What's an Engineer to Do?

Ecological Footprint in Planning for a Wastewater Treatment Facility

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Introduction to Petaluma

- Located 40 miles north of San Francisco
- Population = 55,000 → 70,650
- Current WWTP consists of facilities constructed in 1930s and 1960s

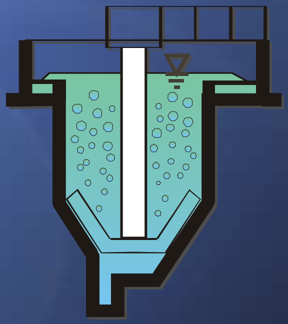
Petaluma WWTP Project Goals

"develop an economically and ecologically sustainable water recycling facility"

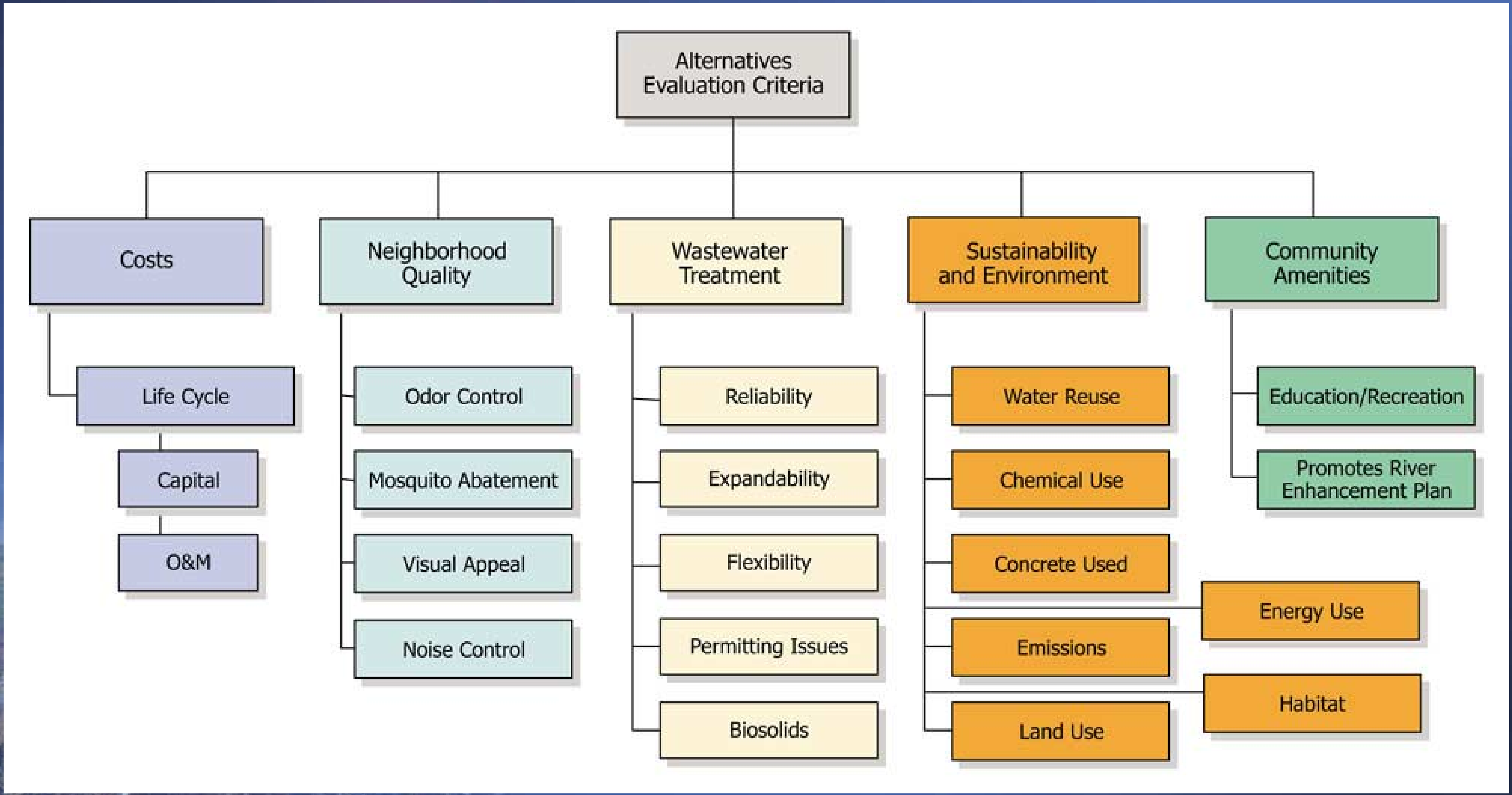
"serves as an amenity to the community by providing educational and recreational opportunities"

