

Opportunity Explorer

Full methodology and data-source record

Version 1.0

Issued 28 August 2026

Applies to public map v0.12 and locked analytical baseline through Stage 3B.10

Important status

This is a strategic screening methodology. It does not determine planning suitability, legal ownership, title control, developable capacity, viability or the outcome of a planning application.

The report follows the engine from the policy question to the public map. Each chapter states the decision taken, the data used, the spatial or analytical operation, the quality controls and the practical limitation. Source identifiers such as [S6] refer to the full source register in Appendix B.

- **“Candidate site”** means a pre-screened polygon assembled by the method; it does not mean an allocated, available or deliverable development site.
- **“Context” or “review signal”** means mapped evidence that warrants examination; it is not an automatic planning conclusion.
- **“Coverage”** means exact area overlap between polygons; it is not a distance from a single point.
- **“Capacity”** is policy-density arithmetic over the in-catchment area; it is not a housing-supply forecast.

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Executive summary

The NPPF Sites Opportunity Explorer has been built to make a complex national screening task transparent and repeatable: identify registered freehold land around existing, well-connected public transport stations in the strongest travel-to-work economies; assemble credible site polygons without allowing minor titles to join sites indiscriminately; attach neutral evidence; and separate strategic opportunity from the amount of review likely to be required.

From policy question to public screening engine

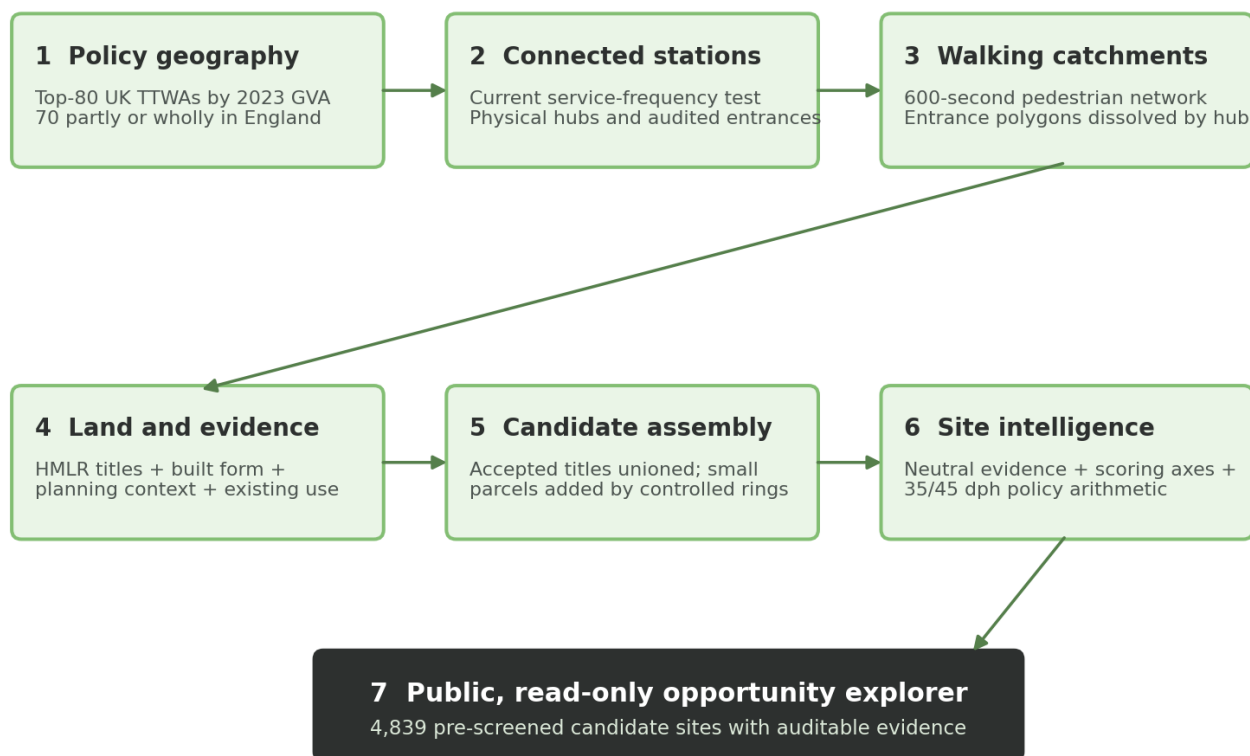


Figure 1. The seven-stage analytical and delivery pipeline.

The central methodological choices

Choice	Reason and effect
Economic geography before local boundaries	The national search starts with the UK Top 80 2011 Travel to Work Areas ranked by ONS 2023 GVA, then retains those partly or wholly in England. This produces 70 eligible TTWAs and preserves relevant cross-border labour markets.
Service evidence before map labels	A station qualifies from a normal weekday passenger-service test, not because a map happens to show it. Heritage railways are excluded; fixed-guideway people movers are included as an explicit interpretation.
Entrances before centroids	Walking is routed from audited passenger access points. A station centroid is not substituted where real entrances exist. Multiple entrance catchments are dissolved into one physical-hub catchment.
Network time before radius	The primary geography is a 600-second pedestrian-network isochrone (800m @ 1.33 m/s).
Polygon overlap before point tests	A site's in-catchment share is the exact intersection area between its polygon and the union of relevant catchment polygons, divided by the whole site area.
Controlled assembly before blanket adjacency	Small titles may enlarge one existing assembly only where affirmative use evidence and context rules allow it. They cannot silently bridge two sites.

Choice	Reason and effect
Two axes before a single ranking	Opportunity Strength is shown separately from Delivery/Review Complexity so mapped constraints do not erase the strategic signal.
Spatial density before gross-site multiplication	45 dph is applied only to land reached by confirmed twice-minimum station catchments; 35 dph applies to the remaining in-catchment land. Outside land receives neither.

Headline analytical baseline

Measure	Locked result
Eligible TTWAs	70
Qualifying mode/station nodes	1,778
Physical station hubs	1,687
Audited walking origins	3,231
Routed representative origins	2,412
Raw isochrones	4,824 in 483 complete batches
HMLR freehold polygons intersecting catchments	2,674,852 unique polygons
Large-title screening population	79,327 titles at least 0.25 ha
Locked candidate sites	4,839 sites, 7,768 title members, 5,516.173 ha
Sites at least 99.9% within the 600-second network catchment	4,225

What “no filters” means on the map

It means all 4,839 pre-screened candidates in the locked Stage 2F universe. It does not mean every HMLR title that intersects a station catchment.

1. Purpose, scope and methodological principles

1.1 The analytical question

“Where does registered freehold land around existing well-connected stations in leading economic travel-to-work areas show a combination of strategic accessibility, scale and regeneration evidence that merits further investigation?”

The question was deliberately framed around evidence that can be assembled consistently across England. It does not attempt to replace the local planning evidence that ultimately determines whether development is suitable, available, achievable or deliverable.

