

Supplementary Information

Routing-Resolved Municipal Landfill Methane Responsibility under Alternative

Accounting Conventions

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SI Table S1. P2 100% facility-specific jurisdiction robustness

Table S1. P2 100%-covered jurisdiction robustness (U2).

Metric	Value
Eligible jurisdictions (n)	141
Included short tons	6,530,155
U0 routed-network share	21.24%
Median $ \Delta $ statewide	38.73%
Median $ \Delta $ county	20.00%
Spearman ρ	0.838
Rank shifts >25	30
>25 as % of n	21.3%

SI-only robustness; not the primary manuscript universe.

SI Table S2. P3 $\geq 95\%$ -covered jurisdiction robustness

Table S2. P3 $\geq 95\%$ -covered jurisdiction robustness (U4).

Metric	Value
Eligible jurisdictions (n)	284
Included short tons	25,275,597
U0 routed-network share	82.20%
Median $ \Delta $ statewide	29.47%
Median $ \Delta $ county	15.51%
Spearman ρ	0.873
Rank shifts >25	116
>25 as % of n	40.8%

Controlled Phase 3E.2 values; SI-only robustness.

SI Table S3. Cross-universe normalized-rank robustness

Table S3. Normalized-rank robustness across analytical universes.

Comparison	Shared jurisdiction	Median $ \Delta $ percentile rank (fraction; $\times 100 =$ percentile points)	Spearman ρ (percentile ranks)	Kendall τ	Top-decile retention	Bottom-decile retention	Leader-class retention	Laggard-class retention
U1 vs U2	141	0.075	1.000	1.000	1.00	1.00	1.00	1.00

Comparison	Shared jurisdictions	Median $ \Delta $ percentile rank (fraction; $\times 100 =$ percentile points)	Spearman ρ (percentile ranks)	Kendall τ	Top-decile retention	Bottom-decile retention	Leader-class retention	Laggard-class retention
U1 vs U3	253	0.022	1.000	1.000	1.00	1.00	1.00	1.00
U1 vs U4	284	0.016	1.000	1.000	1.00	1.00	1.00	1.00
U1 vs U5	299	0.028	1.000	1.000	1.00	1.00	1.00	1.00

Median absolute percentile-rank change is reported as a fraction on the 0–1 scale (e.g., 0.075 equals 7.5 percentile points). Raw rank-position changes across differently sized universes are not directly comparable.

SI Table S4. Coverage-distortion diagnostics

Table S4a. Coverage-distortion association metrics (diagnostic only; no causal interpretation).

Diagnostic	Value
Mixed eligible jurisdictions (n)	196
Spearman(coverage, statewide divergence)	0.021
Spearman(coverage, rank movement)	0.196
Pearson(coverage, divergence)	0.094

Table S4b. Flagged mixed-coverage jurisdictions.

Jurisdiction	County	Facility-specific coverage (%)	Rank shift
Carson	Los Angeles County	61.1	37
Morgan Hill	Santa Clara County	21.0	27
Twentynine Palms	San Bernardino County	64.5	63
Wasco	Kern County	22.6	32

Four jurisdictions with <90% facility-specific coverage and rank shift >25 under P1/U1.

SI Figure S1. Fallback-sensitivity stability

Figure S1. Median statewide divergence across six fallback treatments (P1 primary universe n = 337).

SI Table S5. Full fallback treatment comparison

Table S5. Full fallback sensitivity comparison.

Treatment	n	Included tons	Fallback represented	Excluded tons	Emissions	$ \Delta $ state	$ \Delta $ county	ρ	Shifts >25
U1 facility-specific primary	337	29,117,045	0	1,633,547	4,053,451	28.46%	15.52%	0.896	138
Stored fallback	346	30,750,592	1,633,547	0	4,353,422	25.48%	14.75%	0.887	157
Documented 0.1836	346	30,750,592	1,633,547	0	4,353,426	25.51%	14.75%	0.887	157
Tonnage-weighted	346	30,750,592	1,633,547	0	4,289,832	24.24%	13.83%	0.891	139
Median	346	30,750,592	1,633,547	0	4,249,477	24.28%	13.44%	0.892	137
Winsorized	346	30,750,592	1,633,547	0	4,332,499	25.03%	14.73%	0.889	151

Primary row uses matched-tonnage comparators on facility-specific covered edges. Treatment definitions: FS-covered primary = facility-specific covered-tonnage primary analysis; Stored fallback = stored fallback-inclusive sensitivity; Documented 0.1836 = documented 0.1836 fallback sensitivity; Tonnage-weighted = tonnage-weighted fallback sensitivity; Median = median fallback sensitivity; Winsorized = winsorized fallback sensitivity. Emissions in MT CO₂e. $|\Delta|$ columns are median absolute percent divergence versus matched statewide or county comparators. ρ = Spearman rank correlation. Shifts >25 = jurisdictions shifting more than 25 ranks.

SI Table S6. Analytical-threshold sensitivity

Table S6. Eligibility-threshold sensitivity (P1 matched-tonnage comparators).

