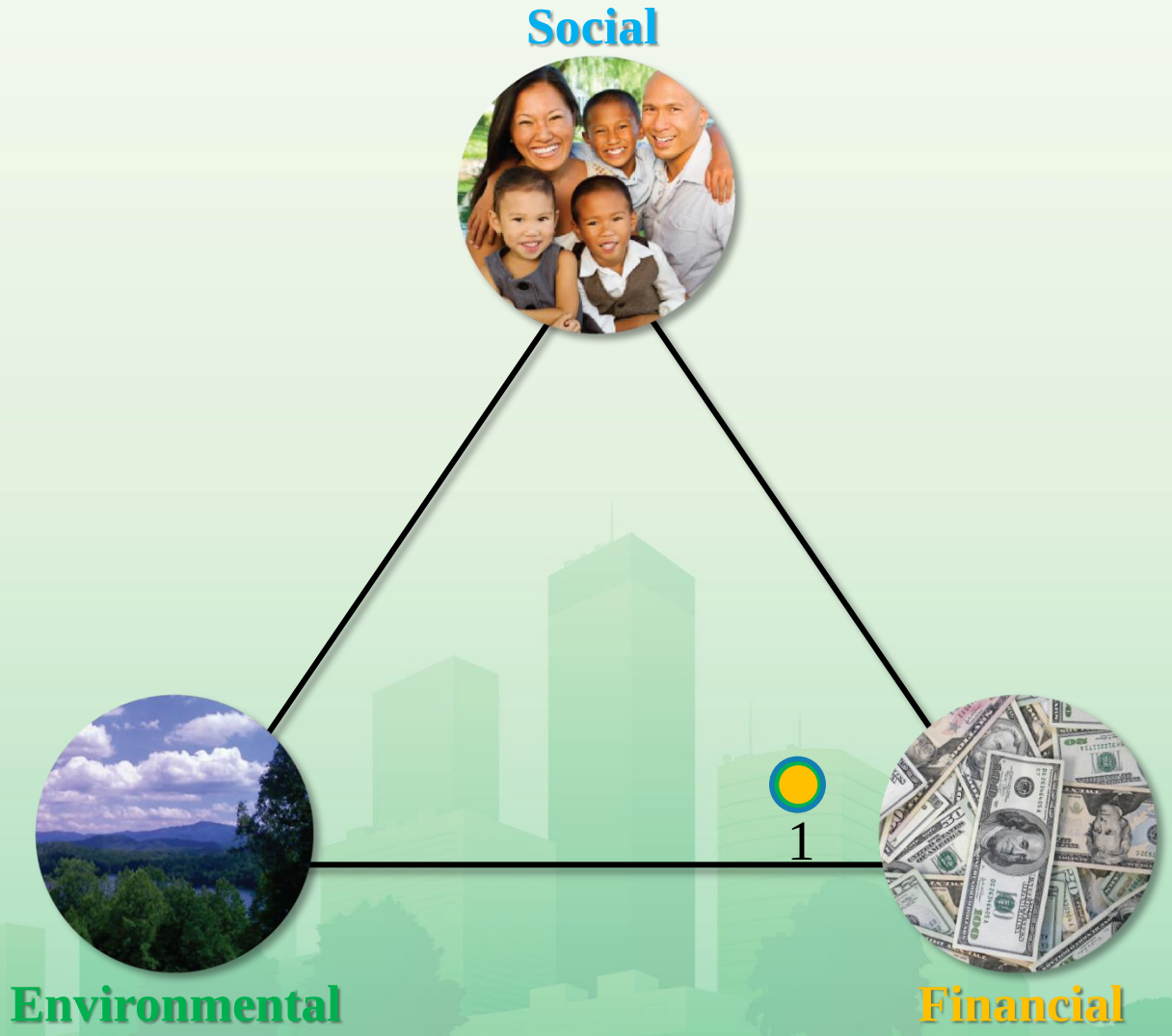
TBL = comprehensive benefit-cost analysis

- Identify and portray *all* benefits & costs
- Internal and external, market and nonmarket