1.2 Coordinate systems and spatial precision

Web and source services commonly supply coordinates in WGS84 (EPSG:4326). Final area, distance, overlap and shape operations were transformed to British National Grid (EPSG:27700), which is appropriate for metre- and square-metre-based work across Great Britain. This avoids treating latitude/longitude degrees as planar metres.

Source geometries were validated and repaired where necessary before intersection. Broad source retrieval could use a bounding box or representative point for efficiency, but final site evidence was only accepted after the documented exact operation. Where a source is inherently generalised, its result remains a screening signal even when the intersection itself is mathematically exact.

1.3 What the engine does not decide

- planning policy compliance or planning balance;
- land availability, ownership intent or control;
- definitive legal title boundaries or rights;
- highway, utilities or access feasibility;
- design capacity, daylight, amenity, open-space or infrastructure requirements;
- viability, abnormal costs, contamination or market demand;
- whether a source dataset’s absence proves that no constraint exists.

2. Policy geography: selecting the economic areas

2.1 Why Travel to Work Areas were used

Travel to Work Areas (TTWAs) describe functional labour-market geographies rather than administrative boundaries. It was decided that this was the most appropriate national frame for a station-led economic opportunity screen because commuting and employment markets commonly cross local-authority borders. The TTWA boundaries were taken from the ONS Open Geography Portal [S1].

2.2 Ranking and England eligibility

1. All 228 UK TTWAs were ranked by total 2023 Gross Value Added using the ONS 1998–2023 release [S2].
2. The UK Top 80 were selected before any England filter was applied. This avoids an England-only reranking that would change the policy interpretation.
3. A TTWA was retained where it lay partly or wholly in England. The result was 70 eligible TTWAs.
4. An England-only rank was retained as a sensitivity field, but it does not replace the UK rank in the primary method.

Cross-border treatment

Chester (UK rank 34) and Newport (UK rank 63) were retained because their functional TTWAs extend into England. Ten Top-80 TTWAs with no English land were excluded: Glasgow, Edinburgh, Belfast, Cardiff, Aberdeen, Motherwell & Airdrie, Swansea, Falkirk & Stirling, Dunfermline & Kirkcaldy and Livingston.

2.3 Boundary effect

The TTWA test determines whether a station enters the national station universe. Once a station qualifies, its 600-second catchment is not clipped back to the TTWA boundary. This is intentional: a policy geography selects the station, while actual pedestrian reach determines the surrounding land. Clipping would create artificial edges through streets and sites.

3. Identifying well-connected stations

3.1 Included and excluded modes

The station universe covers existing railway, Underground, tram and light-rail stops in the eligible TTWAs. Fixed-guideway people movers were included as an explicit project interpretation because they provide regular passenger movement on a defined alignment. Heritage and tourist railways were excluded because they do not represent the normal weekday public-transport offer. The London cable car was excluded. NaPTAN provided the national access-node framework [S3].

Treatment	Examples / rule
Included	National Rail, London Underground, metros, trams, light rail and qualifying fixed-guideway people movers.
Excluded	Heritage or tourist railways; 62 audited records were excluded on this basis.
Explicit interpretation	Fixed-guideway people movers included; London cable car excluded.
Physical hub	Interchange modes at one place are de-duplicated for site relationships, while all relevant entrances remain available for routing.

3.2 Current weekday service-frequency test

A station was treated as well connected where a normal weekday daytime timetable showed at least four passenger services per hour overall, or at least two services per hour in one direction. The directional limb was designed to recognise a strong usable corridor even where the total stopping pattern is asymmetric.

Minimum service test

qualifies if total services ≥ 4 per hour OR same-direction services ≥ 2 per hour

The test is applied to current passenger calls in the selected daytime window.

It was decided to use 09:00–16:59/17:00 as the core window and retain 06:00–22:59/23:00 as an extended sensitivity. Marginal cases were marked for review rather than being concealed inside the headline result.

3.3 Timetable processing

National Rail passenger timetable data were the primary rail source, supported by official operator and network timetables for quality assurance [S4]. The timetable parser applied the following controls:

- short-term overlays and cancellations take precedence over permanent schedules;
- activity codes identify genuine passenger calls; unadvertised “N” calls are excluded;
- the working timetable is used only as operational QA, not as the public passenger-service baseline;
- a direction qualifies only when onward stops fall within a 45-degree same-corridor travel-bearing arc, rather than a broad compass quadrant.

The tightened directional method produced 41 genuine directional-limb qualifiers after four false cases produced by the earlier broad-sector approach were removed.

3.4 Twice-minimum classification

A second service class supports the policy-density calculation. A mode/station node is “twice minimum” where it has at least eight services per hour overall, or at least four per hour in one direction. This does not create a different site universe; it determines whether qualifying catchment land receives the 45 dph or 35 dph policy tier in the capacity screen.

Unit	Twice minimum	Not twice minimum	Total
Qualifying mode/station nodes	1,257	521	1,778
Physical station hubs	1,170	517	1,687

3.5 Existing and future stations

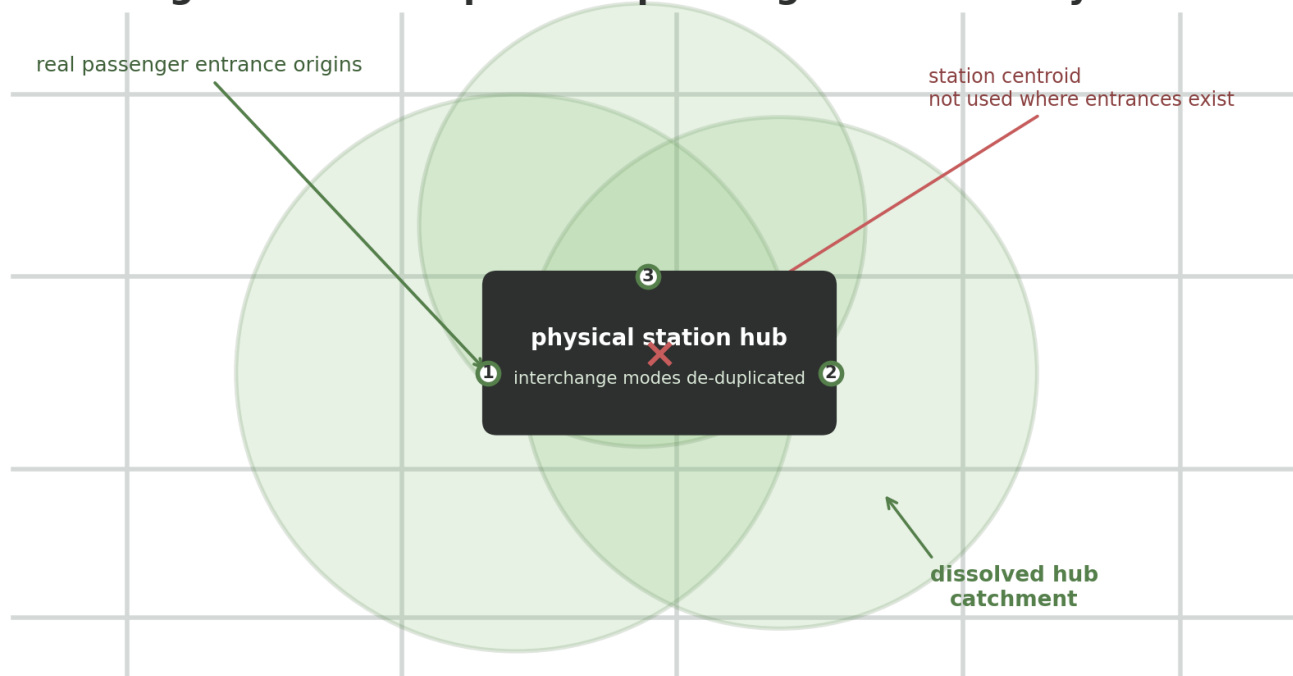
The locked baseline contains the current existing network. Potential future accessibility is deliberately stored as a separate living evidence layer, with categories such as committed, operator agreement and potential/review. It was not folded into the existing-network baseline, because doing so would make a present accessibility result depend on schemes at different levels of certainty.

