

# The construction of MorfO areas

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MorfO is a subdivision of Sweden's urban localities ( $\geq 2\ 000$  inhabitants at the delineation 2015) into small geographical units. The intention has been to categorize the urban landscape and thereby construct a subdivision of urban localities based on urban-morphological variations. Hitherto existing sub-municipal divisions are constructed out of other ideas. DeSO is basically setting out from demographical criteria. Although presented as a subdivision of Sweden into small homogeneous entities, SAMS-areas were – in most cases - created by each municipality and thus varies geographically in terms of both criteria and average area size. This document describes how MorfO have been constructed.

Categorization, by necessity involve some 'subjective' decision making. The categorization of urban localities into MorfO-areas is no exception since these areas have been delimited manually, although guided by several sources of information. The most important of these guiding materials are the construction of clusters of various types of real property units (RPU). For this exercise data from Lantmäteriet on RPUs, land uses, and buildings, retrieved via GET in January 2020, have been used. However, as the aim has been to bring about urban-morphologically cohesive areas, more information is needed to draw borders (see below under the heading *From clusters to MorfO-areas*).

## *Real property units excluded from clustering*

The clustering exercise has meant that similar and neighbouring real property units have been merged to clusters. However, two types of RPUs have been excluded from the clustering procedure. These are either 3D-RPUs, and as such irrelevant to the milieu perceivable at the ground level (exemplified by a turquoise unit holding subterranean railway line in Figure 1) or RPUs made up of street networks (exemplified by the RPUs coloured purple in Figure 1), and thereby firstly generally non-built-up infrastructures, rather than contributors to the urban morphology and, secondly, adjacent to most of the other RPUs in an urban area, although sometimes kilometres from each other and thus not morphologically cohesive.



Figure 1 Real property units and buildings at Södermalm, Stockholm. Real property units excluded from the clustering exercise have been coloured purple and turquoise. Source: GET/Lantmäteriet, January 2020.

## *Clustering of the bulk of real property units*

RPUs in other land use types than perimeter blocks have been categorized based on land use type (according to Lantmäteriet) and the types of buildings (again according to Lantmäteriet) they hold. Moreover, residential buildings have also been supplied with information from the database PLACE concerning ownership. Since the geographical resolution in PLACE is 100 metres, the matching is not

straight forward. Some testing led to the conclusion that the most accurate matching method is to supply the PLACE coordinates concerned with Voronoi polygons and to let them transfer the information to buildings within them.



Figure 3 Geographical matching with the Voronoi method. A real property unit is stretched over several grid squares and its centroid (blue square) is in grid square D2. However, there are no information for this grid square in the PLACE database. On the other hand, PLACE hold information for grid square D1 (the coordinate is indicated by a red dot). The coordinate may well have been outside of the real property unit. To assign the PLACE data to its most probable (based on distance) real property unit, each PLACE coordinate is supplied with a Voronoi polygon (thick red line) and the information is transferred from the PLACE coordinate in grid D1 to the real property unit through its Voronoi polygon.

Many RPUs hold just one building. The classification of this building will then define the classification of its RPU. If not, it is checked whether buildings of similar building- and ownership type consist  $\geq 75\%$  of the built-up area at the RPU (complimentary buildings such as tool sheds or garages not considered). If yes, that will define the categorization of the RPU, otherwise it is considered to be “mixed”. In this way 18 detailed, and four less detailed, categories of RPUs can be identified.

Table 1 Types of real property units (RPUs), due to their composition of buildings

**$\geq 75\%$  residential RPUs**

**$\geq 75\%$  blocks of flats RPUs**

- $\geq 75\%$  low-rise blocks of flats owned by public lessor
- $\geq 75\%$  high-rise blocks of flats owned by public lessor
- $\geq 75\%$  low-rise blocks of flats owned by “bostadsrättsförening” (coops)
- $\geq 75\%$  high-rise blocks of flats owned by “bostadsrättsförening” (coops)
- $\geq 75\%$  low-rise blocks of flats, other owner
- $\geq 75\%$  high-rise blocks of flats, other owner
- $\geq 75\%$  blocks of flats with various owners