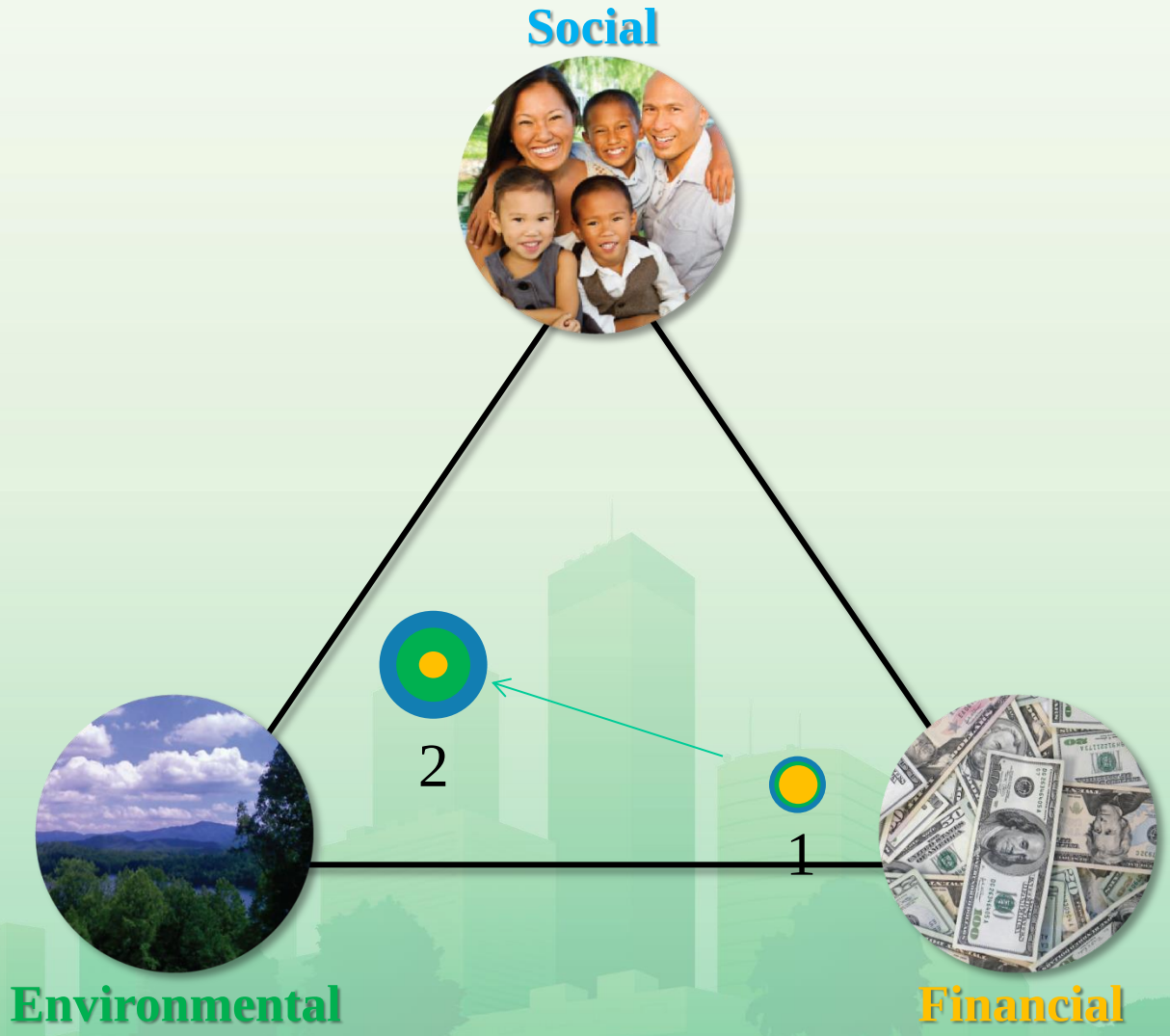
Three bottom lines, to reflect:

- **Financial** results
- **Social** outcomes
- **Environmental** benefits

Choosing Least Cost Option May Not Deliver Social and Environmental Benefits



Options that Meet Broader Goals May Increase Costs to a City, but Yield Larger Net Benefits