4. Building the pedestrian-network catchments

4.1 Why station entrances were used

Walking begins where a passenger can enter the station, not at a label point in the middle of a station footprint, track fan or interchange complex. It was therefore decided to use NaPTAN rail-station entrance and metro/tram access points as the routing origins wherever they were available [S3].

Walking starts at the places a passenger can actually enter



The 600-second polygons from every routed entrance are unioned into one catchment for the physical hub.

Figure 2. Multiple real entrance origins are routed and then dissolved into one physical-hub catchment; a known station centroid is not used as a substitute.

Origin audit	Result
Audited origins	3,231
Actual NaPTAN RSE/TMU entrances	3,111
Station/access-area fallbacks	120
Representative routed origins	2,412
Maximum entrance-to-representative displacement	40 m

Where entrances at the same physical hub were within 40 m of one another, one real entrance could represent the cluster for the national routing run. This reduced duplicate requests without replacing passenger access with a station centroid. The full origin audit was retained, so the simplification is explicit and reversible.

4.2 Routing model

The primary catchments were generated using the openrouteservice foot-walking profile and OpenStreetMap network data [S11, S12]. The request used a destination-style isochrone and avoided ferries and fords. Each origin produced two contours:

- **600 seconds:** the production definition of a ten-minute pedestrian-network catchment.
- **576 seconds:** a QA calibration corresponding to 800 m at the routing engine's nominal 5 km/h walking speed.

An 800 m Euclidean circle was retained only as a visual and statistical reference. It is not the primary search geometry, because it ignores barriers, available streets and paths, bridge locations and the placement of station entrances.

4.3 Contour normalisation

Isochrone services generalise contour polygons independently. At 545 origins, small fragments of the 576-second contour fell outside the separately generated 600-second contour even though a shorter time band should logically be nested inside the longer one. The production 600-second geometry was therefore normalised as the union of the raw 600-second and raw 576-second polygons.

Normalised origin catchment

$$C_{600, \text{normalised}} = C_{600, \text{raw}} \cup C_{576, \text{raw}}$$

The correction added 139.50 ha nationally before entrance catchments were dissolved by physical hub.

Why this is a QA correction, not a policy extension

The union repairs a contour-generalisation inconsistency between two outputs from the same walking model. It does not add an 800 m radial area and does not extend the time threshold beyond 600 seconds.

4.4 Physical-hub dissolve

All normalised 600-second polygons belonging to entrances at the same physical station hub were unioned. This produces one coherent catchment for each of the 1,687 hubs, while retaining the individual entrance evidence for audit. Interchanges therefore do not appear as multiple stations merely because several modes or platforms are recorded.

5. Land-title framework and exact catchment coverage

5.1 HMLR INSPIRE as the national parcel framework

HM Land Registry INSPIRE Index Polygons were used as the open national framework for registered freehold parcels [S5]. The data are suitable for strategic spatial screening but are indicative cadastral extents, not definitive legal title plans. They do not supply leasehold interests, proprietors or evidence of control.

5.2 Extraction population

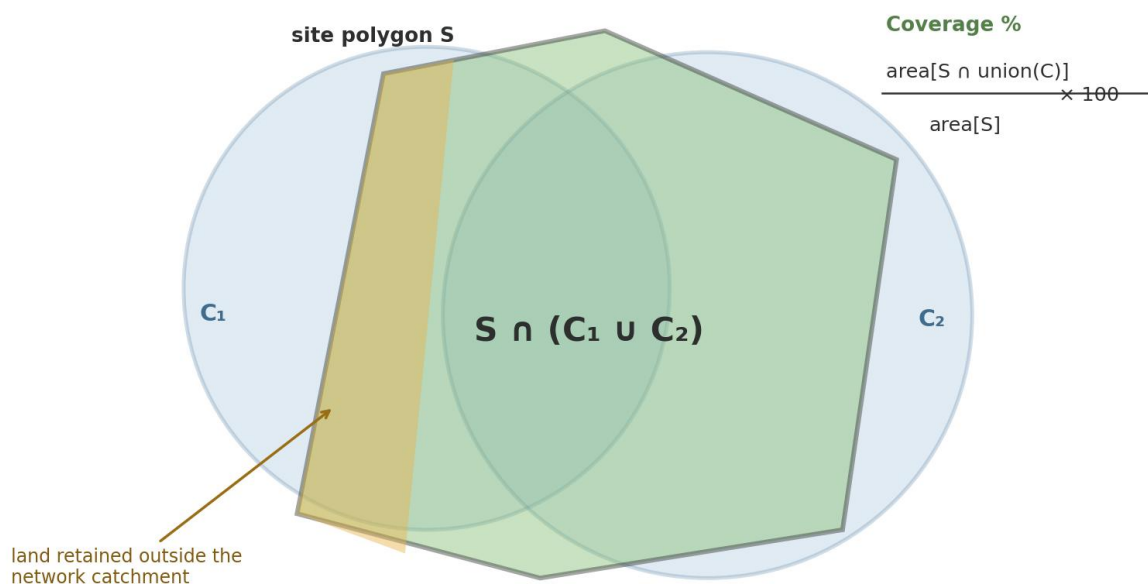
No minimum size was imposed when titles were first extracted. This preserved small parcels for later controlled assembly instead of deleting them before their relationship to a larger opportunity could be tested.

Population	Count / purpose
Unique HMLR freehold polygons intersecting at least one qualifying catchment	2,674,852
Titles at least 0.25 ha passed to the large-title evidence screen	79,327
Sub-0.25 ha titles	Retained separately for controlled adjacency growth

5.3 Exact title and site coverage

A point-in-polygon test would answer only whether one chosen point lies inside a catchment. It would not distinguish a site that is almost wholly accessible from one that barely clips the catchment. It was therefore decided to retain the full polygons and calculate area intersections.

Exact polygon overlay measures how much of each site is reachable



The same overlay is also calculated separately against each physical station hub catchment.