**$\geq 75\%$  single family house RPUs**

- $\geq 75\%$  detached single-family houses privately owned
- $\geq 75\%$  detached single-family houses, owned by public lessor or “bostadsrättsförening” (coops)
- $\geq 75\%$  row houses privately owned
- $\geq 75\%$  row houses, owned by public lessor or “bostadsrättsförening” (coops)
- $\geq 75\%$  single family houses with various owners / of various types
- $\geq 75\%$  unspecified residential buildings
- $\geq 75\%$  residential buildings with various owners / of various types

**$\geq 75\%$  non-residential buildings**

- $\geq 75\%$  industrial buildings
- $\geq 75\%$  buildings for commercial activities
- $\geq 75\%$  societal buildings
- $< 75\%$  buildings of any specific kind (mixed types of RPUs)

The clustering exercise have meant that several rounds of merging of similar RPUs localized close to each other takes place. In a first round, adjacent RPUs of the same kinds are merged. If the areas thereby created cover  $\geq 15\,000\text{ m}^2$ , they are considered to be a cluster. The remaining areas have been supplied with a buffer of 10 metres (i.e. in general enough to reach a neighbouring area across a narrow street in a residential area, but not across a major traffic route or a railway which often function as barriers in the urban landscape). Intersecting buffers built around RPUs of the same kind are merged and considered to be a cluster if they cover  $\geq 15\,000\text{ m}^2$ .

In a third round, the same procedure is repeated, but buffers built around *any* kind of single family RPU are merged, where after the procedure is repeated for buffers built around RPUs holding blocks of flats. Then, the procedure is applied to buffers built around *any* kind of residential RPUs and any kind of non-residential RPU, respectively. Finally, the procedure is repeated merging any kind of RPU.

Similar clustering exercises starting from other categories of RPUs have also been also carried out. However, still a number of RPUs remains, which cannot be merged to any cluster  $\geq 15\,000\text{ m}^2$ . If possible, they are merged with their most similar cluster within their 10 metres-buffer. Still remaining RPUs are then supplied with buffers of 20- and 40 metres, and, in turn, merged to their most similar cluster within these buffers. RPUs still remaining are, if possible, merged with each other no matter their types. However, a few thousand RPUs still remain and are considered to be solitary clusters  $< 15\,000\text{ m}^2$ .

#### *Clustering of perimeter blocks*

The parts of urban localities classified by Lantmäteriet as areas of perimeter blocks can be said to constitute a type of urban morphological area of their own. This is the densest (and usually oldest) parts of the urban areas, and although some buildings may be hundreds of years old they are overlaid by more modern constructions here and there. As a consequence, they are only occasionally naturally 'falling apart' into cohesive homogenous morphological areas. Therefore, they have been considered a separate urban-morphological type (divided into two subgroups) in the clustering process. The subgroups are areas of many small or few large property units (and thus many or few owners and in turn many or few decisions on design and use). Next, this process of subdividing in the city centres will be described.

The summed area of real property units to be included in the clustering and which are localized within areas of Lantmäteriet land use type 12 ('areas of perimeter blocks') have been divided into two. Then all real property units have been ordered based on their area sizes where after these are cumulatively summed starting with the smallest. When the cumulating summing reach half of the total area, the summed real property units are categorized as "smaller". The remaining ones are considered to be "larger". The resulting cut-off point will appear at  $1576.1\text{ m}^2$ . However, as our intention is to construct an indicator of whether an area is dominated by large or small real property units (and thus few or many owners) a second step has been added, meaning that information about the numbers of smaller/larger RPUs have been summed to grid squares of  $100 \times 100$  metres. If at least half of the RPUs within the grid square are "larger" it has been classified as dominated by larger RPUs, otherwise as dominated by smaller. In a final step the classifications of the grids are transferred back to its RPUs. At this stage the RPUs have been supplied with common (i.e. not individual) 8-metre (after some testing) buffers with the intention to reach the equivalent buffer of a neighbouring RPUs across an ordinary inner-city-street, but not on the other side of a main thoroughfare or some other kind of barrier object. These buffers have been cut by objects. Resulting sub-buffers  $> 15\,000\text{ m}^2$  have been saved, whereafter the remaining (i.e. smaller) buffers have been supplied with another 8-metre buffer and merged primarily with another buffer of the same characterization (i.e. small/large) and secondarily with a buffer of the opposite kind. In the latter case, the characterization of the resulting buffer is based on its number of RPUs of each kind. A few buffers can still not be merged and will be

solitary although smaller than 15 000 m<sup>2</sup>. The result, exemplified by two neighbourhoods in central Gothenburg, appears from Figure 2.