Threshold (MT CO ₂ e)	Eligible n	Median Δ statewide	Median Δ county	Spearman ρ	Rank shifts >25	>25 (%)	Rank shifts >10	Median Δ percentile rank
>0	353	28.66%	15.47%	0.910	138	39.1%	218	5.10%
>50	339	28.46%	15.52%	0.898	138	40.7%	218	5.60%
>100	337	28.46%	15.52%	0.896	138	40.9%	218	5.64%
>250	320	27.94%	15.51%	0.879	137	42.8%	216	5.94%
>500	309	27.14%	15.51%	0.868	136	44.0%	207	6.47%

Main manuscript retains >100 MT CO₂e eligibility screen.

SI Figure S2. Metric stability across eligibility thresholds

Figure S2. Primary P1 metrics across analytical eligibility thresholds.

SI Figure S3. Facility-year allocation intensity distribution

Figure S3. Distribution of unique facility-year allocation intensities (facility-specific edges).

SI Table S7a. Commitment scenario definitions and outputs

Table S7a. Commitment scenario definitions and outputs.

Source and derivation of Scenario A: the overall disposed-waste composition is from CalRecycle's 2021 disposal-facility characterization data tables, Table 1 (Statewide Disposal; 88 material types). Mapping those shares to the GPC degradable-organic-carbon categories gives DOC = 0.15258 tonnes C per tonne of wet waste. Using GPC Equations 8.1, 8.3, and 8.4 with DOCf = 0.6, MCF = 1.0, methane fraction = 0.5, oxidation = 0.1, recovery = 0, the conversion 0.90718474 metric tonnes per short ton, and the IPCC AR5 100-year methane GWP of 28 without climate-carbon feedbacks gives $0.90718474 \times 0.15258 \times 0.6 \times 1.0 \times 0.5 \times (16/12) \times (1 - 0) \times (1 - 0.1) \times 28 = 1.395$ metric tonnes CO₂e per short ton. Scenario A is therefore a derived no-recovery upper bound, not an observed California landfill emission factor (CalRecycle, 2022; World Resources Institute et al., 2021; IPCC, 2013). All commitment scenarios hold the 2021 statewide composition constant and do not model subsequent reductions in landfilled organic material under California SB 1383. Scenario F holds these parameters fixed and applies 75% recovery, giving $1.3952559 \times (1 - 0.75) = 0.348814$ MT CO₂e per short ton. The 75% value is a protocol-practice sensitivity, not a measured statewide lifetime recovery rate.

Scenario	Readable label	Composition source	Recovery assumption	Ambiguity treatment	Calculated MT CO ₂ e per short ton
A	GPC managed anaerobic landfill, no methane recovery	CalRecycle 2021 Table 1 (total-stream pct basis)	No methane recovery	None	1.395
B	GPC managed landfill with hypothetical 35% lifetime recovery	CalRecycle 2021 Table 1 (total-stream pct basis)	35% lifetime recovery (hypothetical)	None	0.907
C	IPCC 2006 default MSW composition and landfill parameters	IPCC 2006 Vol.5 default mix (pct of total)	No methane recovery	None	1.697
D	CalRecycle 2021 composition with IPCC 2006 DOC and landfill defaults	CalRecycle 2021 Table 1 crosswalk to IPCC DOC	No methane recovery	None	1.163

Scenario	Readable label	Composition source	Recovery assumption	Ambiguity treatment	Calculated MT CO ₂ e per short ton
E	CalRecycle 2021 with ambiguous-material DOC overrides	CalRecycle 2021 Table 1 with explicit ambiguous DOC overrides	No methane recovery	Explicit ambiguous-material DOC overrides (Phase 2B.3 crosswalk)	1.285
F	GPC managed landfill with protocol-practice 75% recovery sensitivity	CalRecycle 2021 Table 1 (total-stream pct basis)	75% lifetime recovery (protocol-practice sensitivity; not a statewide estimate)	None	0.349

Frozen scenario manifest + protocol_parameters.yaml.

SI Table S7b. Common numerical commitment parameters

Table S7b. Common numerical commitment parameters.

Scenario	Short-ton conversion (MT/st)	DOCf	MCF	CH ₄ volume fraction	Oxidation fraction	CH ₄ GWP (100-yr) and basis
A	0.90718474	0.6	1.0	0.5	0.1	28.0 (IPCC AR5)
B	0.90718474	0.6	1.0	0.5	0.1	28.0 (IPCC AR5)
C	0.90718474	0.5	1.0	0.5	0.1	28.0 (IPCC AR5)
D	0.90718474	0.5	1.0	0.5	0.1	28.0 (IPCC AR5)
E	0.90718474	0.5	1.0	0.5	0.1	28.0 (IPCC AR5)
F	0.90718474	0.6	1.0	0.5	0.1	28.0 (IPCC AR5)

SI Table S7c. DOC mapping and ambiguity overrides

Table S7c. DOC mapping and ambiguity overrides.