Figure 3. Site coverage is an exact area ratio against the union of all relevant 600-second catchments; per-station overlaps are also retained.

Walk coverage percentage

$$\text{coverage}(S) = \text{area}[S \cap \text{union}(C_1 \dots C_n)] \div \text{area}[S] \times 100$$

S is the whole title or assembled site polygon; $C_1 \dots C_n$ are the relevant physical-hub 600-second catchments.

The same intersection is stored separately for every relevant station hub. This preserves multi-station accessibility, supports the map's station relationships and allows the 35/45 dph calculation to operate on spatially distinct catchments.

5.4 Partial sites

A parcel was not automatically discarded merely because part of it falls outside the 600-second network catchment. The whole site polygon is retained, the accessible share is measured, and only the in-catchment land contributes to policy-density capacity. This keeps the physical land assembly visible while preventing outside land from receiving an accessibility-derived density.

Coverage result

Of the 4,839 locked candidate sites, 4,225 are at least 99.9% within the 600-second pedestrian-network catchment.

6. Three evidence families: built form, planning context and existing use

It was decided to build three independent evidence families before candidate assembly. They answer different questions and should not be conflated: what is physically built, what mapped planning or environmental contexts apply, and what the land appears to be used for.

6.1 Built-form evidence

OS OpenMap Local generalised building footprints were used in British National Grid [S7]. The national processing covered 20 OS grid downloads and scanned 12,785,290 building features, 32,637 functional sites, 805 glasshouses and 207,616 important buildings.

For title pre-screening, ordinary building footprints were assigned by the footprint centroid to avoid double-counting a generalised building across neighbouring titles. Buildings crossing a title edge were counted separately. The title building-coverage measure was:

Title built-form coverage

$$\text{centroid-assigned generalised building footprint area} \div \text{title area} \times 100$$

This is a screening measure derived from generalised mapping, not a cadastral measurement of site coverage.

Functional Site polygons were intersected, while Important Building and glasshouse counts and themes were retained. Planning Data brownfield land was also attached, but its representative-point evidence was not misdescribed as complete polygon coverage [S9].

Final-site correction

For the locked final sites, building coverage was rebuilt from the union of OS building footprints intersected directly with each assembled site. This removed overlap/deduplication artefacts, ensured values did not exceed 100%, and the earlier title metric was not used in the current v0.2 score.

6.2 Planning and environmental context

Twenty-five current-period Planning Data datasets were retrieved [S9]. Broad bounding-box or point screening was used only to collect potentially relevant records; the original WKT geometry was retained and transformed for final exact intersection in EPSG:27700.

The layers cover policy, flood, heritage, ecological, landscape, local-control and infrastructure contexts. They are listed in Appendix C. High-sensitivity contexts could prevent automatic parcel growth; they did not amount to a planning refusal. Green Belt was retained as policy context and was not treated as an automatic negative in the opportunity score.

Absence is not proof

Planning Data coverage varies by dataset and provider. A site with no returned feature must not be described as unconstrained without checking authoritative local and national sources.

6.3 Existing-use evidence

Existing-use signals were assembled from OS Open Greenspace [S8] and OpenStreetMap extracts supplied through Geofabrik [S10, S11]. The OSM families included landuse polygons, POI areas, traffic areas and transport areas. The processing scanned 2,844,128 OSM polygon features across those families and retained 205,163 relevant records; OS Open Greenspace added 17,547 relevant features.

Two evidence strengths were recorded. A polygon intersection shows that an activity touches a title. A feature centroid inside the title is treated as stronger evidence that the use belongs to that title. Proxy feature-area percentages remain screening indicators and are not legal land-use surveys.

Use signal	Examples	Effect in screening
Priority redevelopment evidence	Employment, industrial or commercial use; surface parking; large retail; brownfield recorded separately	Can support a seed or controlled small-parcel inclusion, subject to context.
Secondary redevelopment evidence	Other mapped opportunity uses	Can support a screening cohort, subject to the locked seed logic and review.
Inhibit / review evidence	Residential, greenspace, institutional, open/natural, recreation and transport-complex uses	Prevents automatic propagation or sends the parcel to review.
Ambiguous / no mapped use	No affirmative centroid evidence or only uncertain intersection	Does not automatically propagate.

7. Controlled candidate-site assembly

7.1 Why titles were assembled

A development opportunity can span more than one registered title, while one legal title can also contain land outside the walking catchment. It was therefore decided that the public candidate should be a physical union of accepted title polygons, not simply a list of raw title records. Internal title boundaries disappear from the displayed site geometry, but title-member counts and fragmentation metrics remain available.

7.2 Initial large-title assembly

The 79,327 titles of at least 0.25 ha were evaluated against redevelopment, built-form, existing-use and high-sensitivity evidence. Accepted touching titles could form an initial physical assembly. A block field inhibited automatic grouping where context or mapped use required review; it did not label the land unsuitable.

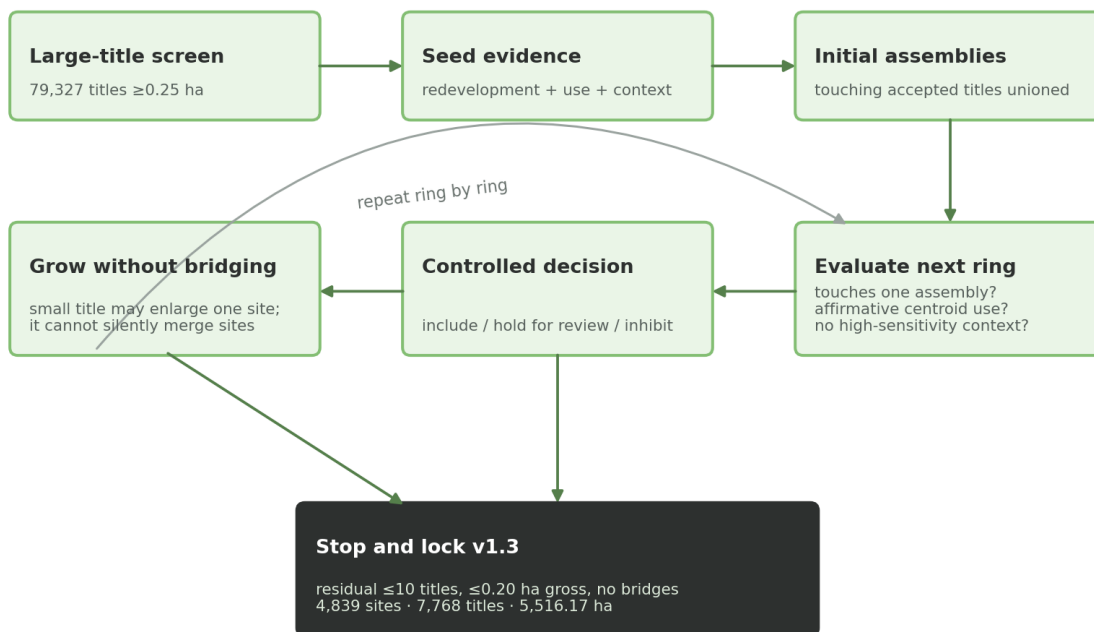
7.3 Controlled small-title growth

Sub-0.25 ha titles were then evaluated ring by ring around existing assemblies. A small title could be automatically included only where all the following conditions were met:

- it touched one existing assembly, rather than bridging two candidate sites;

- conservative affirmative centroid-use evidence supported inclusion;
- no positive high-sensitivity context was present;
- intersection-only redevelopment evidence was treated as review-only;
- residential, greenspace or institutional centroid evidence inhibited automatic inclusion;
- ambiguous, unmapped, open, natural or recreation evidence did not propagate;
- an unclassified residual parcel could never become the basis for further automatic growth.

