eurostat

Statistiska centralbyrån
Statistics Sweden

Material flow study of sand and gravel in Sweden

by Elisabeth Bergstedt, Irene Linder
Statistics Sweden, Environment Statistics

January 1999

Foreword

Statistics Sweden has developed physical environmental accounts since 1993. To begin with, the focus has been on developing the environmental accounts for energy and certain emissions. This report is a result of developmental work on incorporating descriptions of material flows into the Swedish environmental accounts.

Within this project, the possibilities to carry out material flow studies for the construction minerals; sand, gravel and crushed stone have been examined. These materials are of special importance in the construction industry, where they are the largest (in weight) materials used. The study focus on the input in and output from the economy, but also on the input and output between sectors within the economy. The result is both an account of the material flow and a description of data sources.

The report is prepared on commission from EUROSTAT, who supports and co-ordinates development of environmental accounts in the EU member states. The European commission (DG XVI) has contributed financially to the project. Elisabeth Bergstedt and Irene Linder have contributed in preparing this report.

Contents

1 Introduction

Gravel (including crushed stone) and sand are two large material flows in Sweden as well as in other countries. These materials are of special importance in the construction and demolition industry, where they are two of the largest (in weight) materials used. Furthermore, the construction and demolition industry is a large industry, both concerning material use, energy use, other environmental factors and economic importance.

Within this project, the possibilities to carry out material flow studies for sand and gravel has been examined. The basis for the project has been information about extraction, construction and demolition activities. The project also includes aspects of natural resource accounting, such as depletion of the stock of natural gravel. The flow of sand and gravel is described, from extraction to use and disposal.

Statistics from the Geological Survey of Sweden has been a major source of information for this study. Data from Swedish official statistics about building activities, production, foreign trade and waste is also used.

The report contains a data inventory, description of the method used to calculate the data, as well as tables and figures of flow statistics with accumulation in society and depletion of natural resources.

1.1 Material flow analyses in Sweden

Material flow analyses belong to a rather new family of methods for environmental assessment, which is reflected in the many different types of statistics or investigations that can be included. In Sweden, statistics on energy, as well as statistics on the mining and production of metals and other natural resources, such as wood, have been collected for a long time. However, they are not labelled as material flow data. This kind of data have however been used for making material flow studies by researchers, as e.g. the doctoral thesis ”Industrial metabolism. The emerging landscape of heavy metal immission in Sweden”, by Bo Bergback, from 1992. The thesis outlines the material flows of chromium, lead and cadmium in Sweden during the 20th century and is largely based on statistics of import and export. Another national study based on official statistics is ”Chromium and nickel in Sweden” by Palm *et. al*., 1995. Similar types of material flow studies for smaller regions have also been performed by a number of people, but here we will focus on the national perspective.

The work on presenting material flow data in a condensed way and with a coupling to environmental pressure data has only recently begun. This material flow statistics work is closely connected to Statistics Sweden’s project to create a physical Environmental Accounting system. It is planned to be used to connect the economy’s outflow data on emissions and money with the inflow data of resources and energy, by creating indicators for efficiency.

The connection between material flows and the environmentally important areas of energy use, waste production and diffuse emissions is of special interest. In some cases, the scarcity of the material is also of concern, notably for sand and gravel from glacial deposits, which also serve as important ”cleaning agents” for the ground water.

Until now, three material flow pilot studies have been published within the environmental accounting system: Firstly, an elaborate study on *the mass flow of wood*[1], with input-output analyses and some thoughts about what statistics are possible to produce with today's data. Then, a study on the flows of *iron and steel*[2] in Sweden, which has been published in English for Eurostat. However, the iron and steel study did suffer from lack of data. A third report investigated possibilities to single out material flows that are of special interest to issues on energy efficiency[3].

Another related study within the Environmental Accounts is the Forest Accounts, where the stocks and services of the forests are calculated. Other surveys that have connection to the material flow area are *statistics of water use*, that are performed regularly. Also, *product based waste statistics* such as the recycling of batteries, drinking bottles, tyres etc. are produced.