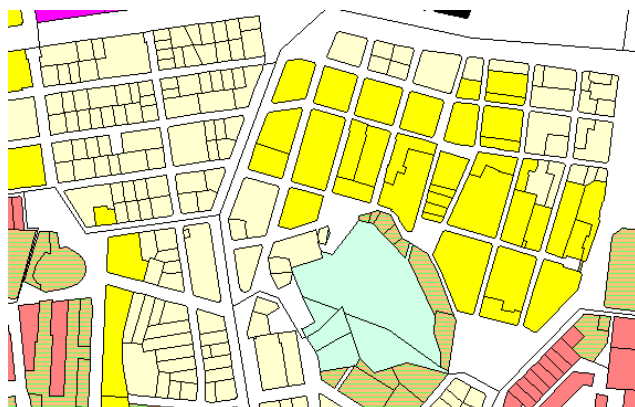


Figure 2 Real property units (black lines) and clusters of RPUs in areas characterized by many small (bleak yellow) or few large (sharp yellow) in Linnéstaden and Haga, Gothenburg.

### Resulting clusters

These exercises result in about 90 000 clusters of RPUs, categorized into 20 types. These are presented in Table 2 and illustrated in Figure 4 (using Mariestad as an example).

Table 2 Clusters used to delineate MorfO-areas.

Code	Type of cluster	Clusters	RPUs
4070	Perimetre blocks, large property units	384	3 094
4060	Perimetre blocks, small property units	458	23 384
3332	Blocks of flats, homogenous (public lessors), high-rise buildings	1 021	4 534
3322	Blocks of flats, homogenous (public lessors), low-rise buildings	467	2 312
3335	Blocks of flats, homogenous (other lessors), high-rise buildings	741	3 933
3325	Blocks of flats, homogenous (other lessors), low-rise buildings	222	1 372
3333	Blocks of flats, homogenous (cooperative), high-rise buildings	1 218	6 007
3323	Blocks of flats, homogenous (cooperative), low-rise buildings	451	1 966
3300+3311	Blocks of flats, unknown height	2 870	33 571
3200+3211	Mixed area of single family houses	20 814	828 228
3246	Detached houses (ownership)	1 347	123 275
3244	Row houses (ownership)	187	3 119
3256	Detached houses (other tenancies)	9 184	304 815
3254	Row houses (other tenancies)	6 238	31 214
3100+3101	Unknown or mixed types of residential buildings	2 419	44 908
2500	Activities	2 610	9 230
2400	Manufacturing areas	7 232	28 506
2600	Societal areas	6 063	24 763
1100+2100	Mixed areas	22 369	292 770
9000	Solitary	2 595	4 734
		88 890	1 775 735

\*(Some of the categories in Table 1 have been merged: '≥75% blocks of flats with various owners' with '≥75% blocks of flats RPUs'; '≥75% single family houses with various owners / of various types' with '≥75% single family house RPUs'; and 'residential buildings with various owners / of various types' with 'unspecified residential buildings'.)