Controlled assembly prevents small parcels from bridging sites by accident



Unclassified residual parcels never propagate. Intersection-only evidence is review-only; centroid evidence is stronger.

Figure 4. The ring-by-ring controlled-assembly logic and locked stopping rule.

7.4 Growth audit

Ring	Frontier reviewed	Added	Area added
First	55,519	1,454	160.316 ha
Second	2,877	165	13.582 ha
Third	282	25	2.068 ha
Fourth	64	3	0.340 ha
Residual fifth	8	0; held for review	0.185454 ha gross
Total included growth	—	1,647	176.307 ha

The stopping rule was reached when the residual was no more than ten titles, no more than 0.20 ha gross and contained no multi-site bridge. The eight residual fifth-ring titles affected only two sites and were held for professional review rather than being allowed to propagate.

7.5 Locked candidate geometry

Measure	Stage 2F v1.3
Candidate sites	4,839
Accepted title members	7,768
Total assembled area	5,516.173 ha
Derived accepted parcels before controlled growth	6,121 (audit arithmetic only)

Interpretation

A candidate site is the output of this conservative pre-screen and assembly process. It is not a representation of every title in the catchment and is not an allocation, availability statement or ownership conclusion.

8. Neutral site intelligence

8.1 Evidence before weighting

Stage 2G was deliberately neutral. It attached exact site geometry and evidence to each of the 4,839 locked candidate polygons before any weighting was chosen. This preserves the ability to inspect a source field independently of the public score.

8.2 Title fragmentation and concentration

Actual proprietor data are not available in the open INSPIRE product. Delivery measures are therefore geometric title-fragmentation proxies, not ownership or control measures. The engine stores the number of title members, the largest-title share, the top-three share, a Herfindahl–Hirschman concentration index and an effective title count.

Title concentration

$$HHI = \sum s_i^2 \quad \text{and} \quad \text{effective title count} = 1 \div HHI$$

s_i is each title member's share of the assembled site area. A concentrated site has a higher HHI and lower effective title count.

Title-member class	Sites
Single title	3,247
Two to three titles	1,299
Four or more titles	293
Ten to twenty-four titles	16

8.3 Shape indicators

Three shape measures help users identify awkward geometry without pretending to determine design feasibility:

- **Polsby–Popper compactness:** $4\pi A/P^2$, where 1 is maximally compact and lower values indicate a more irregular perimeter.
- **Convex-hull fill:** site area divided by convex-hull area, expressed as a percentage.

- **Minimum rotated rectangle aspect ratio:** the long side divided by the short side of the smallest oriented bounding rectangle.

8.4 Exact final-site context

Final site polygons were intersected against the retained Planning Data geometries. The most frequent mapped contexts in the locked evidence were Article 4 areas (1,100 sites), conservation areas (792), Flood Zone 2 (437), tree-preservation zones (195), nutrient-neutrality catchments (146), heritage-at-risk records (140) and Green Belt (129).

There were 2,575 sites with no mapped Stage 2D context and 2,264 with one or more. In the extracted evidence, no locked site intersected Flood Zone 3, a listed-building outline, scheduled monument, ancient woodland, SSSI, SAC, SPA, Ramsar site, NNR, registered park and garden, World Heritage Site, National Park, National Landscape/AONB or infrastructure-project polygon. This is a statement about the retained source snapshot, not a warranty that no such issue exists.

8.5 Redevelopment evidence highlights

Evidence	Sites
Surface parking	3,183
Employment-related use	1,793
Brownfield evidence	1,187
Large retail	622

9. The two-axis screening model

9.1 Why two axes were adopted

It was decided that a single score would conflate two different questions: how strong is the strategic opportunity signal, and how much mapped delivery or review complexity is present? The public calibration therefore reports Opportunity Strength separately from Delivery/Review Complexity.

The model separates strategic signal from review burden



Figure 5. A high strategic signal can coexist with a high need for review; neither axis substitutes for professional appraisal.

9.2 Opportunity Strength

Component	Weight	Calculation
Accessibility	33.3333%	90% direct 600-second site coverage + 10% multi-station bonus. Bonus: one station 0, two 50, three or more 100.
Economic / TTWA	13.3333%	$100 \times (80 - \text{UK GVA rank}) \div 79$.
Scale	20.0000%	Percentile rank of $\log(1 + \text{assembled site area})$.
Regeneration / redevelopment	33.3333%	$60\% \times (\text{redevelopment evidence-type count} \div 4) + 40\% \text{ brownfield binary}$.

Opportunity Strength

$$O = 0.333333A + 0.133333E + 0.20S + 0.333333R$$

All component scores are normalised to 0–100 before weighting.

Accessibility coverage is clamped to 0–100 and rounded after the exact polygon operation. The multi-station bonus rewards choice and resilience but remains deliberately smaller than direct site coverage. The scale component uses a logarithm and percentile so a few very large sites do not overwhelm the distribution.

Built-form coverage is not used in the current v0.2 Opportunity Strength score. It remains contextual evidence.

9.3 Delivery readiness and review complexity

Readiness component	Weight	Calculation
Title simplicity	46.153846%	$55\% \times (100 \div \text{effective title count}) + 45\% \times \text{largest-title share}.$
Context simplicity	38.461538%	$55\% \times \max(0, 100 - 25 \times \text{review-layer count}) + 45\% \times \max(0, 100 - \min(\text{overlap-sum}, 100)).$ Green Belt excluded.
Shape	15.384615%	Retained composite shape component from the earlier calibration.

Delivery / Review Complexity

$$\text{complexity} = 100 - \text{delivery readiness}$$

A higher complexity score means more mapped matters to investigate; it is not a probability of failure.

Score interpretation

The current map displays a calibrated screening indicator. It does not rank planning prospects, predict consent or value land. Review contexts do not reduce Opportunity Strength; they appear on the separate complexity axis and in the detailed evidence.

9.4 Top-band convention

The public interface can display the Top 20% Opportunity band. With 4,839 candidate sites, that band contains 968 records. It is a distributional screen, not a policy threshold.