An overview of work with material Accounting in each Nordic country is presented as a part of a joint Nordic project on Natural resource and Environmental Accounting[4]. The report covers studies of e.g. wood, solvents and lead. Statistics on the use of chemicals are regularly produced at the Chemicals Inspectorate. An example of a study based on these data can be seen in the Eurostat report mentioned above.

1.2 Definition of included materials

Industrial minerals and rocks are defined by the Geological Survey of Sweden as minerals and rocks extracted for other purposes than for using the contents of metals or energy. According to this definition, sand, gravel and crushed stone (aggregates) as well as unhewn stone belong to industrial minerals. Other industrial minerals are usually called qualified industrial minerals. To simplify this, the three clusters are called aggregates, unhewn stone and industrial minerals. This report focus on aggregates, even though the other groups are mentioned for explanatory reasons and sometimes for reasons of comprehensiveness.

Delimitation of what should be included in the study has been difficult. We have included the large amounts of aggregates used in the construction industry for housing and infrastructure. This includes also the products concrete and asphalt, which contain aggregates and are used in the construction sector. Some amounts of the same type of material that have been used for other purposes (filter sand for water cleaning, sand against slipperiness, sandpaper etc.) have also been included in the data on input in the society, due to the design of the data. These amounts are small compared to the use in constructions. We have not included the minerals in cement (mainly limestone) and also not construction stone.

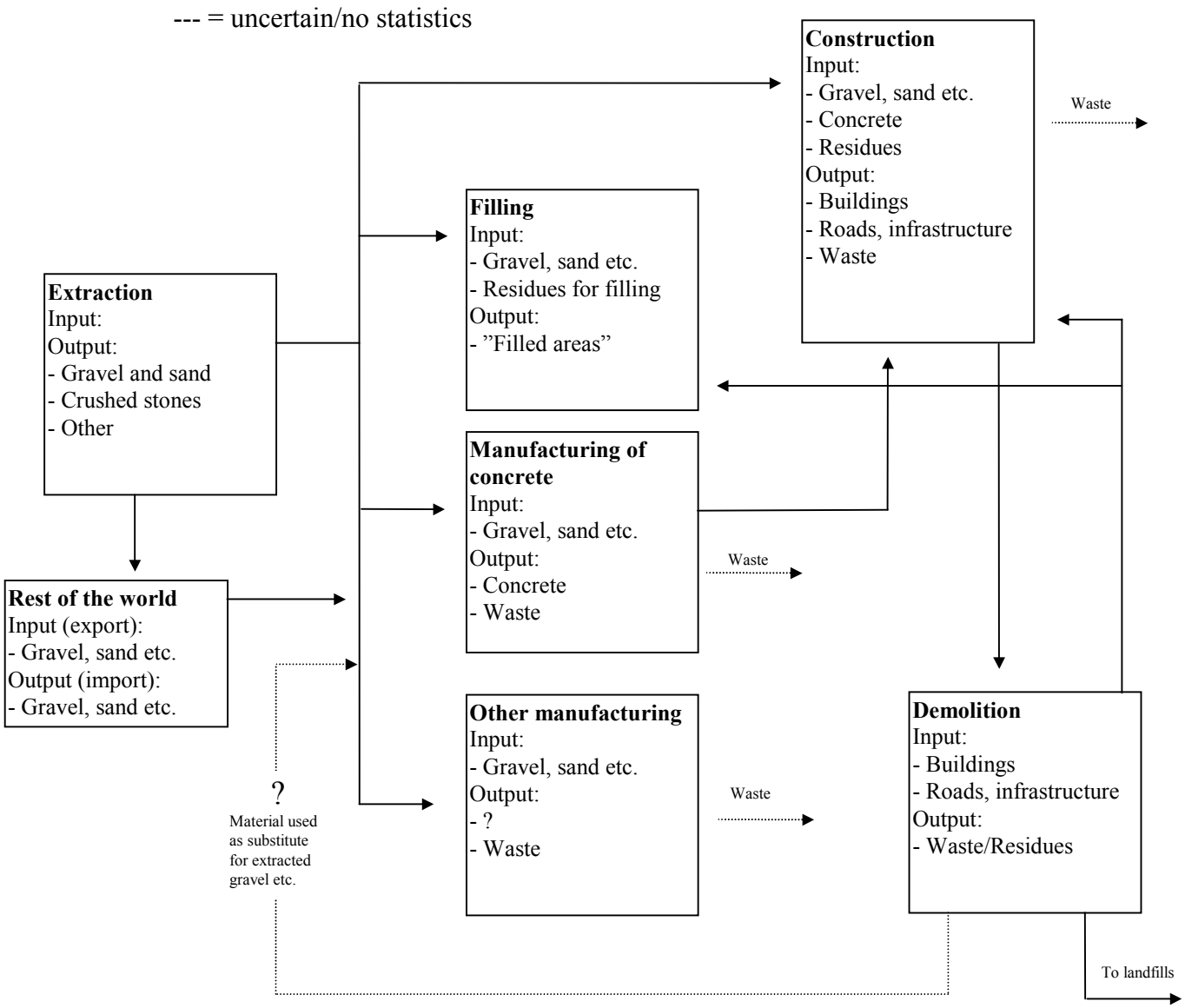
The aggregates sand, gravel and crushed stone are in some parts of the study named ”sgs” for practical reasons.