Treatment Alternatives Evaluated

- **Five treatment alternatives**
  - All include using existing oxidation ponds → produce algae
  - All include filtration/ disinfection for reuse
- **Subalternatives**
  - Algae removal
  - Disinfection



Alternatives Evaluation Criteria



The Dilemma

"How do I assess relative ecological impacts of different alternatives within my limited budget?"

The Ecological Footprint

"Aha! I'll use the Ecological Footprint!"

Amount of land and water (area of the earth) required to produce all the resources we consume and to absorb all the wastes we produce

Ecological Footprint

	Who	*Acres/Person*
What we Have	**World**	**4.7**
What we Use	**World**	**5.6**
	U.S.	**24**
	China	**3.9**

Calculating the Footprint

- **Scope, Boundaries & Assumptions**
- **Identify material & and energy use**
- **Determine quantities**
  - Weight of materials
  - Amount of earth cut and fill
  - Delivery trips
- **Find conversion factors**
- **Spreadsheet**

Scope, Boundaries, and Assumptions

- Five Secondary Treatment Processes
- UV vs. Hypochlorite Disinfection
- Wetlands vs. DAF for Algae Removal
- End of life activities not considered
- Land Conversion not considered
- Life of facility = 40 years

Identify Material and Energy Use

- Construction Materials: Concrete (CY) and Steel (Tons)
- Chemicals to Operate (Tons)
- Energy to Operate (kWh)
- Energy to Construct (Barrels of Oil)
- Emissions: Methane and Carbon Dioxide (Tons)