PWD CSO Control Program Alternatives

- Green hybrid approaches
  - LID with stream restoration
- Grey approaches
  - Tunneling
  - Transmission, Plant Expansion and Treatment
  - Transmission and Satellite Treatment
- 17 options

Green Infrastructure/LID Program Components

Four GI/LID alternatives (25%, 50%, 75% and 100%)

- Trees
- Green Streets
- Green roofs
- Bioretention areas
- Stream restoration
- Green space, urban parks
- Wetlands (created and restored)

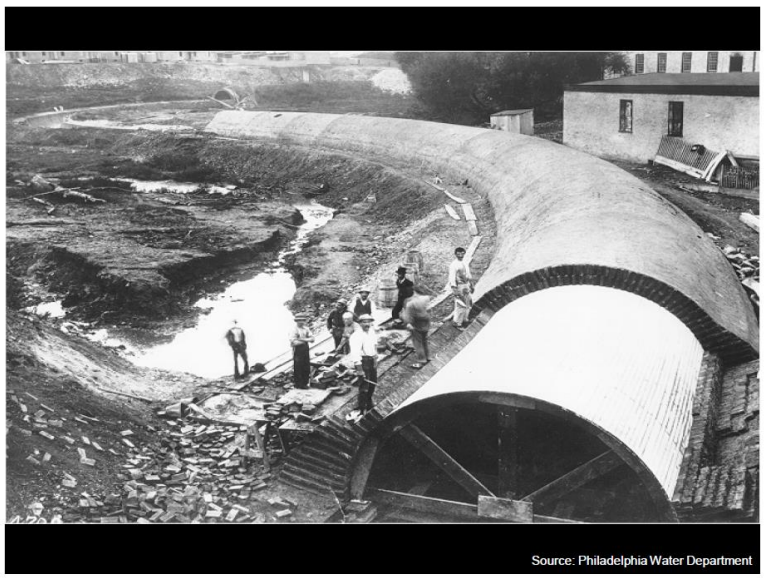
Scale of Implementation

50% LID

- 637,483 trees
- 402 acres green roofs
- 5,011 acres vegetated area
- 351,415 Heavy vehicle trips
- 149,768 Light vehicle trips
- 26,801kWhr of energy
- 193 acres of wetlands