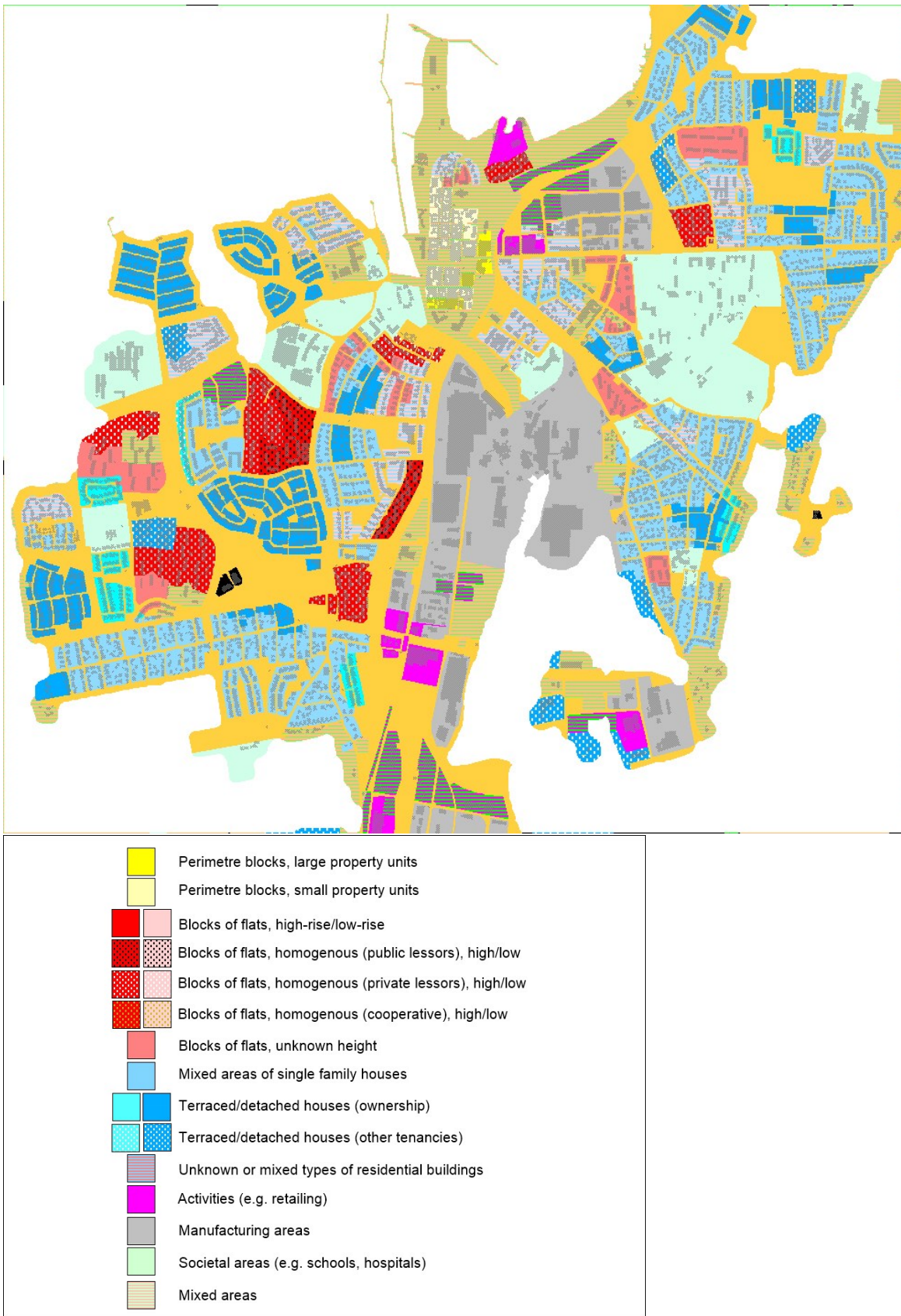


Figure 4 RPU clusters using Mariestad as an example. Most of the RPUs end up in a cluster, but a few 'solitary' RPUs remain and appear in black. The centre consist of perimeter blocks. Thus, the clusters there (bleak and sharp yellow) are constructed in the second way described above whereas the first way is used in other areas

### *From clusters to MorfO-areas*

The subdivision of urban areas into clusters of RPU's described above, has been the main guide used to construct the MorfO-areas, but the work has been manual. Although intuitive hints about where to draw borders between various kinds of urban morphological areas are inherent in any map of the clusters (including Figure 4), other geographical objects also need to be considered. These include various barriers in the urban landscapes, such as water, scarps, railway lines, main thoroughfares, etc.

Although the same kind of morphological category may be found on both sides of a railway line or river, it would be far-fetched to argue that it is the same area that continues as any direct connections are cut off. The urban barrier effect means that the areas on both sides of the barrier will be used (and probably perceived) as two. Roads may also connect areas. Thus, connective and dividing physical objects have been added to the map to further guide where to draw borders between the MorfO-areas to be, or where not.

Still, doubts sometimes remain. For example, a river may be crossed by several bridges in the central parts of a city, and there are examples of thoroughfares designed to connect the areas on its both sides rather than separate them. Thus, objects may have other roles than those firstly expected. Therefore, aerial photographs and tools such as Google StreetView and Google Maps have also been used.

There has also been a strive to keep areas once planned as wholes together (to enable studies of certain planning ideas). Thus, plans and historical aerial photographs have also been considered. Finally, as an updated version of Statistics Sweden's delimitation of urban localities (as of 2018) were published during the period when the MorfO-areas were constructed, this has also been taken into consideration.