Conversion Factors / Calculation

lbs. X kWh/lb. X acres/kWh = global acres

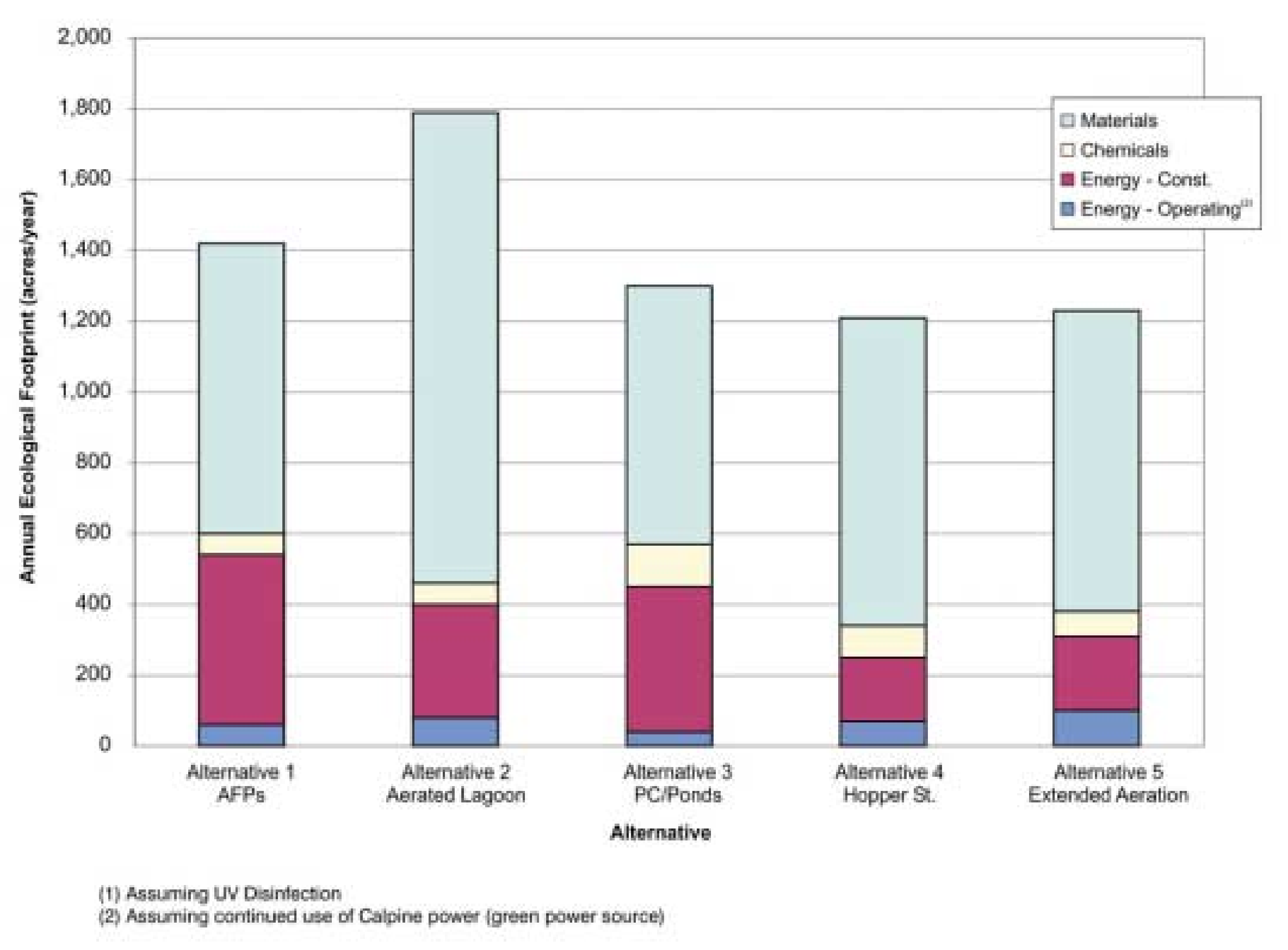
	Who	*Source*
Material Quantity	Carollo	Cost Estimate
Embodied Energy per Unit of Material	Carollo / RP	Vendor, Reports
Acres per Unit of Energy	RP / Footprint Network	

Spreadsheet

Table J-9 Sustainability Analysis							
Alternative 5A - Extended Aeration (with UV)							
Components	**Quantity**	**Units**	**Time, years**	**Conversion Factor**	**Units**	**Footprint, acres**	**Footprint/years, acres**
Operational Energy							
Electric	14,242,888	[kWh-Cal]	1	0.0006	acre/KWh	8550	8550
Fuels		[barrels]	1	0.38	acre/barrel	0	0
Construction Energy							
Site clearing	3,066,215	ft2	40	0.0012	acre/ft2	3600	90
Compaction of Materials	136,148	ft2	40	0.0002	acre/ft2	30	0
Excavation	285,848	yd3	40	0.0067	acre/yd3	1900	50
Backfill	364,480	yd3	40	0.0067	acre/yd3	2400	60
Seeding and planting	5,662,800	ft2	40	0.00009	acre/ft2	510	10
Chemicals							
Aluminum Sulfate	661,005	lb	1	0.00000	acre/lb	1	1
Ferric Chloride	228,490	lb	1	0.00003	acre/lb	7	7
Polymer	51,728	lb	1	0.001094915	acre/lb	60	60
Construction Materials							
Concrete	18,736	yd3	40	0.334	acre/yd3	6300	160
Emissions due to Concrete Prod.	16,694	tons concrete	40	0.36	acre/ton	6000	150
Concrete Block	9,205	ft2	40	0.003	acre/ft2	30	1
Steel	1,237	tons	40	13.5	acre/ton	16700	420