30’ Tunnel

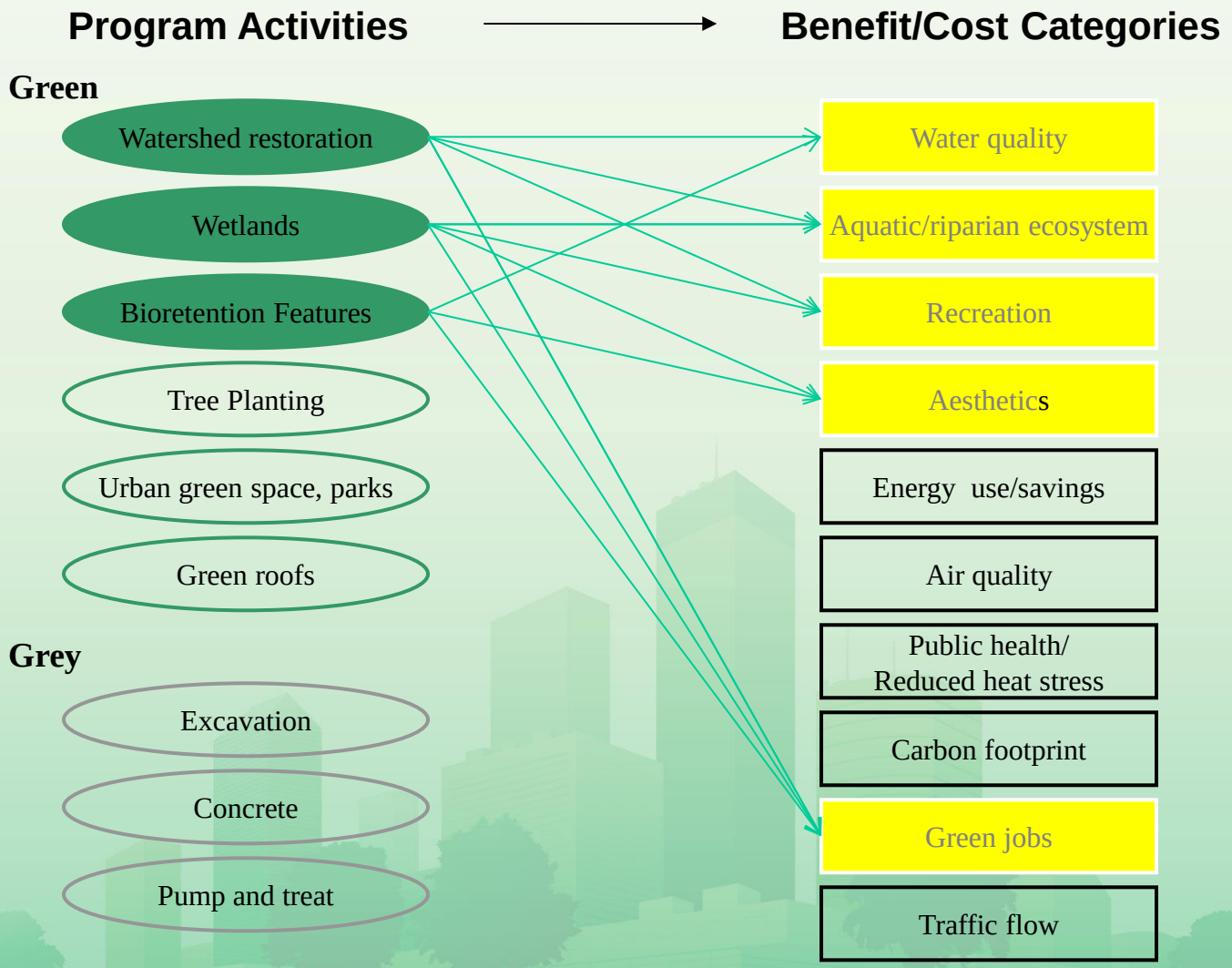
- 579,837 heavy vehicle trips
- 289,919 concrete truck trips
- 2.0 million kW-hr of energy
- 36.3 million cu ft concrete
- 11.2 million kW-hr of energy for pumping/treatment per year



