Whole Life Costs and Benefits of Sustainable Urban Drainage Systems in Dunfermline, Scotland

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Sustainable Urban Drainage Systems (SUDS)

- Alternative to traditional stormwater management practices

Tunnel and Reservoir Project (TARP), Chicago, IL

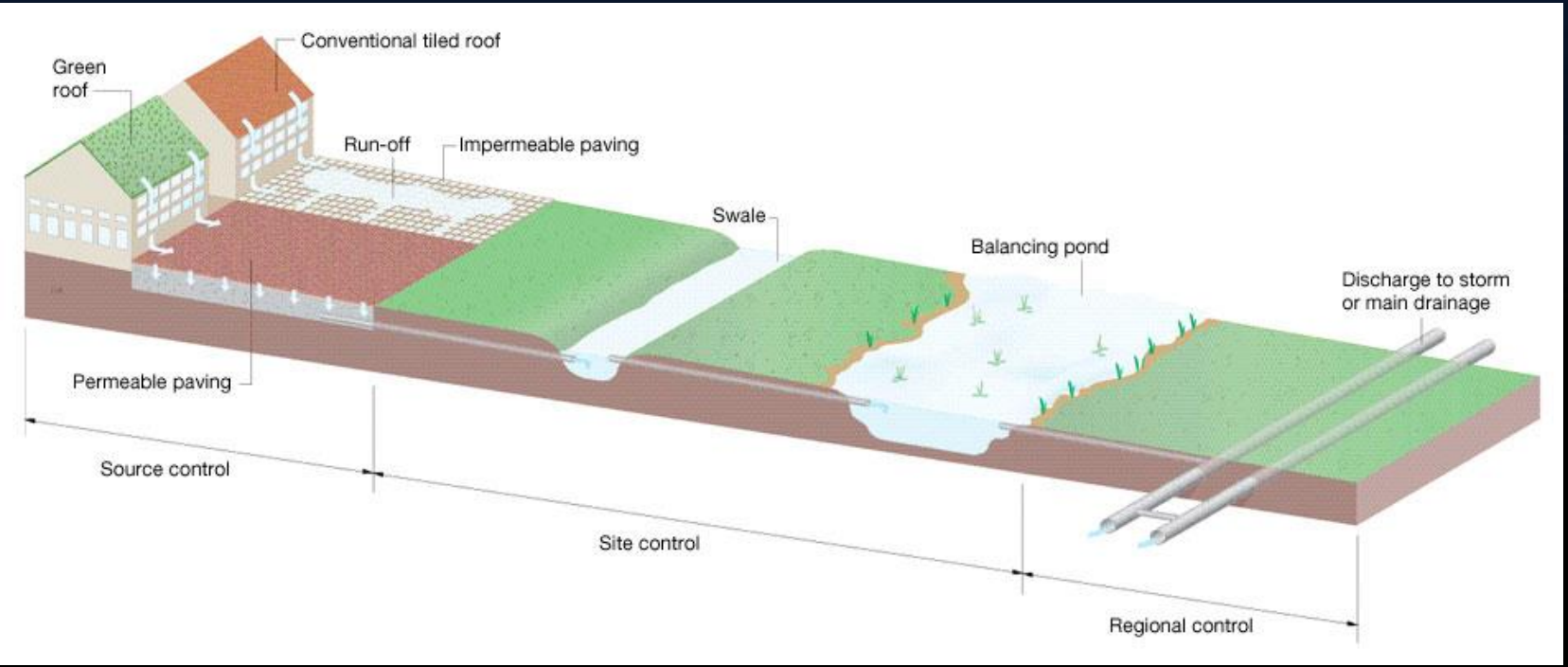
Sustainable Urban Drainage Systems (SUDS)

- Mimic natural drainage regimes

Pinkerton Basin, Dunfermline, Scotland

SUDS Components

Stormwater Treatment Train



Source: Brett Group

Current Knowledge of SUDS

- Provide multiple benefits
- Whole Life Cost (WLC) Analysis
- Quantity of benefits?
- Maintenance activities and costs?