Scenario	DOC source / mapping	Crosswalk source	Material-category overrides	Uncertainty notes
A	CalRecycle 2021 Table 1 → IPCC DOC crosswalk (DRRR-2024-1737)	DRRR-2024-1737 CalRecycle 2021 Table 1 crosswalk	None	Frozen manifest; no additional scenario- specific uncertainty override.
B	CalRecycle 2021 Table 1 → IPCC DOC crosswalk (DRRR-2024-1737)	DRRR-2024-1737 CalRecycle 2021 Table 1 crosswalk	None	Frozen manifest; no additional scenario- specific uncertainty override.
C	IPCC 2006 Vol.5 Table 2.4 default MSW DOC values	IPCC 2006 Vol.5 default mix (pct of total)	None	Frozen manifest; no additional scenario- specific uncertainty override.
D	CalRecycle 2021 Table 1 → IPCC DOC crosswalk (DRRR-2024-1737)	DRRR-2024-1737 CalRecycle 2021 Table 1 crosswalk	None	Frozen manifest; no additional scenario- specific uncertainty override.
E	CalRecycle 2021 Table 1 with explicit ambiguous DOC overrides	DRRR-2024-1737 CalRecycle 2021 Table 1 crosswalk	Explicit ambiguous- material DOC overrides (Phase 2B.3 crosswalk)	Ambiguous-material DOC overrides per Phase 2B.3 crosswalk.

SI Table S8. Composition crosswalk (CalRecycle 2021 Table 1)

Table S8. Composition crosswalk : all material groups.

CalRecycle 2021 material group	Mass share (%)	IPCC DOC category	DOC (kg C/kg wet waste)	Mapping status	Ambiguity flag
Corrugated Cardboard	4.1	Paper and cardboard	0.4	direct	No
Paper Grocery Bags	0.1	Paper and cardboard	0.4	aggregated	No
Other Paper Bags/Kraft Paper	0.4	Paper and cardboard	0.4	aggregated	No
Newspapers/ Newspaper Inserts	0.3	Paper and cardboard	0.4	aggregated	No
White Office-type Paper and Mail	0.6	Paper and cardboard	0.4	aggregated	No
Magazines and Catalogs	0.4	Paper and cardboard	0.4	aggregated	No
Folding Cartons and Other Paperboard Packaging	1.2	Paper and cardboard	0.4	aggregated	No
Aseptic Containers	0.1	Paper and cardboard	0.4	aggregated	No
Gable-top Cartons	0.1	Paper and cardboard	0.4	aggregated	No
Paper/Fiber Food Service Ware	2.1	Paper and cardboard	0.4	aggregated	No
Other Recyclable Paper	1.3	Paper and cardboard	0.4	aggregated	No
Other Paper/Fiber - Packaging	0.8	Paper and cardboard	0.4	aggregated	No
Other Compostable Paper	3.5	Paper and cardboard	0.4	aggregated	No
Remainder/ Composite Paper	0.6	Paper and cardboard	0.4	mixed_uncertain	Yes

CalRecycle 2021 material group	Mass share (%)	IPCC DOC category	DOC (kg C/kg wet waste)	Mapping status	Ambiguity flag
PETE Beverage Containers - CRV	0.6	Not reported	0.0	zero_doc	No
PETE Bottles and Jars - Non-CRV	0.2	Not reported	0.0	zero_doc	No
HDPE Beverage Containers - CRV	0.1	Not reported	0.0	zero_doc	No
HDPE Bottles and Jars - Non-CRV	0.4	Not reported	0.0	zero_doc	No
Expanded Polystyrene Packaging	0.2	Not reported	0.0	zero_doc	No
Plastic Trash Bags	1.5	Not reported	0.0	zero_doc	No
Plastic Grocery and Other Merchandise Bags	0.6	Not reported	0.0	zero_doc	No
Film Products- Non-Packaging	0.5	Not reported	0.0	zero_doc	No
Flexible Plastic Pouches	0.0	Not reported	0.0	zero_doc	No
Non-Bag Commercial and Industrial Packaging Film	1.4	Not reported	0.0	zero_doc	No
Other Film Bags and Plastic Mailing Pouches	0.4	Not reported	0.0	zero_doc	No
Rigid Plastic Food Service Ware	1.3	Not reported	0.0	zero_doc	No
Other Plastic Packaging	3.1	Not reported	0.0	zero_doc	No
Durable Plastic Items	2.3	Not reported	0.0	zero_doc	No

Table S8 (continued)

CalRecycle 2021 material group	Mass share (%)	IPCC DOC category	DOC (kg C/kg wet waste)	Mapping status	Ambiguity flag
Remainder/ Composite Plastic	1.1	Not reported	0.0	mixed_uncertain	Yes
Clear Glass Bottles and Containers - CRV	0.5	Not reported	0.0	excluded_inert	No
Clear Glass Bottles and Containers - Non-CRV	0.7	Not reported	0.0	excluded_inert	No
Green Glass Bottles and Containers - CRV	0.1	Not reported	0.0	excluded_inert	No
Brown Glass Bottles and Containers - CRV	0.2	Not reported	0.0	excluded_inert	No
Green and Brown Glass Bottles and Containers - Non CRV	0.3	Not reported	0.0	excluded_inert	No
Other Colored Glass Bottles and Containers	0.1	Not reported	0.0	excluded_inert	No
Remainder/ Composite Glass	0.5	Not reported	0.0	excluded_inert	No