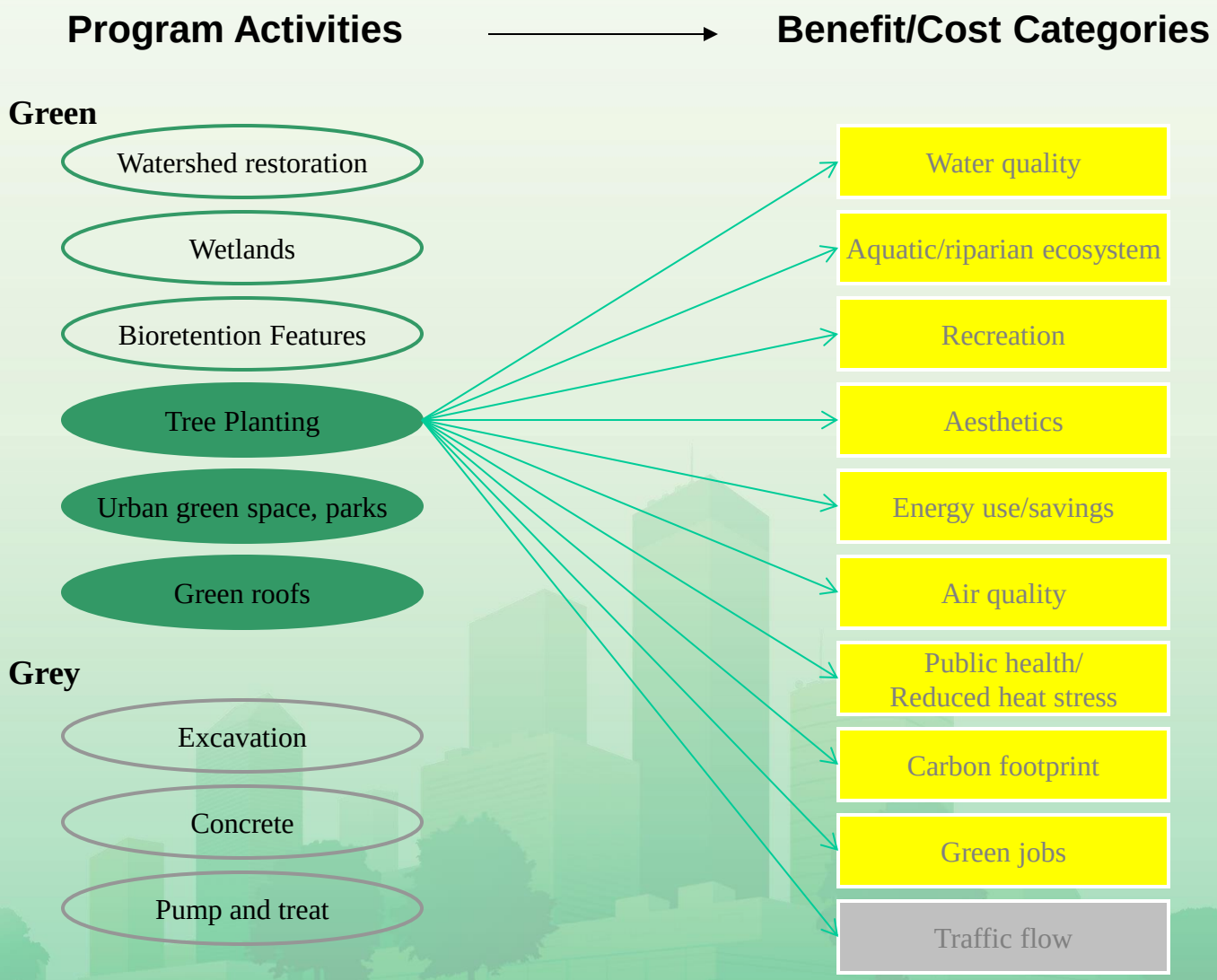
Methods and Assumptions

- Map program components to TBL outcomes
- External costs and benefits
- Standard economic approaches
- Present values over 40-years
- Physical and monetary units
- Omissions, biases, and uncertainties
- Sensitivity analyses