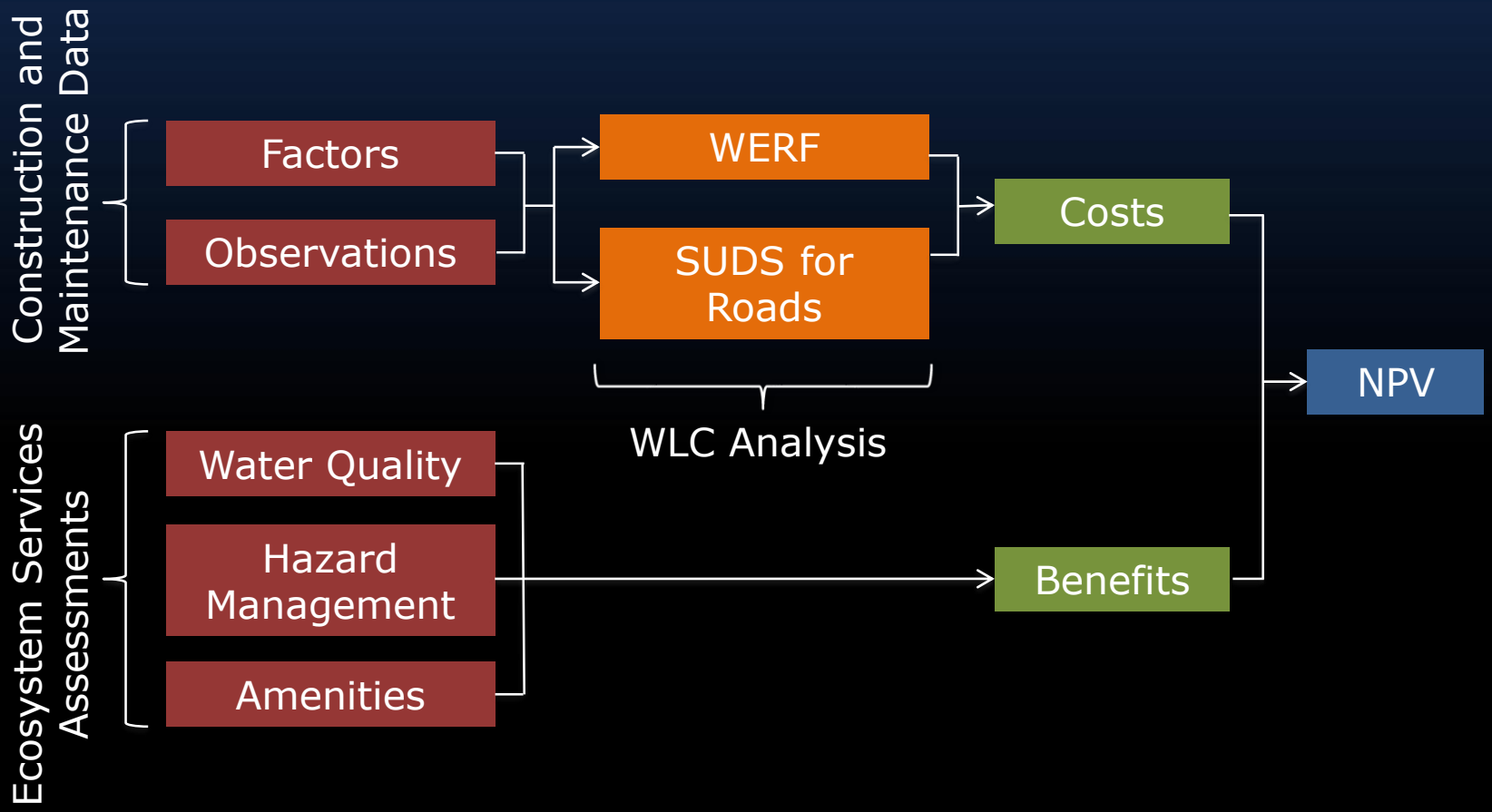
What's Novel About This Study?

- Robust cost/benefit analysis
- Costs: actual maintenance data
- Benefits: Ecosystem Services Assessments

Ecosystem Services

- Goods and services produced by nature; consumed by people
- Inform policy decisions
- Allows market exchange
- Increasingly prominent in recent years

Methods


Construction and Maintenance Data
Factors
Observations
WERF
SUDS for Roads
WLC Analysis
Costs
NPV
Ecosystem Services Assessments
Water Quality
Hazard Management
Amenities
Benefits

Site Selection

Dunfermline Eastern Expansion (DEX)

Site Selection

Dunfermline Eastern Expansion (DEX)