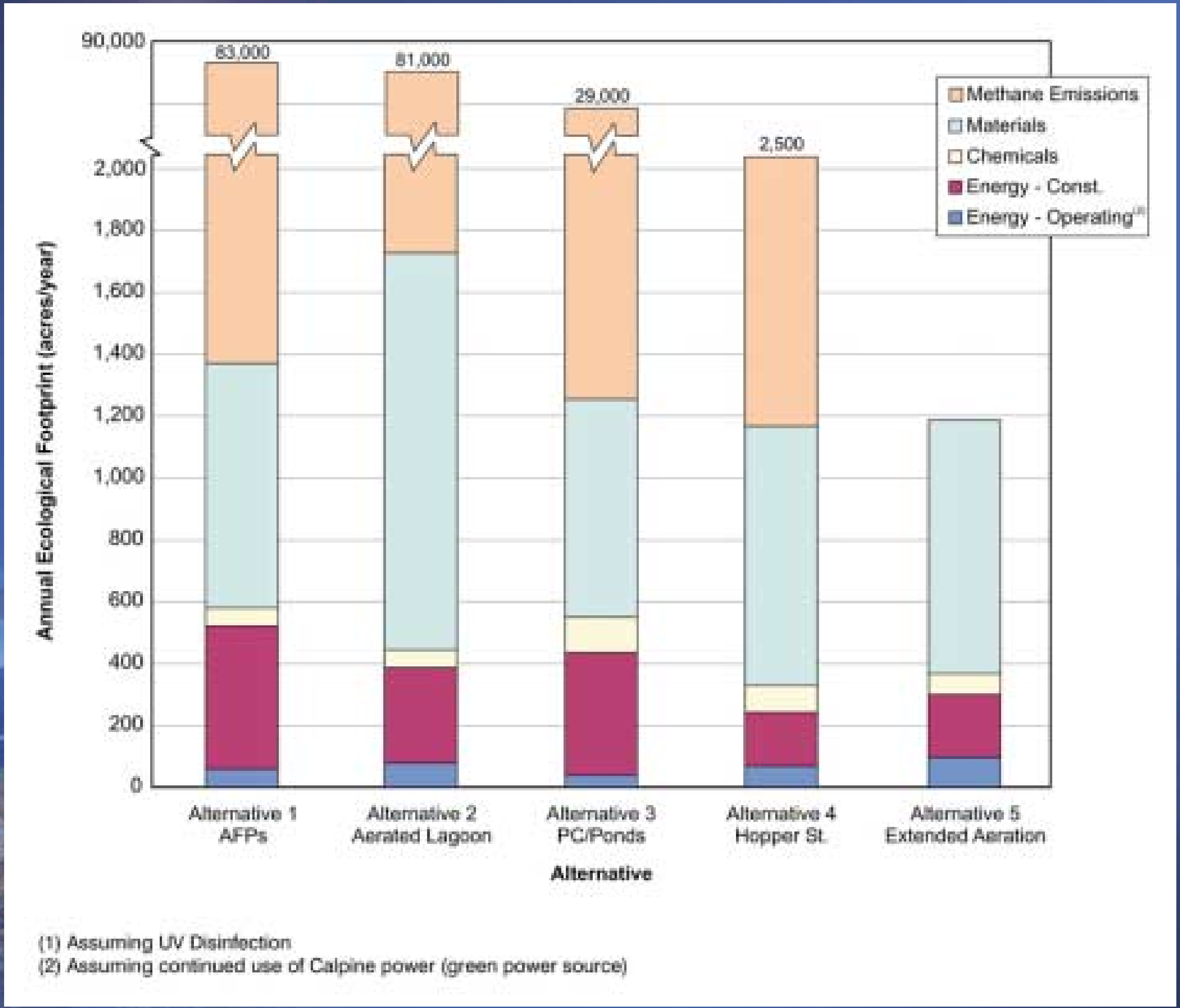
Ecological Footprint

(global acres, not acres/year)



Ecological Footprint (with Methane Emissions)

(global acres, not acres/year)