[1] Carbon Flow Analysis in Sweden, 1996, Statistics Sweden.
[2] Material flow studies at Statistics Sweden and the National Chemicals Inspectorate, 1996, the National Chemical Inspectorate and Statistics Sweden.
[3] Reduced emissions of carbon dioxide through changed use of materials, to be published in 1999, Statistics Sweden.
[4] Nordiska naturresurs- och miljöräkenskaper - delrapport II (Nordic environmental- and natural-resource account - part II), 1997, Nordic Council of Ministers.

2 Inventory of data on construction minerals in Sweden

It is necessary to begin an analysis of a material flow with identifying the materials presence in society - from extraction to final use. For the construction minerals sand, gravel and crushed stone this is done in the chart below. The boxes are activities producing and/or using gravel etc. The arrows are the flow. In the boxes, existing input and output is specified. This is both primary input in the society and the continuous input, for example from one economic sector to another. The flow is a rough outline to catch the large tonnage and are not totally complete (see comments in chapter 3.1 on possibly missing parts in the flow).

The flow chart is possible to translate into input and output tables (see annex 3). The activities - the boxes - become column headings in the tables, the goods/materials in the boxes are the rows and the arrows are the statistics in the tables. If the flow chart covers a longer time period, the stock will be built up in the boxes. For example: buildings ”stay” in the construction box until they are demolished after several years - then they goes to the demolition box and further on to use or disposal of residues.



In chapter 2.1 to 2.5 below, the different parts of society shown in the flow chart above are briefly described. Description of data sources is also included.

2.1 Extraction and primary use

The industry for extraction of aggregates is necessary for the development of housing and infrastructure. It supplies material for construction of buildings, roads, railways etc. and for manufacturing of concrete and asphalt.

Since deposits of sand and gravel are often important reservoirs for groundwater, there can be conflicts about how to use the resource. Should the gravel ridge be used as gravel pit or be preserved to supply water in the future? Extraction of gravel change the conditions for generation and storage of groundwater. There is also a risk that the aquifers become polluted. Both the quantity and the quality of groundwater can be influenced. This question is not further discussed in this report but is discussed for example in Report 4570 from the Swedish Environment Protection Agency[1].

Sand and gravel from natural deposits are limited. Regional inventories have been performed since 1983. Remaining, detachable volumes of sand and gravel have been estimated to more than seven thousand millions m^3 in those two third of the surface of Sweden that has been covered until now. All of this is not available for extraction, as shown in the chart below. Except that sand and gravel are limited, there are many reasons that gravel ridges cannot be extracted. Below the chain from total volume to practically detachable net volume is shown.