Site Selection

- 1996 -2020
- 52 SUDS Features total

Site Selection

Five Ponds

Site Selection

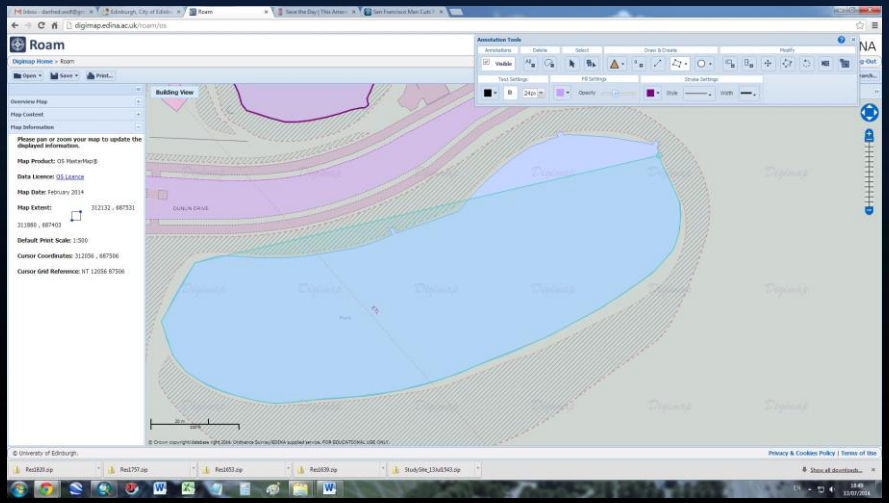
Five Basins

Site Selection

Five Swales

GIS Database

- Data sources:
  - EDINA
  - Fieldwork/GPS
- Purpose:
  - Facilitate subsequent analysis
  - Communication tool



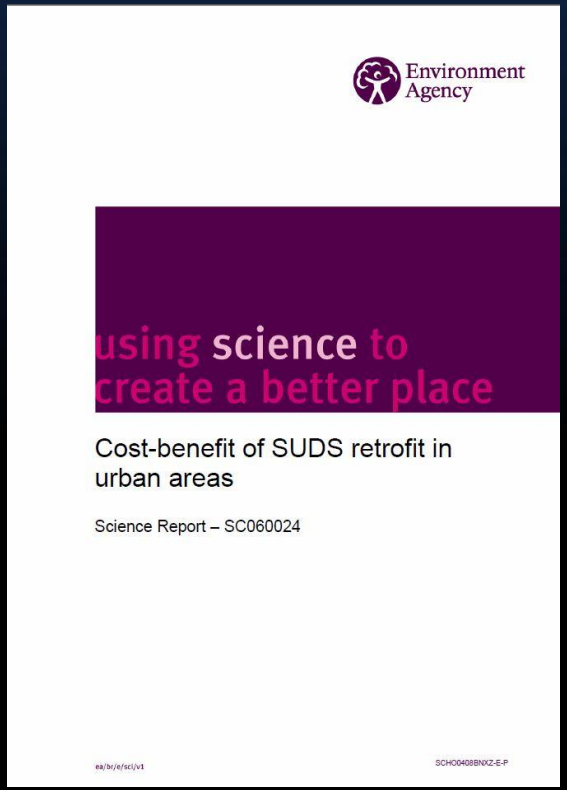
Maintenance Data

- Payment certificates
- Interviewed residents
- Contacted Factors
- Maintenance checklists
- Collated database

Ecosystem Services Assessments

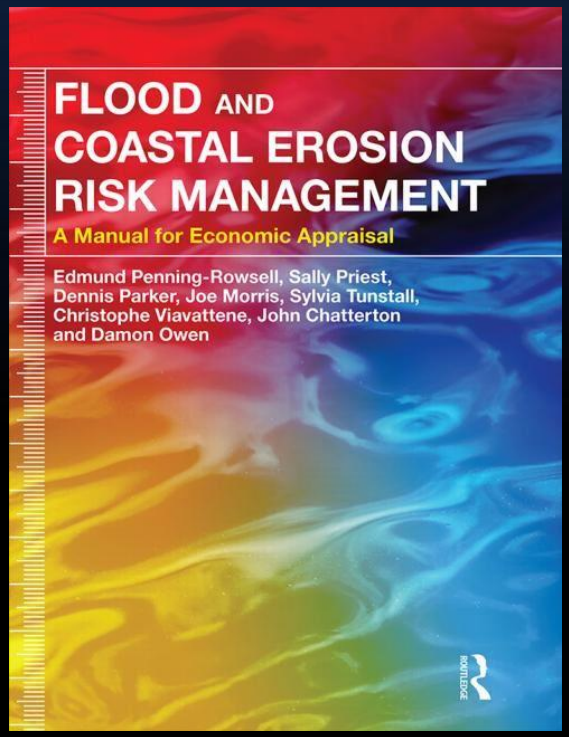
Water Quality

- UK Environment Agency 2007
- Runoff reduction → Combined sewer overflow (CSO) reduction
- Cost of each CSO = £51,000
- Spitzer 2007 flow rates into and out of SUDS at DEX
- Ofwat 2007 CSO frequency/ unit catchment area
- Value of avoided water quality impairment