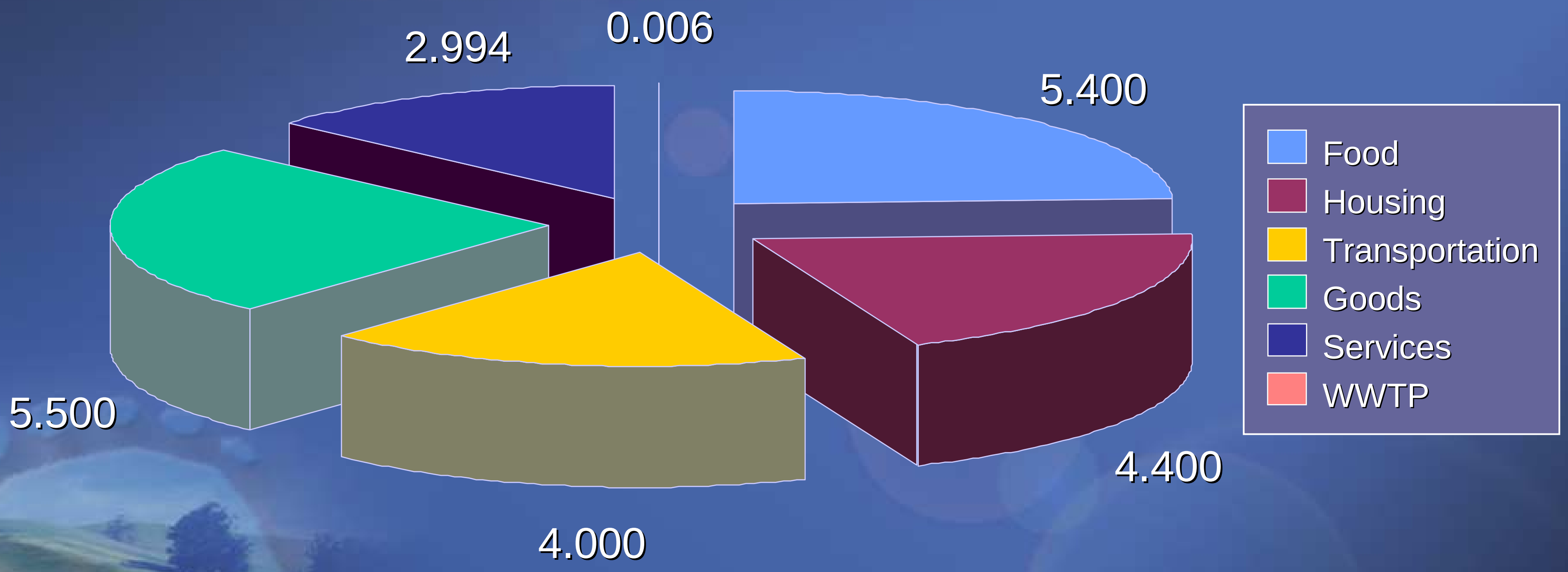
Ecological Footprint for UV vs. Hypochlorite Disinfection

	CA Power	Green Power
Hypochlorite (1)		
Materials →	30 gac	30 gac
Chemicals →	121 gac	121 gac
Power →	10 gac	≈0 gac
Total	**161 gac**	**151 gac**
UV (1)		
Materials →	6 gac	6 gac
Equipment →	6 gac	6 gac
Power →	150 gac	2 gac
Total	**162 gac**	**14 gac**

(1) 4 mgd Urban Recycle Water System Only (Title 22)
Construction energy negligible

Petaluma WRF

Sonoma County Ecological Footprint 1999



How Much Did this Analysis Cost?

- Consultant = $5,000
- 100 in house hours

We Learned

- Moving dirt takes a LOT of energy
- Land based systems not necessarily better due to methane emissions
- Green energy makes a huge difference
- The more you learn, the less you know!

We Learned

- **Data availability is a problem**
  - Ours
    - In study phase, quantity estimates are not very accurate
  - Vendors
    - Weight / composition of equipment
    - Embodied energy of equipment
  - Conversion factors
    - How to quantify land conversion from agricultural to wetland?

We Learned

- **Doesn't cover everything**
  - Radioactive materials, heavy metals, persistent organic toxins, bio-hazardous wastes
  - Water quality differences not measured

Strengths of the Ecological Footprint

- **Can assess relative ecological impacts of alternatives**
- **Excellent visual tool to reveal the impacts of facilities**
  - Makes carrying capacity real
- **Would work well in Pre-Design for materials selection**

Conclusions

- Increase LCA thinking in engineers
- As a first exercise, very informative
- Would like to test conclusions with actual construction data & against another LCIA tool

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