CalRecycle 2021 material group	Mass share (%)	IPCC DOC category	DOC (kg C/kg wet waste)	Mapping status	Ambiguity flag
Tin/Steel Cans	0.4	Not reported	0.0	excluded_inert	No
Aluminum Cans - CRV	0.2	Not reported	0.0	excluded_inert	No
Aluminum Cans - Non-CRV	0.1	Not reported	0.0	excluded_inert	No
Major Appliances	0.4	Not reported	0.0	excluded_inert	No
Other Ferrous	2.4	Not reported	0.0	excluded_inert	No
Other Non-Ferrous	0.7	Not reported	0.0	excluded_inert	No
Remainder/ Composite Metal	0.7	Not reported	0.0	excluded_inert	No
Covered Video Display Devices	0.2	Not reported	0.0	excluded_electronics	No
Consumer Electronics and Small Equipment	0.5	Not reported	0.0	excluded_electronics	No
Large Equipment	0.2	Not reported	0.0	excluded_electronics	No
Food - Potentially Donatable - Vegetative (Perishable/Fresh)	1.5	Food waste	0.15	direct	No
Food - Potentially Donatable - Eggs, Dairy, and Dairy Alternatives	0.2	Food waste	0.15	direct	No
Food - Potentially Donatable - Meat	0.3	Food waste	0.15	direct	No
Food - Potentially Donatable - Cooked/Baked/Prepared Perishable Items	0.3	Food waste	0.15	direct	No
Food - Potentially Donatable - Packaged Non perishable	1.4	Food waste	0.15	direct	No
Food - Not Donatable - Meat	0.9	Food waste	0.15	direct	No
Food - Not Donatable - Non-meat	4.0	Food waste	0.15	direct	No
Food - Inedible	2.3	Food waste	0.15	direct	No
Leaves and Grass	2.2	Garden, yard and park waste	0.2	direct	No
Prunings and Trimmings	2.8	Garden, yard and park waste	0.2	direct	No

Table S8 (continued)

CalRecycle 2021 material group	Mass share (%)	IPCC DOC category	DOC (kg C/kg wet waste)	Mapping status	Ambiguity flag
Branches and Stumps	1.0	Garden, yard and park waste	0.2	direct	No
Manures	0.7	Garden, yard and park waste	0.2	direct	No
Clean Dimensional Lumber	2.8	Wood	0.43	direct	No
Clean Engineered Wood	1.9	Wood	0.43	direct	No

CalRecycle 2021 material group	Mass share (%)	IPCC DOC category	DOC (kg C/kg wet waste)	Mapping status	Ambiguity flag
Clean Pallets and Crates	1.4	Wood	0.43	direct	No
Treated/Painted/Stained Wood	3.4	Wood	0.43	mixed_uncertain	Yes
Other Recyclable Wood	0.2	Wood	0.43	direct	No
Remainder/Composite Organic	0.9	Industrial waste / other	0.15	mixed_uncertain	Yes
Concrete	1.9	Not reported	0.0	excluded_inert	No
Asphalt Roofing	1.4	Not reported	0.0	excluded_inert	No
Gypsum Board	1.8	Not reported	0.0	excluded_inert	No
Carpet	1.3	Textiles	0.24	mixed_uncertain	Yes
Rock, Soil and Fines	2.0	Not reported	0.0	excluded_inert	No
Remainder/Composite Inerts and Other	3.6	Not reported	0.0	excluded_inert	No
Paint	0.1	Not reported	0.0	excluded_hhw	No
Used Oil	0.0	Not reported	0.0	excluded_hhw	No
Lead-acid (automotive) batteries	0.0	Not reported	0.0	excluded_hhw	No
Other batteries	0.0	Not reported	0.0	excluded_hhw	No
One-Pound or Less Propane Gas Cylinders	0.0	Not reported	0.0	excluded_hhw	No
Pharmaceuticals	0.0	Not reported	0.0	excluded_hhw	No
Remainder/Composite Household Hazardous	0.1	Not reported	0.0	excluded_hhw	No
Tires	0.1	Rubber and leather	0.0	mixed_uncertain	Yes
Mattresses and Foundations	1.1	Textiles	0.24	mixed_uncertain	Yes
Bulky Items	3.6	Industrial waste / other	0.15	mixed_uncertain	Yes
Remainder/Composite Special Waste	0.4	Industrial waste / other	0.15	mixed_uncertain	Yes
Textiles - Cloth and Clothing	2.5	Textiles	0.24	direct	No
Textiles - Shoes, Purses, Belts	0.5	Textiles	0.24	direct	No
Personal Protective Equipment (PPE)	0.5	Textiles	0.24	mixed_uncertain	Yes

Table S8 (continued)

CalRecycle 2021 material group	Mass share (%)	IPCC DOC category	DOC (kg C/kg wet waste)	Mapping status	Ambiguity flag
Solar Panels	0.0	Not reported	0.0	excluded_electronics	No
Diapers & Sanitary Products	2.4	Nappies/disposable diapers	0.24	direct	No
Miscellaneous Inorganics	1.5	Not reported	0.0	excluded_inert	No
Mixed Residue	9.5	Industrial waste / other	0.15	mixed_uncertain	Yes

Total mass share = 100.0%; categories not renormalized; remainder/composite organic mapped per crosswalk (11 ambiguous flags).