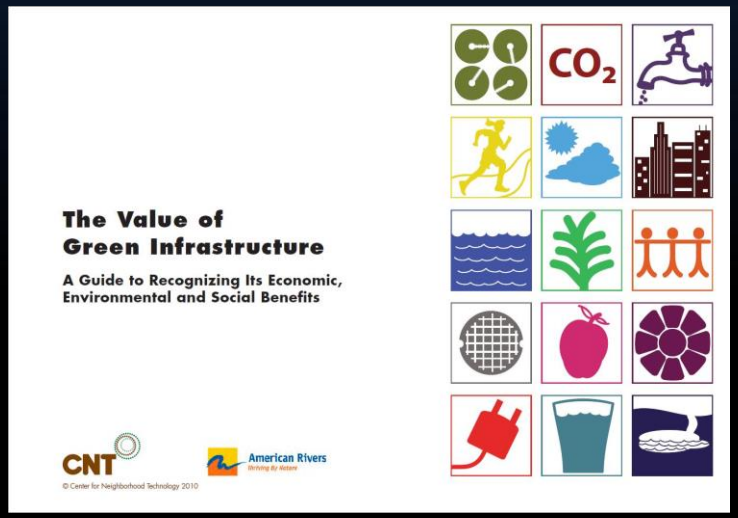
Hazard Management

- Flood Hazard Research Center (FHRC) Manual
- Weighted Average Annual Property Damages (WAADs)
- Values for storm threshold return periods of 5, 10, 25, 50, 100 years
- SUDS features designed for different return periods
- Counted residences whose risk of flooding mitigated by SUDS; applied respective WAADs



Amenity

- Center for Neighborhood Technology 2010
- Proximity to SUDS increases residential value by 3.5%
- Using average house price in DEX
- Count residences w/ in 50m of SUDS



Whole Life Cost Analysis

Present Value

r = 3.5% discount rate

t = 50-year time horizon

C_t = cost in year t

$$\mathbf{PV} = \sum_{t=0}^{t=N} \frac{C_t}{(1+\frac{r}{100})^t}$$

WERF

- Water Environment Research Foundation
- BMP and LID WLC models (2009)
- 9 tools available
  - Retention Pond
  - Detention Basin
  - Swale

WERF

- Design Specifications
  - Drainage area
  - Impervious cover
  - Watershed land use type
  - Facility Storage Volume
- Construction Costs
- Maintenance Activities
  - Routine (6)
  - Corrective/infrequent (6)