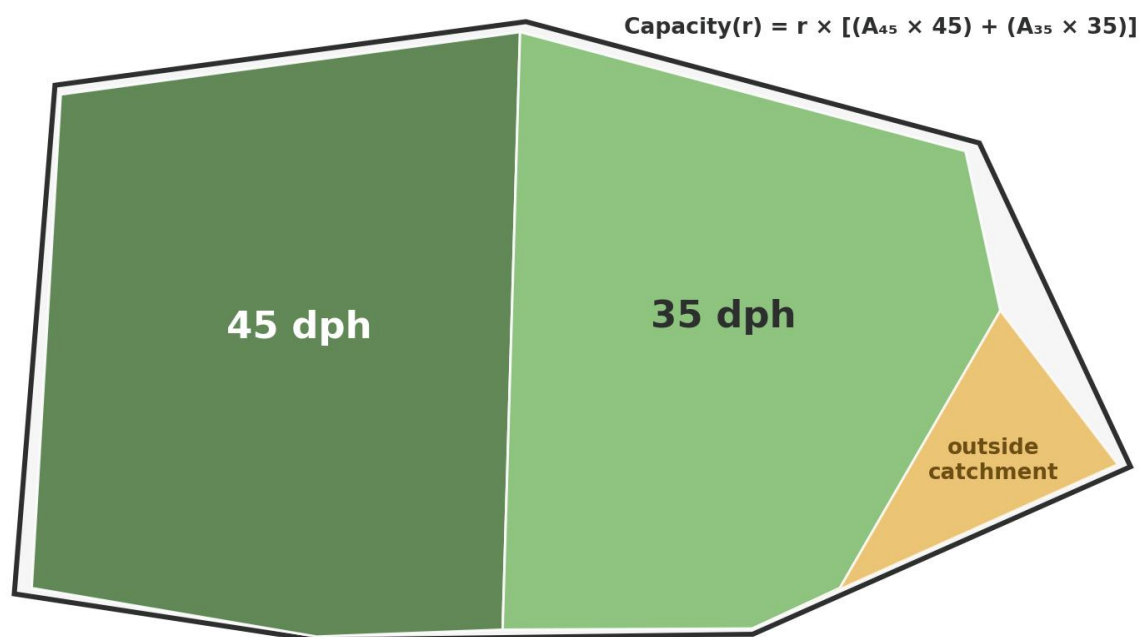
10. Policy-density and capacity arithmetic

10.1 Spatial allocation of 45 and 35 dph

Capacity was calculated by overlaying the locked site polygon with the confirmed station-hub catchments, rather than multiplying the whole gross site by a single density. The sequence is:

1. Intersect the site with the union of confirmed twice-minimum 600-second catchments. This becomes the 45 dph area.
2. Intersect the remaining in-catchment land with confirmed qualifying-but-not-twice-minimum catchments. This becomes the 35 dph-only area.
3. Where the two catchment classes overlap, 45 dph takes precedence.
4. Land outside both classes receives no policy density.

Only the in-catchment parts of a site receive the policy density



Where 35 dph and 45 dph catchments overlap, 45 dph takes precedence; land outside both receives no density.

Figure 6. Capacity is calculated from spatially partitioned in-catchment hectares; the outside part of a site is retained but receives no density.

10.2 Net-area sensitivities

Capacity at net ratio r

$$\text{capacity}(r) = r \times [(45\text{-area ha} \times 45) + (35\text{-area ha} \times 35)]$$

Sensitivities are reported at $r = 65\%$, 75% , 85% and 100% ; 75% is a reference case, not an adopted design assumption.

Existing building coverage is retained as context and is not automatically deducted. A real capacity appraisal would also need design, access, infrastructure, open-space, flood, heritage, ecological, amenity, mix and viability assumptions.

Spatial class	Sites
45 dph throughout the in-catchment area	3,450
35 dph throughout the in-catchment area	1,360
Mixed 45/35 dph	29

The 75% reference arithmetic totals 168,265 homes across the national candidate universe, with 276 sites at or above 100 homes. These are screening quantities, not a forecast, allocation or contribution to housing supply.

11. Location and accessibility enrichment

11.1 Postcode and ONS geography

All 4,839 site representative points were joined locally to the nearest current postcode in the ONS Postcode Directory, May 2026 [S15]. The join also supplied OA21, LSOA21, MSOA21 and LAD25 codes. No candidate coordinates were transmitted to a public geocoding service.

The greatest nearest-postcode distance was 341.411 m. These geography codes describe the geography attached to the nearest postcode, not the result of intersecting the entire site polygon with an administrative boundary. That distinction is retained in the metadata.

11.2 GLA Sustainable Access Measure

For London, the Greater London Authority Sustainable Access Measure (SAM) source polygons were downloaded from the Draft London Plan 2026 evidence package [S13]. All 112,105 source features were transformed and intersected locally with the locked site polygons.

The engine records the dominant class, dominant percentage, total SAM coverage, best and worst class and class-area shares. This exact polygon approach is more informative than assigning the value at a site centroid. It produced SAM evidence for 1,217 sites; seven London-context sites had no source intersection.

11.3 TfL PTAL 2023

The complete TfL PTAL 2023 100 m grid was retrieved from the official GIS Open Data Hub [S14]. A completeness check required 159,451 unique grid points before results were accepted. All 1,224 London-context sites received evidence.

PTAL join basis	Sites	Rule
Within-site grid point	736	The representative point is the grid point closest to the site representative point; minimum and maximum PTAL values within the site are retained.
Nearest grid point	488	Used only for small sites with no point inside, subject to a 150 m control. Maximum observed distance: 68.047 m.

No borough, OA or LSOA average was substituted. PTAL remains a strategic accessibility indicator and should be interpreted in line with TfL's WebCAT guidance.

11.4 DfT Connectivity

The schema and public interface can store the DfT 100 m connectivity measures: overall sustainable connectivity (excluding driving), public transport, walking and cycling [S16, S17]. However, no exact-grid values were loaded into the locked baseline because an authoritative supported bulk route had not been confirmed. OA or LSOA averages were not presented as exact site scores.

Current treatment

The DfT card is hidden when exact evidence is absent. It will activate automatically only after an approved, reproducible 100 m enrichment is loaded and quality assured. This is preferable to showing a dead field or a misleading area proxy.

11.5 Neutrality of enrichment

Postcode, ONS geography, SAM and PTAL are neutral evidence fields. Their addition did not alter the locked candidate geometry, Opportunity Strength, Delivery/Review Complexity or capacity arithmetic.

12. Public interface, filtering and user data

12.1 Read-only delivery

The analytical data are delivered through a public, read-only web application. Visitors do not log in and cannot write to the project evidence store. The interface presents candidate polygons, physical station hubs, 600-second walking catchments, filters, site details, charts and CSV outputs. The basemap uses MapLibre with OpenFreeMap/OpenMapTiles and OpenStreetMap attribution [S18].

12.2 Filters and map view

Filters reduce the locked universe of 4,839 pre-screened candidates. The results list can show either all candidates meeting the filter criteria or only the filtered candidates currently visible in the map extent. Changing the map extent does not change the underlying analytical score; it changes only which filtered records are in view.

12.3 Shortlists

A visitor can add candidate sites to a shortlist and open the shortlist view from the results panel. The shortlist is stored in the browser's local storage under the website domain. It is not sent to the application database and is not shared with Velocity or other users.