As the complementary sources of information were considered, some preliminary sketched MorfO-areas were merged and others added. Finally, the number of MorfO-areas amounts to 8 540. MorfOs have also been merged to a second-tier subdivision of 1 602 (not morphologically homogeneous) 'Tätortsdelar'. Figure 6 illustrates what the finalized subdivisions look like, again using Mariestad as an example. Some main physical barriers (lake (blue), river (blue), railways (crossed grey) and main thoroughfares (red)) are included in the map. An aerial photo of Mariestad and the subdivisions of the town into DeSO and SAMS areas are supplied for comparative reasons (Figures 5 and 7).



Figure 5 Aerial photograph of Mariestad

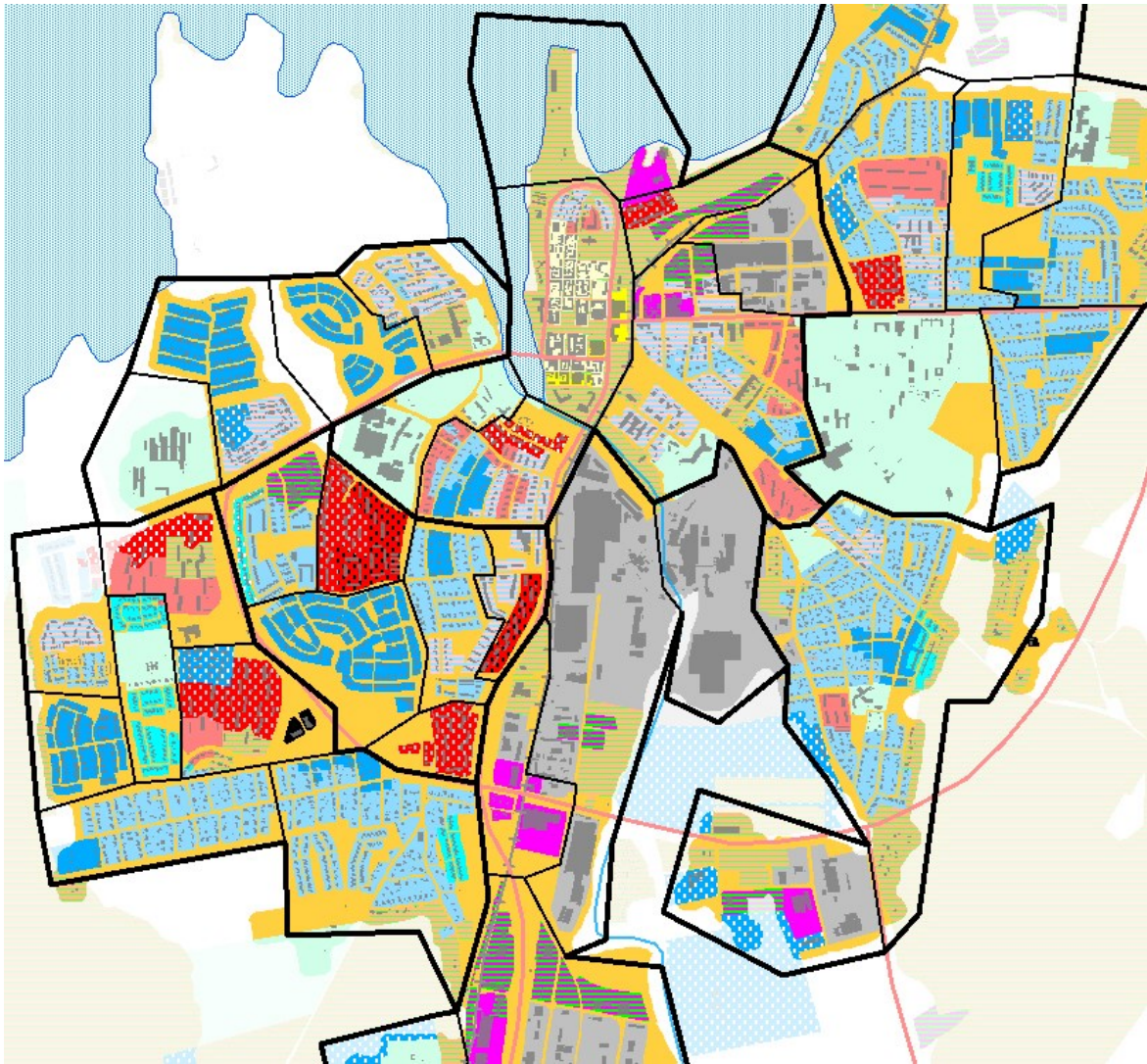


Figure 6 MorfO-areas (thin black lines), 'Tåtortsdelar' (thick black lines), RPU-clusters (coloured) and barrier objects (main thoroughfares, railways, rivers and lakes) in Mariestad.