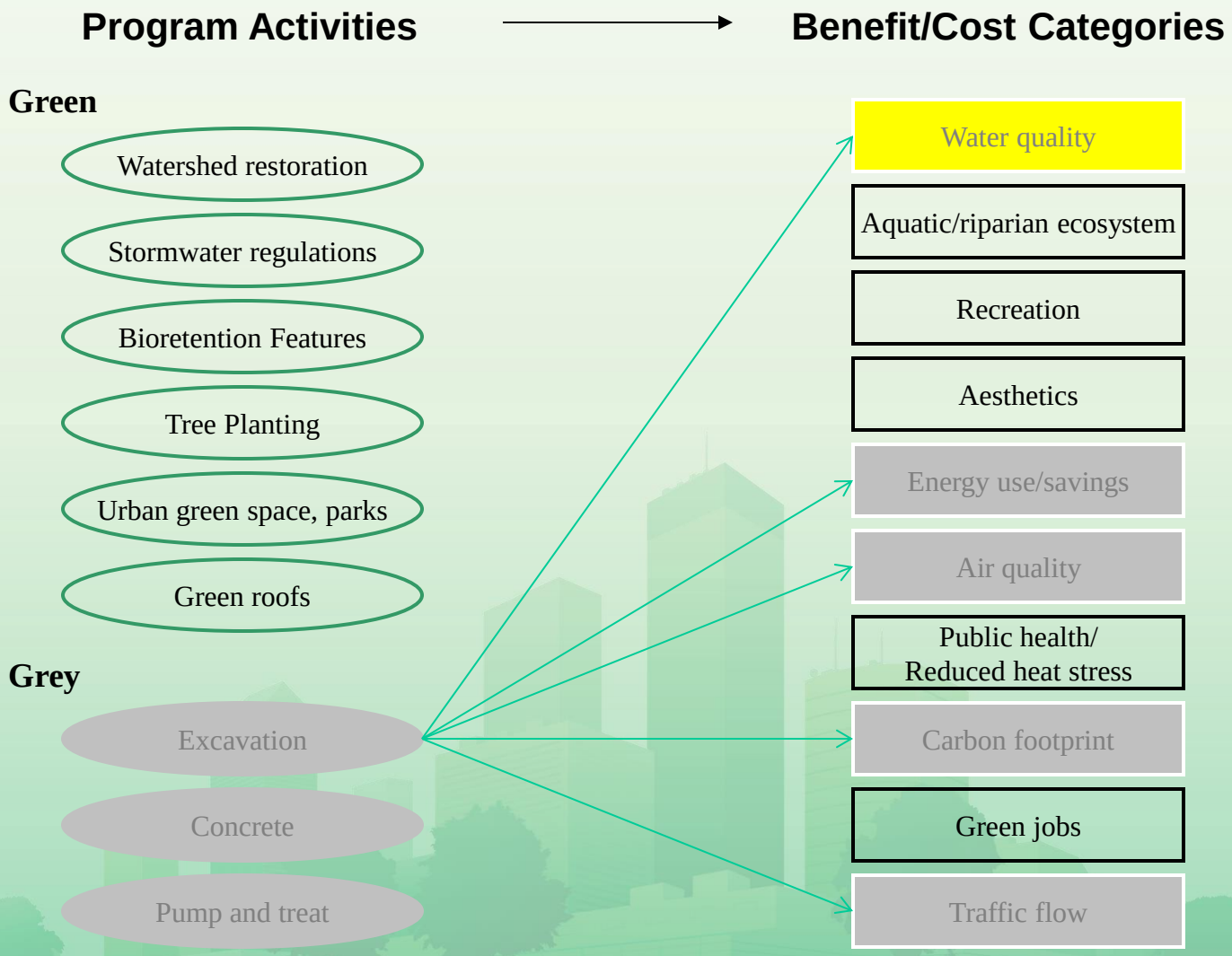
TBL Outcomes



TBL Outcomes



TBL Outcomes



TBL Benefit/Cost Categories

Social

- Recreation
- Green jobs
- Community livability
- Energy use/savings
- Public health/reduced heat stress
- Traffic flow

Financial

Green = Grey

Environmental

- Water quality and aquatic habitat
- Wetlands
- Carbon footprint
- Air quality

Recreation Benefits

- Benefits a function of additional *"user days"* and *"direct use value"*
- Analysis tailored to individual watersheds
- "Non-creek-side" and "creek-side" uses
- General park uses and specialized uses

Recreation Benefits (cont.)

- Non-creekside: 101.7 million new user days
- Creekside: 247.5 million new user days
- Visits to Fairmount Parks increase > 6% annually (average)

RECREACTIONAL BENEFITS =
$524.5 million

Community Livability/Property Value Benefits

- 2 - 5% increase applied to median home value
- # of affected properties corresponds to proportion of greened area
- Assumes 50% due solely to aesthetics

PROPERTY VALUE BENEFITS = $574.7 million

Urban Heat Stress Reduction

- Increased vegetation mitigates "urban heat island effect"
- Reduced deaths from Excessive Heat Events (EHEs)
- EHE-mortality calculated using mortality algorithms from existing work

Heat Stress Reduction Benefits (cont.)

- 196 lives saved
- EPA Value of Statistical Life ($7 million per life saved)

HEAT STRESS REDUCTION BENEFITS = $1,057.6 million

EPA/economists calculate the value of statistical life based on what people are willing to pay to avoid certain risks, and on how much extra employers pay their workers to take on additional risks. Most of the data is drawn from payroll statistics; some comes from opinion surveys.

Air Quality Health Benefits: Tree Pollutant Removal

- Based on USFS research in Philadelphia (PM_{10} and ozone)
- Tree planting schedule and average assumptions about tree growth
- EPA BenMap model estimates projected health impacts
- EPA methods to assess dollar value

Air Quality Health Benefits: Tree Pollutant Removal (cont.)