Behaviour	Practical effect
Same browser profile, device and domain	The shortlist is restored on a later visit.
Different browser or device	A separate shortlist is created.
Private/incognito mode	The shortlist normally disappears when the private session ends.
Browser/site data cleared	The shortlist is removed.
Shared device and browser profile	People using that same profile can see the same local shortlist.
Domain changes	Local storage does not automatically transfer between domains; CSV export is the portable record.

13. Use and Limitations

13.1 Appropriate use

The engine is most useful for national and regional market scanning, portfolio triage, comparative station-area research, early policy conversations and identifying where deeper work may be worthwhile. A professional follow-up should verify the site boundary, ownership/control, local plan, designations, flood risk, access, servicing, infrastructure, viability, availability and current planning history.

13.2 Known limitations

Limitation	Implication
Policy version	The August 2026 NPPF requires a concordance and, if necessary, recalibration.
HMLR INSPIRE	Indicative registered-freehold extents only; not definitive legal boundaries, leases, proprietors or control.
Timetables	A dated normal-weekday snapshot; temporary patterns and future services are not the current baseline.

Limitation	Implication
Pedestrian network	Dependent on source-network completeness, routing profile and entrance coding; not a site visit or accessibility audit.
Planning Data	Coverage and currency vary by dataset/provider. Absence is not proof of no constraint.
OS/OSM use evidence	Generalised or volunteered mapping is a strategic proxy, not a lawful-use or occupation determination.
Seed-tier provenance	The exact archived Priority-led/Secondary-led wording is unavailable and has not been reverse-engineered.
Fragmentation	Title geometry proxies are not proprietor counts or evidence of assembly control.
Scoring	A calibrated comparison tool, not a probability, valuation or planning judgement.
Capacity	Policy-density arithmetic only; no design, infrastructure, mix, viability or deliverability conclusion.
DfT connectivity	Exact 100 m values are pending; coarser area averages are not substituted.

Appendix A — Formula and decision-rule register

Measure	Rule	Interpretation
TTWA economic score	$100 \times (80 - \text{UK GVA rank}) \div 79$	Rank 1 scores 100; rank 80 scores 0.
Current station minimum	total ≥ 4 /hour OR same direction ≥ 2 /hour	Core weekday daytime window; extended window retained as sensitivity.
Twice minimum	total ≥ 8 /hour OR same direction ≥ 4 /hour	Supports 45 dph classification.
Normalised 600 s catchment	raw 600 s U raw 576 s	Repairs independent contour-generalisation nesting anomalies.
Site walk coverage	$\text{area}[S \cap \text{union}(C)] \div \text{area}[S] \times 100$	Exact polygon ratio in EPSG:27700.
Polsby–Popper	$4\pi A/P^2$	Compactness from 0 to 1.
HHI	$\sum s_i^2$	Area-share concentration of title members.
Effective title count	$1 \div \text{HHI}$	Fragmentation proxy, not proprietor count.
Accessibility component	$0.90 \times \text{coverage} + 0.10 \times \text{station bonus}$	Bonus: 1 station 0; 2 =50; ≥ 3 =100.
Regeneration component	$0.60 \times (\text{evidence types}/4) + 0.40 \times \text{brownfield}$	Normalised to 0–100.
Opportunity Strength	$0.333333A + 0.133333E + 0.20S + 0.333333R$	Separate from complexity.
Title simplicity	$0.55 \times (100/\text{effective count}) + 0.45 \times \text{largest share}$	Delivery-readiness input.
Context simplicity	$0.55 \times \max(0, 100 - 25n) + 0.45 \times \max(0, 100 - \min(o, 100))$	n = review-layer count; o = overlap sum; Green Belt excluded.
Complexity	100 – delivery readiness	Higher means more mapped review need.
Capacity	$r \times [(A45 \times 45) + (A35 \times 35)]$	r = 65%, 75%, 85% or 100%; hectares used.

Appendix B — Source and attribution register

The table identifies the external information sources drawn on to build or present the engine. URLs were checked on 28 August 2026 unless noted. A source licence governs reuse of the source material; it does not constitute endorsement of the engine or its conclusions.

S1	ONS Travel to Work Areas (December 2011) Boundaries UK BGC (V3) Use: Functional economic geography and England-intersection test. Vintage: 2011 boundaries Licence / caution: OGL v3; digital boundaries include OS attribution https://geoportal.statistics.gov.uk/datasets/ons::travel-to-work-areas-december-2011-boundaries-uk-bgc-v3-1/about
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S2	ONS UK gross value added and productivity estimates for other geographies Use: 2023 total GVA ranking of all UK TTWAs. Vintage: 1998–2023 edition, released 22 September 2025 Licence / caution: OGL / Crown copyright unless otherwise stated https://www.ons.gov.uk/economy/grossvalueadded/gva/datasets/ukgvaandproductivityestimatesforothergeographies
S3	DfT National Public Transport Access Nodes (NaPTAN) Use: Station, mode and passenger-access-point framework. Vintage: Build snapshot retained in the station audit Licence / caution: OGL v3 https://www.gov.uk/government/publications/national-public-transport-access-node-schema
S4	Rail Data Marketplace — Timetable Full Refresh Use: National Rail passenger timetable; official operator/network timetables used for QA. Vintage: Build timetable snapshot Licence / caution: Rail data product terms / developer conditions https://raildata.org.uk/dataProduct/P-1caaf2e8-3d5e-466d-8bf8-06d97e675bef/overview
S5	HM Land Registry INSPIRE Index Polygons Use: Open registered-freehold parcel framework. Vintage: Authority-file snapshot used in Stage 2B Licence / caution: OGL; indicative extents, not legal title plans https://use-land-property-data.service.gov.uk/datasets/inspire
S6	HM Land Registry public-data guidance Use: Status, scope and reuse terms for HMLR public datasets. Vintage: Checked August 2026 Licence / caution: Dataset-specific public-data terms https://www.gov.uk/government/publications/hm-land-registry-data/public-data
S7	Ordnance Survey OS OpenMap – Local Use: Generalised building footprints, functional sites, important buildings and glasshouses. Vintage: Stage 2C source snapshot Licence / caution: OS OpenData / OGL; OS attribution required https://www.ordnancesurvey.co.uk/products/os-open-map-local