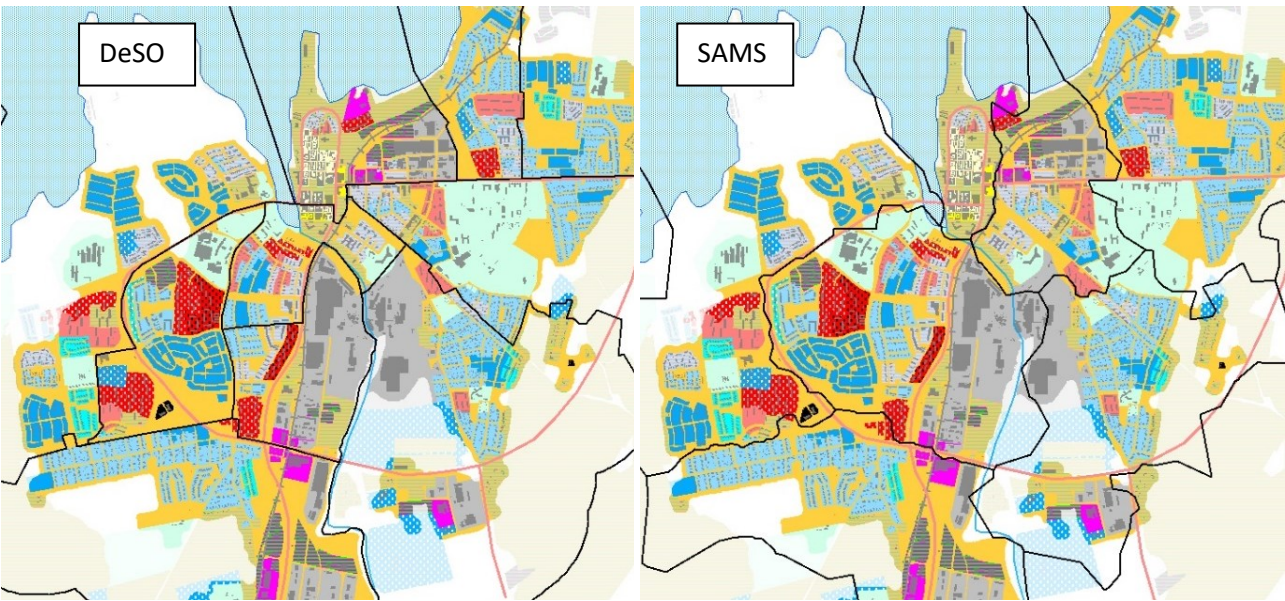


Figure 7 DeSO- and SAMS- areas (black lines), RPU-clusters and barrier objects in Mariestad.

### *Describing and categorizing the MorfO-areas*

The MorfO-areas may be used as they are. However, in a separate following step, they have been supplied with various kinds of rough descriptive information intended to be used in studies focusing on (or excluding) certain urban-morphological types. Firstly, they have been categorized based on the type of buildings (according to Lantmäteriet's categorization) they hold. The cut-off point for "monotypic" is if >60% of the built-up area in the MorfO consist of the same type of buildings ( i.e. if the footprint of residential houses exceeds 60% of the total footprint of all the buildings in the area, it is considered "residential", etc). This strictly criteria-based categorization has also been developed into a variant where various types of central areas (e.g. MorfO dominated by perimeter blocks, with 'small-town-centre-like' morphologies, etc) have been broken out based on manual assessment.

Secondly, a main period of construction has been added. However, this is very rough information since it is based on data from PLACE (merged with the Voronoi-method described above), limited to residential buildings, and – where such data are missing – from comparisons of historical aerial photographs. The periods are intended to correspond to various dominant ideas in Swedish town-planning. The number of MorfO-areas in the various categories is clear from Table 3.