SI Table S9. Routing-window sensitivity (complete-coverage pilot cases)

Table S9. Routing-window documentation.

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Riverside - Corona	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	7513.7	6342.9	15.6
Riverside - Corona	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	7513.7	7513.7	0.0
Riverside - Corona	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	7513.7	6826.6	9.1
Riverside - Corona	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	7513.7	6508.7	13.4
Riverside - Corona	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	7513.7	6672.4	11.2
Riverside - Corona	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	7513.7	7257.1	3.4
Riverside - Corona	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	7513.7	7537.1	0.3
San Francisco	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	1015714.0	715788.1	29.5
San Francisco	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	1015714.0	1015714.0	0.0
San Francisco	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	1015714.0	757199.5	25.5
San Francisco	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	1015714.0	732374.3	27.9
San Francisco	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	1015714.0	746072.4	26.5
San Francisco	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	1015714.0	736368.1	27.5
San Francisco	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	1015714.0	764721.7	24.7
Fresno - Fresno	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	384374.8	384374.8	0.0
Fresno - Fresno	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	384374.8	184761.2	51.9
Fresno - Fresno	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	384374.8	175592.9	54.3
Fresno - Fresno	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	384374.8	197399.7	48.6

Table S9 (continued)

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Fresno - Fresno	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	384374.8	216325.8	43.7

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Alameda - Alameda	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	7253.3	9056.8	24.9
Alameda - Alameda	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	7253.3	7253.3	0.0
Alameda - Alameda	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	7253.3	8705.0	20.0
Alameda - Alameda	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	7253.3	8949.6	23.4
Alameda - Alameda	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	7253.3	8829.2	21.7
Alameda - Alameda	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	7253.3	8430.6	16.2
Alameda - Alameda	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	7253.3	8248.2	13.7
Kern - Bakersfield	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	862449.8	862449.8	0.0
Kern - Bakersfield	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	862449.8	502948.5	41.7
Kern - Bakersfield	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	862449.8	731530.9	15.2
San Diego - San Diego	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	208019.8	229148.4	10.2
San Diego - San Diego	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	208019.8	208019.8	0.0
San Diego - San Diego	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	208019.8	223814.5	7.6
San Diego - San Diego	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	208019.8	227371.8	9.3
San Diego - San Diego	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	208019.8	225573.0	8.4
San Diego - San Diego	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	208019.8	220868.4	6.2
San Diego - San Diego	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	208019.8	212779.3	2.3

Table S9 (continued)

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Sacramento - Sacramento	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	963200.3	1443420.0	49.9
Sacramento - Sacramento	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	963200.3	963200.3	0.0
Sacramento - Sacramento	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	963200.3	1345978.1	39.7
Sacramento - Sacramento	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	963200.3	1408358.6	46.2

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Sacramento - Sacramento	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	963200.3	1375385.5	42.8
Sacramento - Sacramento	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	963200.3	1228127.5	27.5
Sacramento - Sacramento	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	963200.3	1303705.5	35.4
Alameda - Oakland	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	55678.4	71328.9	28.1
Alameda - Oakland	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	55678.4	55678.4	0.0
Alameda - Oakland	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	55678.4	67480.6	21.2
Alameda - Oakland	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	55678.4	70113.1	25.9
Alameda - Oakland	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	55678.4	68807.7	23.6
Alameda - Oakland	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	55678.4	64882.6	16.5
Alameda - Oakland	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	55678.4	59899.6	7.6
Santa Clara - San Jose	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	156209.9	234591.9	50.2
Santa Clara - San Jose	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	156209.9	156209.9	0.0
Los Angeles - Santa Monica	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	9566.6	9566.6	0.0
Los Angeles - Santa Monica	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	9566.6	8924.4	6.7

Table S9 (continued)

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Riverside - Palm Springs	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	18979.4	18979.4	0.0
Riverside - Palm Springs	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	18979.4	12425.8	34.5
Riverside - Palm Springs	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	18979.4	14733.8	22.4
Alameda - Berkeley	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	16811.0	16811.0	0.0
Alameda - Berkeley	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	16811.0	16573.5	1.4
Alameda - Berkeley	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	16811.0	16483.0	2.0

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Orange - Irvine	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	52375.4	49053.7	6.3
Orange - Irvine	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	52375.4	52375.4	0.0
Orange - Irvine	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	52375.4	51284.4	2.1
Orange - Irvine	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	52375.4	49835.5	4.8
Orange - Irvine	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	52375.4	50592.5	3.4
Orange - Irvine	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	52375.4	53349.9	1.9
Orange - Irvine	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	52375.4	54345.0	3.8
Los Angeles - Long Beach	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	55119.7	55119.7	0.0
Los Angeles - Long Beach	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	55119.7	64710.6	17.4
Orange - Anaheim	2019	Cumulative historical tonnage shares	Cumulative historical tonnage shares	complete coverage	493842.7	153496.1	68.9
Orange - Anaheim	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	493842.7	493842.7	0.0
Orange - Anaheim	2019	Decay-weighted shares (k high)	Decay-weighted shares (k high)	complete coverage	493842.7	220150.8	55.4