S8	Ordnance Survey OS Open Greenspace Use: Mapped open-space and recreation context for existing-use screening. Vintage: Stage 2E source snapshot Licence / caution: OS OpenData / OGL; OS attribution required https://www.ordnancesurvey.co.uk/products/os-open-greenspace
S9	Planning Data platform Use: Brownfield and 25 planning/environmental datasets; current-period entities and original geometries. Vintage: Stage 2C–G snapshots Licence / caution: Mostly OGL; dataset-specific metadata and provider attribution apply https://www.planning.data.gov.uk/docs
S10	OpenStreetMap Use: Pedestrian network and existing-use polygon evidence. Vintage: Build extracts Licence / caution: ODbL 1.0; attribution and database obligations apply https://www.openstreetmap.org/copyright
S11	Geofabrik England OpenStreetMap download Use: Reproducible England extract used for landuse, POI, traffic and transport areas. Vintage: Stage 2E source snapshot Licence / caution: OpenStreetMap ODbL 1.0 https://download.geofabrik.de/europe/united-kingdom/england.html
S12	openrouteservice / HeiGIT isochrone service Use: 600-second and 576-second foot-walking catchments. Vintage: Stage 2A routing run Licence / caution: API results CC BY 4.0; underlying OSM ODbL https://giscience.github.io/openrouteservice/api-reference/endpoints/isochrones/
S13	Greater London Authority — London Plan evidence / Sustainable Access Measure Use: Exact site-polygon SAM intersections for London. Vintage: Draft London Plan 2026 evidence Licence / caution: London Datastore reuse terms; acknowledge source and no endorsement https://data.london.gov.uk/dataset/london-plan-evidence-mbul-2j8nl

S14	Transport for London — PTAL 2023 Grid 100 m × 100 m Use: Site-level PTAL evidence for London-context sites. Vintage: 2023 scenario; complete 159,451-point grid Licence / caution: OGL v3 plus TfL/WebCAT interpretation terms https://gis-tfl.opendata.arcgis.com/datasets/0646faf45243463aa04ca685e598f471/about
S15	ONS Postcode Directory (May 2026) Use: Nearest postcode and postcode-linked OA21, LSOA21, MSOA21 and LAD25 codes. Vintage: May 2026 Licence / caution: ONS postcode-product terms; contains ONS, OS, Royal Mail and Gridlink IP https://geoportal.statistics.gov.uk/datasets/6fff67d204fd4f339591ed667a6e3642/about
S16	DfT Transport Connectivity Metric Use: Method and published area-level connectivity metrics. Vintage: 2026 publication route Licence / caution: OGL v3 https://www.gov.uk/government/publications/transport-connectivity-metric/transport-connectivity-metric
S17	DfT Connectivity Tool Lite guidance Use: Definition and interpretation of exact 100 m overall, public transport, walking and cycling scores. Vintage: 2026 public tool Licence / caution: Exact bulk retrieval/republication route not confirmed in locked baseline https://connectivity-tool-lite.dft.gov.uk/help/guidance
S18	OpenFreeMap / OpenMapTiles / OpenStreetMap Use: Public web basemap only; not an analytical input to the locked engine beyond the separately identified OSM sources. Vintage: Live public service Licence / caution: Open-source stack; map-data attribution required; no SLA https://openfreemap.org/
S19	TfL Transport Data Service terms Use: Terms and attribution relevant to TfL station/timetable and accessibility data. Vintage: Checked August 2026 Licence / caution: TfL terms; do not imply endorsement https://tfl.gov.uk/corporate/terms-and-conditions/transport-data-service

Required attribution summaries

- Ordnance Survey: “Contains OS data © Crown copyright and database right 2026” (or the appropriate year for the delivered source snapshot).
- openrouteservice: “© openrouteservice.org by HeiGIT | Map data © OpenStreetMap contributors”.
- OpenStreetMap: credit OpenStreetMap contributors and identify the Open Database Licence; database-export obligations require separate classification where applicable.
- GLA and TfL: retain source, scenario/vintage and required disclaimers; do not imply endorsement or precision beyond the source method.
- ONS Postcode Directory: retain the product-specific ONS, OS, Royal Mail and Gridlink acknowledgements supplied with the release.

Appendix C — Planning and environmental layer register

Theme	Planning Data datasets queried with period=current
Policy / local control	green-belt; conservation-area; article-4-direction-area; tree-preservation-zone; nutrient-neutrality-catchment
Flood	flood-risk-zone; flood-storage-area
Heritage	listed-building; listed-building-outline; scheduled-monument; park-and-garden; world-heritage-site; world-heritage-site-buffer-zone; heritage-at-risk
Nature / ecology	ancient-woodland; site-of-special-scientific-interest; special-area-of-conservation; special-protection-area; Ramsar; local-nature-reserve; national-nature-reserve
Landscape	national-park; area-of-outstanding-natural-beauty / National Landscape
Other	educational-establishment; infrastructure-project

Dataset naming follows the build record. Planning Data names can evolve; refreshes should use the current dataset metadata and preserve a source-to-engine mapping table.

Appendix D — Locked output and provenance summary

Output family	Locked result	Provenance
Policy/economic geography	70 eligible TTWAs	2011 TTWA boundaries; 2023 GVA ranking
Station evidence	1,778 mode/station nodes; 1,687 physical hubs	Stage 1 / Stage 2I
Walking evidence	1,687 hub catchments; 600-second network primary	Stage 2A
Upstream land population	2,674,852 unique freehold polygons intersecting catchments	Stage 2B
Large-title screen	79,327 titles ≥0.25 ha	Stage 2B–E
Candidate geometry	4,839 sites; 7,768 title members; 5,516.173 ha	Stage 2F v1.3 locked
Neutral evidence	site geometry, catchments, titles, uses, planning context, shape	Stage 2G canonical
Scoring	Opportunity Strength + Delivery/Review Complexity	Stage 2H v0.2
Capacity	35/45 dph spatial allocation; four net sensitivities	Stage 2I
Location	4,839 postcode/ONS geography joins	Stage 3B.10

Output family	Locked result	Provenance
GLA SAM	1,217 site intersections	Stage 3B.10
TfL PTAL	1,224 London-context sites	Stage 3B.10
DfT exact connectivity	0 loaded; schema retained; public null card hidden	Pending supported 100 m bulk route

Appendix E — Glossary

Term	Meaning in this engine
Candidate site	A pre-screened polygon formed by the union of accepted freehold title polygons under Stage 2F.
Catchment	The polygon reachable through the pedestrian network within 600 seconds from one or more audited station entrances.
Centroid evidence	A source feature whose representative centroid lies within a title; treated as stronger use evidence than a boundary intersection alone.
Controlled assembly	The rule-bound process that unions accepted titles and permits conservative ring-by-ring small-parcel growth without automatic bridging.
Delivery readiness	A composite of title simplicity, context simplicity and shape; complexity is its inverse.
Effective title count	The inverse of the title-area HHI; a geometric fragmentation proxy.
Hub	A de-duplicated physical station or interchange. Multiple modes and entrances may belong to one hub.
Intersection	The geometric area common to two polygons.
Isochrone	A polygon representing locations reachable within a stated travel time through a network.
Opportunity Strength	The weighted strategic screening indicator combining accessibility, economic rank, scale and regeneration evidence.
Representative point	A controlled point used for a nearest-neighbour or label operation; it does not replace polygon intersection where area evidence is required.
Review signal	Mapped evidence that warrants investigation and is not an automatic conclusion.
TTWA	Travel to Work Area: a functional labour-market geography defined from commuting patterns.
Union / dissolve	Combining overlapping or touching polygons into one geometry and removing internal boundaries.