Table 3 Number of MorfO-areas of various types

Code	Type of MorfO	Main period of construction (rough)							Sum
		unknown	-1939	1940-1964	1965-1974	1975-1991	1992-	mixed	
<b>0</b>	less than 1% built-up	32	8	2	3	5	34	15	99
<b>110</b>	Semi-rural outskirts		8	14	3	9	12	98	144
<b>111</b>	residential area, single fam, detached	1	219	384	553	660	340	649	2 806
<b>112</b>	residential area, single fam, row houses		1	40	182	132	11	2	368
<b>119</b>	residential area, single fam, mixed hous		5	30	112	99	17	12	275
<b>120</b>	residential area, blocks of flats		207	481	545	232	178	133	1 776
<b>190</b>	residential area, mixed housing types		34	43	38	76	51	69	311
<b>230</b>	activity area, industrial	3	86	71	84	83	66	544	937
<b>240</b>	activity area, societal	6	39	37	64	33	46	137	362
<b>250</b>	activity area, commercial	3	11	22	28	28	74	94	260
<b>290</b>	activity area, mixed types	1	29	31	28	36	38	154	317
<b>900</b>	mixed types of buildings	1	88	149	180	127	84	256	885
<b>Sum</b>		<b>47</b>	<b>735</b>	<b>1 304</b>	<b>1 820</b>	<b>1 520</b>	<b>951</b>	<b>2 163</b>	<b>8 540</b>

\*less than 1% built-up refers to large parks or cemeteries, etc, localized within urban localities

Thirdly, as certainly the information concerning types of buildings are obviously erroneous or irrelevant in many cases, a manually assessed categorisation of the MorfO-areas have also been supplied, It is based on predominating – if any – types of buildings in the MorfO-area (e.g. 'blocks of flats' or 'buildings designated for retail activities') and the way the area is developed (e.g. 'perimetre blocks' or 'rows of dwellings').

Fourthly, the MorfO-areas have also been supplied with information about whether they are designated residential areas for students, historical town centres or areas of semi-rural morphology (although within Statistics Sweden's delimitation of 'urban localities' i.e. 'tätorter') . This information is manually assessed.

Fifth and finally, the numbers of buildings of various types represented in each area has been calculated and a rough measure of the internal building mix have been calculated for each MorfO. The intention is to indicate to what extent various types of buildings (if there are various types) in a MorfO-area are localized higgledy-piggledy or in type-wise groups (exemplified in Figure 8). The



measure has been calculated in the following way. First, every proper building (i.e. excluding complementary buildings like sheds, garages, etc; ‘Other buildings’ in Figure 8) is supplied with a buffer of 100 metres radius. Various types of buildings within each buffer is counted and entropy indices are calculated. Then the entropy indexes for all the buffers in a MorfO-area are summarized and normalized to the entropy index of the area as a whole. The result is a score between 0 (if the various types of buildings within a MorfO are localized in such a way as all of them reach the other types of buildings within 100 metres) and 1 (if the various types of buildings within a MorfO are localized in such a way as they only reach buildings of the same type within 100 metres). This can be illustrated by an example from the western outskirts of Örebro (Figure 8). The two neighbourhoods Björkhaga and Oxhagen are roughly of the similar size and both are dominated by single-family houses of row- or detached type, but both of them also hold blocks of flats and a few societal and commercial buildings. However, whereas the various houses are localized group wise in Oxhagen (built in the 1960s), they are mixed in Björkhaga (a neighbourhood of the 1980s). Thus, whereas most buffers in Björkhaga will hold several types of buildings, they will typically just hold one type in Oxhagen. As a consequence, Björkhaga scores 0,13 and Oxhagen 0,77.



Figure 8 Internal mix of building types in two MorfOs in the western outskirts of Örebro. (The 100-metre buffers are showed in the map for just five houses to keep the map clear and readable. They appear as circles.)

This exercise is problematic for several reasons. Entropy index does not go well with very small numbers of buildings, various number of categories, various numbers of buildings in each category, etc. However, the intention is not to come up with a final and precise categorization, but rather to find a rough way to guide a selection of internally very mixed (or not) MorfOs (e.g. to select MorfO which may be appropriate to consider for a case study of morphologically mixed – or homogeneous – urban areas).

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