SUDS for Roads

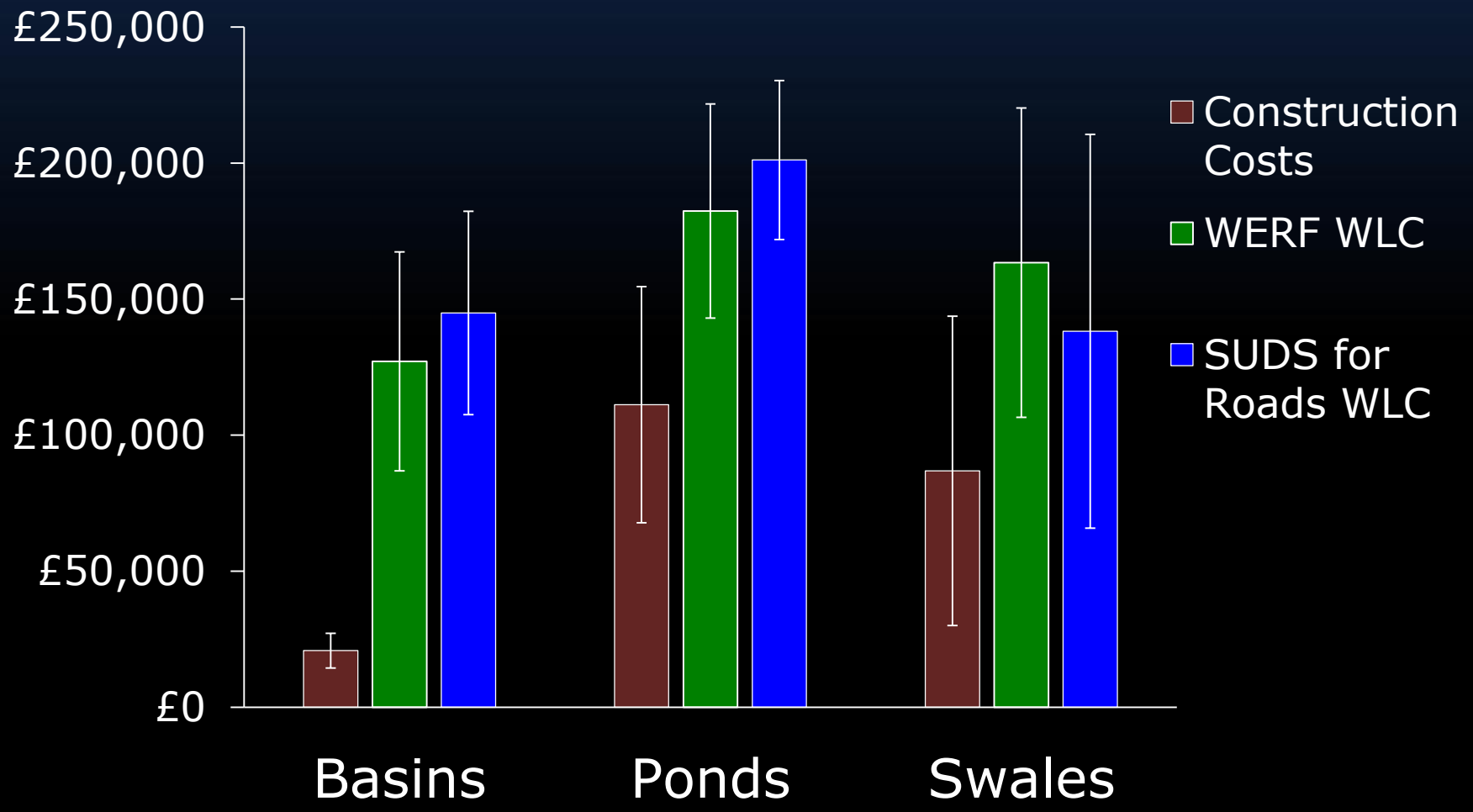
- Scottish SUDS Working Party
- Similar to WERF
- Supports Treatment Train Analysis
- Pond 6 analyzed as Treatment Train

Results

Ecosystem Services

- Within range of similar SUDS in UK

Whole Life Costs



Net Present Value

- Ecosystem Services not included in WLC methodologies
- ES – WLC = NPV

Net Present Value

Site	Water quality	Hazard Management	Amenity	NPV WERF	NPV SUDS for Roads
Halbeath Pond	£394	£0	£17,100	-£185,522	-£150,090
Linburn Pond	£19	£2,535,145	£5,700	£2,318,011	£2,292,833
The Wetland	£484	£0	£0	-£145,805	-£214,839
Masterton Lea	£249	£0	£17,100	-£105,656	-£207,107
Pond 6	£1,228	£507,029	£222,300	£513,926	£495,602
DM Basin S	£42	£65,808	£0	-£40,974	-£51,393
DM Basin N	£134	£201,387	£0	£61,520	£90,909
Pinkerton Basin	£76	£868,380	£68,400	£857,281	£822,967
U1 Basin	£61	£868,380	£51,300	£720,087	£732,772
Roundabout Basin	£453	£0	£0	-£109,049	-£195,352
Highway Swale 1	£1,328	£57,263	£0	-£50,078	-£10,161
Highway Swale 2	£7	£184,891	£0	£4,499	£25,871
Highway Swale 3	£22	£104,173	£22,800	-£8,036	£24,666
Highway Swale 4	£24	£736,940	£114,000	£727,219	£763,009
Wetland Swales	£31	£2,763,525	£85,500	£2,580,001	£2,576,019

Uncertainties

- Did not assess effect of maintenance on value of ES
- No robust methodologies for assessing other ES
- Other SUDS may provide ES

Acknowledgements

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Questions?

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