Health impacts avoided each year at full implementation:

- 1 to 2 premature deaths
- 1 heart attack
- 3 hospital admissions
- 250 days of work loss or school absence

HEALTH BENEFITS FROM TREE POLLUTANT REMOVAL = $131 million

Water Quality and Ecological Habitat Benefits

- Meta-analysis of “willingness to pay” (WTP)
- Scaled values for households outside City
- WTP = $9.70 to $15.54 per year per HH

WATER QUALITY BENEFITS = $336.4 million

Poverty Reduction from Local Green Jobs

- Grey and green generate different types of jobs
- Average annual cost of social services = $10,000 per unemployed worker
- 15,266 work years (380 jobs per year)

GREEN JOB BENEFITS = $124.9 million

Energy Savings Due to Cooling Effect of Trees

- Energy used for excavation, O&M, and fuel wasted in traffic delays
- Energy saved due to cooling effects
- Over 40-year period:
  - 490,000 gallons of fuel used
  - 600,000 kBtu natural gas saved
  - 370 million kWh of electricity saved

VALUE OF ENERGY SAVINGS
= $33.7 million

Air Pollutant Emissions Benefits

- Net reduction in emissions
  - 1,530 MT SOx
  - 38 MT NOx
- EPA valuation methods applied to value health benefit ($ per ton)

EMISSION REDUCTION BENEFITS = $46.3 million

CO_2 Emission Reduction Benefits

- Construction and O&M increase CO_2
- Reduced energy use and absorption by trees decrease CO_2
- 1.1 million MT net reduction
- Internationally recognized valuation approaches ($/ton) – Social Cost of Carbon

CARBON FOOTPRINT REDUCTION = $21.2 million

Construction-related Disruption

- Additional fuel use and emissions due to added time and distances
- Time lost due to longer travel times
- Total delay under 50% LID = 346,883 hrs

COSTS OF CONSTRUCTION DISRUPTION = $5.6 million

Summary of Results

City-wide physical unit benefits: Cumulative through 2049

Benefit categories	50% LID	30' Tunnel
Recreational user days	349,262,828	
Reduction in heat-related fatalities	196	
Annual willingness to pay (WTP) for water quality and aquatic habitat improvements	$9.70–$15.54	$5.63–$8.59
Wetlands created or restored (acres)	193	
Local green jobs (job years)	15,266	
Change in particulate matter ($PM_{2.5}$) due to trees ($\mu g/m^3$)	(0.01569)	
Change in ozone due to trees (ppb)	(0.04248)	
Electricity savings due to cooling effect of trees (kWh)	369,739,725	
Natural gas savings due to cooling effect of trees (kBtu)	599,199,846	
Fuel used (gallons)	493,387	1,132,409
Sulfur dioxide (SO_2) emissions (metric tons)	(1,530)	1,452
Nitrogen oxides (NO_x) emissions (metric tons)	(38)	6,356,083
Carbon dioxide (CO_2) emissions (metric tons)	(1,091,433)	347,970
Vehicle delay from construction and maintenance (hours)	346,883	796,597

Summary of Results

City-wide present value benefits (2009 million USD)

Benefit categories	50% LID option	30' Tunnel option
Increased recreational opportunities	$524.5	
Property value increase (50%)	$574.7	
Reduction in heat stress mortality	$1,057.6	
Water quality/aquatic habitat enhancement	$336.4	$189.0
Wetland services	$1.6	
Local green jobs	$124.9	
Air quality improvements from trees	$131.0	
Energy savings/usage	$33.7	$(2.5)
Reduced (increased) damage from SO_2 and NO_x emissions	$46.3	$(45.2)
Reduced (increased) damage from CO_2 emissions	$21.2	$(5.9)
Disruption costs from construction and maintenance	$(5.6)	$(13.4)
Total	**$2,846.4**	**$122.0**

Other relevant examples

- Washington D.C.
  (Local economic impacts)
- Sun Valley Watershed, Los Angeles, CA
- San Diego, CA

Questions?

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