Table S9 (continued)

Case name	Target year	Historical window	Window definition	Factor coverage	Target-year allocation (MT CO ₂ e)	Counterfactual allocation (MT CO ₂ e)	Percent difference
Orange - Anaheim	2019	Decay-weighted shares (k low)	Decay-weighted shares (k low)	complete coverage	493842.7	173504.7	64.9
Orange - Anaheim	2019	Decay-weighted shares (k mid)	Decay-weighted shares (k mid)	complete coverage	493842.7	196033.2	60.3
Orange - Anaheim	2019	Trailing 10-year tonnage-weighted shares	Trailing 10-year tonnage-weighted shares	complete coverage	493842.7	237857.2	51.8
Orange - Anaheim	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	493842.7	356675.0	27.8
Los Angeles - Industry	2019	Current-year routing shares (target year)	Current-year routing shares (target year)	complete coverage	16555.7	16555.7	0.0
Los Angeles - Industry	2019	Trailing 5-year tonnage-weighted shares	Trailing 5-year tonnage-weighted shares	complete coverage	16555.7	21517.7	30.0

Pilot scope; complete factor coverage only.

SI Table S10. Commitment scenario case results (Scenarios A, B, F, D)

Table S10. Commitment case results.

Scenario	Jurisdiction	Commitment (MT CO ₂ e)	Current-flow (MT CO ₂ e)	Ratio
A	Riverside - Corona	370516.8	7508.8	49.34

Scenario	Jurisdiction	Commitment (MT CO ₂ e)	Current-flow (MT CO ₂ e)	Ratio
B	Riverside - Corona	240835.9	7508.8	32.07
D	Riverside - Corona	308764.0	7508.8	41.12
A	San Francisco	994896.0	1015725.9	0.98
B	San Francisco	646682.4	1015725.9	0.64
D	San Francisco	829080.0	1015725.9	0.82
A	Fresno - Fresno	845104.4	384374.5	2.20
B	Fresno - Fresno	549317.9	384374.5	1.43
D	Fresno - Fresno	704253.7	384374.5	1.83
A	Butte - Paradise	1402657.3	Not reported	Not reported
B	Butte - Paradise	911727.2	Not reported	Not reported
D	Butte - Paradise	1168881.1	Not reported	Not reported
A	San Diego - San Diego	2188160.8	208061.6	10.52
B	San Diego - San Diego	1422304.5	208061.6	6.84
D	San Diego - San Diego	1823467.3	208061.6	8.76
A	Alameda - Oakland	478701.8	55670.3	8.60
B	Alameda - Oakland	311156.2	55670.3	5.59
D	Alameda - Oakland	398918.1	55670.3	7.17
A	Santa Clara - San Jose	855694.7	156218.3	5.48
B	Santa Clara - San Jose	556201.6	156218.3	3.56
D	Santa Clara - San Jose	713078.9	156218.3	4.56
A	Humboldt - Humboldt-Unincorporated	63195.0	Not reported	Not reported
B	Humboldt - Humboldt-Unincorporated	59218.6	Not reported	Not reported
D	Humboldt - Humboldt-Unincorporated	52662.5	Not reported	Not reported
A	Los Angeles - Long Beach	444964.3	55120.8	8.07
B	Los Angeles - Long Beach	289226.8	55120.8	5.25
D	Los Angeles - Long Beach	370803.5	55120.8	6.73
A	Butte - Butte County Regional Waste Management Authority	979338.7	Not reported	Not reported
B	Butte - Butte County Regional Waste Management Authority	636700.1	Not reported	Not reported
D	Butte - Butte County Regional Waste Management Authority	816115.6	Not reported	Not reported
F	Riverside - Corona	92629.2	7508.8	12.34
F	San Francisco	248724.0	1015725.9	0.24
F	Fresno - Fresno	211276.1	384374.5	0.55
F	Butte - Paradise	350664.3	Not reported	Not reported
F	San Diego - San Diego	547040.2	208061.6	2.63
F	Alameda - Oakland	119675.4	55670.3	2.15
F	Santa Clara - San Jose	213923.7	156218.3	1.37
F	Humboldt - Humboldt-Unincorporated	15798.8	Not reported	Not reported
F	Los Angeles - Long Beach	111241.1	55120.8	2.02
F	Butte - Butte County Regional Waste Management Authority	244834.7	Not reported	Not reported

: indicates that no compatible current-flow estimate was available.

SI Table S11. Broad mixed-entity diagnostic universe

Table S11. Broad mixed-entity diagnostic universe (diagnostic only).

Universe	Reporting entities	Destinations	Routing edges	Reported tons	FS edges	Fallback edges
landfills_final_output_csv_mixed_entity_2019	416	111	4153	39,191,275	3669	484

Not the primary manuscript universe; contains mixed reporting-entity types; must not be used for primary factor-coverage claims.

SI Table S12. Destination codes and facility-status classifications

Table S12. Destination codes and facility-status classifications (Figure 2).

Authoritative final-disposition QA: all 3,029 U1 facility-specific edges (29,117,045 short tons) were verified as final-landfill destinations using CalRecycle SWIS and EPA GHGRP identifiers. This included 403 edges totaling 3,221,207 short tons at six mixed-name or abbreviated facilities that a name-only classifier had initially misclassified. Non-landfill and unresolved destinations remain on fallback edges outside U1.

Destination code	Destination name	Factor type	State
D01	El Sobrante Landfill	facility-specific	California
D02	Frank R. Bowerman Sanitary LF	facility-specific	California
D03	Olinda Alpha Landfill	facility-specific	California
D04	Sunshine Canyon City/County Landfill	facility-specific	California
D05	Chiquita Canyon Sanitary Landfill	facility-specific	California
D06	Simi Valley Landfill & Recycling Center	facility-specific	California
D07	Otay Landfill	facility-specific	California
D08	Altamont Landfill & Resource Recovery	facility-specific	California
D09	Mid-Valley Sanitary Landfill	facility-specific	California
D10	West Miramar Sanitary Landfill	facility-specific	California
D11	Badlands Sanitary Landfill	facility-specific	California
D12	Recology Ostrom Road LF Inc.	facility-specific	California
D13	Potrero Hills Landfill	facility-specific	California
D14	Forward Landfill, Inc.	facility-specific	California
D15	Recology Hay Road	facility-specific	California
D16	Antelope Valley Public Landfill	facility-specific	California
D17	Corinda Los Trancos Landfill (Ox Mtn)	fallback	California
D18	American Avenue Disposal Site	facility-specific	California
Other	All other destinations (aggregated)	mixed	Not reported

Complete destination key for numbered codes D01–D18 shown in Figure 2; all remaining destinations are aggregated as Other.

SI Table S13. Alternative temporal and responsibility accounting conventions

Table S13. Alternative temporal and responsibility accounting conventions.

Convention	Question and time basis	Main inputs	Appropriate interpretation	Not measured
Contemporaneous-flow attribution	Who receives an annual burden under current flows?	Annual environmental extension plus current transaction, capital-service, or waste-flow shares.	Attributional period account (static EEIO, capital endogenization, WIO).	Historical cohorts or marginal consequences.
Current-flow allocation	Who receives the target-year facility burden under current disposal routing?	Current jurisdiction-to-facility shares × target-year facility intensities.	Municipal application of contemporaneous-flow attribution.	Methane physically generated by current or historical waste cohorts.
Prospective commitment	What lifetime methane commitment is implied by disposed waste composition? Disposal-year mass × lifetime decay and recovery assumptions.	DRS disposal tons; CalRecycle/IPCC composition; GPC/IPCC landfill parameters.	Protocol-based lifecycle commitment sensitivity on pilot cases.	Additive adjustment to current-flow totals or statewide ranking.
Operational historical-routing counterfactual	How would allocations change if historical routing shares were applied to target-year intensities?	Historical routing shares; target-year facility factors; predefined factor-coverage rule.	Pilot routing-window sensitivity; not a settled inventory standard.	Cohort-level physical methane attribution.

Historical physical attribution	What methane was physically generated from historical waste cohorts?	Historical cohorts; decay; recovery; oxidation; facility history (conceptual).	Conceptual contrast only Not reported not implemented in this study.	Implemented estimate or municipal inventory total.
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Alternative accounting conventions (technical summary).

SI Table S14. Historical routing-stability and routing-window pilot results

Table S14. Historical routing-stability and routing-window pilot results.

Metric	Result	Scope or qualification
Pilot cases collected	30	Historical routing pilot scope
Eligible routing-window cases	16	Complete factor coverage only
Valid annual observations	559	Baseline routing stability series
Finite adjacent-year TVD comparisons	530	Non-missing adjacent-year pairs
Median TVD	0.0578	Zero = identical routing; one = no overlap
Routing-window comparisons	62	Pilot routing-window counterfactual pairs
Median absolute allocation difference	22.9%	Versus current-year routing
Maximum absolute allocation difference	68.9%	Pilot maximum
Factor-coverage rule	Complete coverage	Per Phase 2B.3 inclusion rule
Principal exclusions	Incomplete EF coverage; non-finite TVD pairs	Documented pilot exclusions

Historical routing sensitivity : pilot results only.

SI Table S15. Prospective methane-commitment scenarios for paired pilot cases

Table S15. Prospective methane-commitment scenarios for paired pilot cases.

Scenario	Recovery assumption	Commitment intensity	Paired cases	Median commitment/current-flow ratio	Above/below current-flow
A: managed landfill, no recovery	None ($f_{rec} = 0$)	1.395 MT CO ₂ e per short ton	7	8.07	6 above / 1 below
B: hypothetical 35% lifetime recovery	Hypothetical 35% lifetime recovery	0.907 MT CO ₂ e per short ton	7	5.25	6 above / 1 below
D: CalRecycle composition with IPCC DOC defaults	None ($f_{rec} = 0$)	1.163 MT CO ₂ e per short ton	7	6.73	6 above / 1 below
F: protocol-practice 75% recovery sensitivity	75% lifetime recovery sensitivity	0.349 MT CO ₂ e per short ton	7	2.02	5 above / 2 below

Steady-state parity diagnostic. Holding all Scenario A parameters except recovery

fixed, the recovery fraction that makes commitment equal current-flow is $R^* = 1 - ICF/IA$.

Across the seven paired cases, R^* was -2.0% for San Francisco, 54.5% for Fresno, 81.8% for San Jose, 87.6% for Long Beach, 88.4% for Oakland, 90.5% for San Diego, and 98.0% for Riverside–Corona; the median was 87.6%. These are conditional parity values, not measured collection efficiencies.

Protocol-practice benchmark. Manual parameter review covered all 97 California CAP PDFs. Four template-deduplicated jurisdictions applied 75% as a baseline protocol default; five additional jurisdictions used 75% in forecast or mitigation contexts, and several scenarios used 80%, 85%, or 90%. The recurring ICLEI-style parameter set: 0.06 MT CH₄ per wet short ton, 75% capture, 10% oxidation, and GWP100 = 28: yields 0.378 MT CO₂e per short ton and

exactly matches the Ukiah printed factor. Five verified baseline factor observations from Glendale, Ukiah, and South Pasadena ranged from 0.306515 to 0.406243, with a median of 0.378. Applied to the seven paired cases, 0.378 gives a median ratio of 2.19. These values describe municipal accounting practice, not measured statewide physical recovery.

Commitment scenario comparison (Scenarios A, B, F, D; pilot scope).

SI Table S16. California CAP landfill-methane protocol-practice audit

Table S16. Manually verified recovery and factor evidence from the 97-document California CAP corpus.

Evidence class	Verified result	Jurisdictions / examples	Interpretation	Source / page
Baseline 75% protocol default	4 template-duplicated jurisdictions	Alameda, San Diego, Stockton, Ukiah	Recurring accounting default; not measured statewide recovery	
75% forecast / mitigation contexts	5 additional jurisdictions	Anderson, Hollister, Shasta Lake, Stockton, Yucaipa	Kept separate from baseline inventory assumptions	
Higher future capture assumptions	80%, 85%, and 90%	Hollister, San Diego, San Luis Obispo	Shows that future scenarios are not limited to 75%	
Facility-weighted illustration	73%	South Pasadena	Facility-weighted assumption, not protocol default	
Recurring ICLEI-style factor	0.378 MT CO ₂ e/short ton	0.06 CH ₄ yield × 25% uncaptured × 90% unoxidized × GWP 28	Median ratio to paired current-flow = 2.19	
Verified baseline factors	0.306515–0.406243; median 0.378	Five observations, three jurisdictions	Small, heterogeneous sample; no statewide standard	

Note: Recovery observations were classified as baseline inventory assumptions, forecasts, mitigation targets, facility-weighted values, or false positives before summary. Many apparent 75% values referred to SB 1383 organics diversion and were excluded. The primary ICLEI worksheet was not obtained; attribution of 75% to the U.S. Community Protocol is supported by multiple CAP methods statements and the exact 0.378 reconstruction.

SI Table S17. Tonnage-universe bridge, routing completeness, and provenance

Table S17a. Definitions and contextual coverage of the 2019 analytical universes.

Quantity	Short tons	Coverage / scope	Interpretation
Official California landfill-disposal reference	42,200,000	2019 statewide	Contextual published denominator
Place activity total	43,909,961	455 place jurisdictions	Different scope from official total; not directly additive
U0 routed place-level network	30,750,592	356 jurisdictions; 3,450 edges; 72.87% of official	Primary route network
U1 facility-specific matched final-landfill subset	29,117,045	355 jurisdictions; 3,029 edges; 94.69% of U0; 69.00% of official	Primary current-flow universe
Fallback tonnage in U0 but excluded from U1	1,633,547	421 edges	Enters only labeled fallback analyses
County / unincorporated routing	8,057,766	Separate universe	Excluded from incorporated-place U0

Note: U0 and U1 are calendar-year 2019 DRS edge sums. The official total and place activity table use partly different jurisdiction and disposition scopes. The 94.69% figure is U1/U0, not statewide coverage.

Table S17b. Routing-completeness categories relative to the place activity universe.

Routing status	Jurisdictions	Tonnage / example	Interpretation
Complete or near-complete ($\geq 95\%$)	282	21,533,298 routed tons	Strong route representation
Partial routing	63	Includes Los Angeles at $\sim 46\%$ routed coverage	Systematic incompleteness
Zero routing with positive activity	110	6,669,555 activity tons	Absent from U0
Routing-only, no activity record	11	182,772 routed tons	Attribution mismatch

Route missingness was systematic. Complete- and zero-routing jurisdictions differed in disposal tons, population, and per-capita disposal (Mann-Whitney $p = 0.012$, 1.8×10^{-10} , and 2.2×10^{-14}). The 337-jurisdiction comparison sample therefore represents jurisdictions with facility-specific routing rather than all place jurisdictions or statewide disposal.

Provenance and transfer QA. The canonical landfills_final_output.csv is retained as a checksum-controlled frozen derived input because its original builder was unavailable. The scientific workflow reproduces from local inputs and scripts without Supabase. DRS records form a single-hop jurisdiction-to-destination schema; no evidence of transfer-to-landfill double

counting was found, and the authoritative facility crosswalk excludes non-landfill destinations from U1.