Nature reserve Valuable nature, classified Common roads Buildings	Not detachable volume because of geological and technical facts	Water protection Care of culture Relic of antiquity Other interests of ground	Practical detachable volume
←----------Total volume----------→			
	←---------- Theoretical volume----------→		
		←---Geological volume----------→	
			←-Net volume---→

At the beginning of the inventory of assets there was a focus on sand and gravel, but then crushed stone, and to some extent moraine, were also taken into account. The information is collected in a database, ”The archive for gravel data”, at the Geological Survey of Sweden. The database includes 14 000 gravel, 600 moraine and 1 500 stone deposits. The quantities and quality of the gravel varies across Sweden and large volumes are situated far away from the urban areas where the demand is high.

Usually there is a lack of coarse-grained material, while sand and fine sand are less scarce. Lack of sand and gravel from natural deposits, problems with quality and a will to economise with limited natural resources are reasons to use crushed stone and moraine at many places. Moraine consists of varying quantities of boulders, stones, sand, fine sand, silt and clay. The most common type of moraine is sand - fine sand with moderate frequency of boulders.

[1] Grustäkters inverkan på grundvattnet (The influence of gravel pits on the groundwater).

In Sweden it is necessary to have a licence to open a pit. Below you can see the number of licensed pits according to the Geological Survey of Sweden.

Type of pit	**1993**	**1995**	**1997**
Gravel/sand	4 146	3 785	3 323
Crushed stone	399	487	585
Industrial mineral	173	203	211
Total	**4 718**	**4 475**	**4 119**

In 1995 there were 4 475 licensed pits of gravel, sand, crushed stone and industrial mineral covering an area of 16 600 hectares according to the report ”Land use in Sweden” (Statistics Sweden 1998). The pits can be resting, i.e. they do not have to produce anything during the year. In 1995 the number of producing pits was 2 660 and in 1997 the number was 2 205. In 1997 33 percent of the pits produce between 1 - 2 500 tons, 27.6 percent produce 2 501 - 10 000 tons and 39.4 percent produce more than 10 000 tons.

Every year those who have gravel pits and quarries report data on production to the county administrative board. This data is collected and reported by the Geological Survey of Sweden. According to the statistic from the Geological Survey of Sweden about 87 millions tons were produced 1995.

Two sources for extracted aggregates have been found. Statistics from the Geological Survey of Sweden and Industrial statistics from Statistics Sweden.

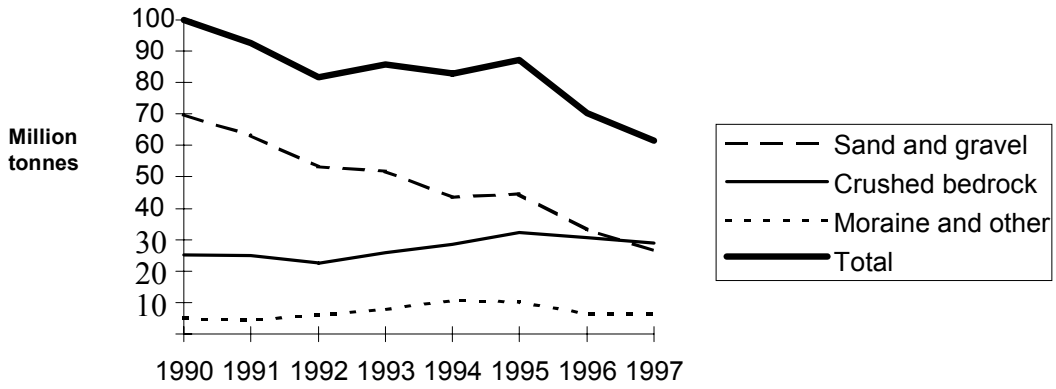
Most of the pits are small with few employees per establishment. In the industrial statistics there are data on the level that is needed (for each type of material/good) only from industrial companies with at least 10 employees and at least 5 employees per establishment. According to the business statistics at Statistics Sweden there were 534 establishments in 1997 for sand, gravel and crushed stone (SNI 14210). Of these, 477 establishments (89 percent) had fewer than 10 employees and 393 (74 percentage) had fewer than 5 employees. This means that a great deal of the quantity data is not included in the industrial statistics. In the industrial statistics goods are distributed according to HS-code: The item 251710 - Small stones, gravel and crushed stone - has a total sum of about 25 millions tons for the year 1995. This is a lot less than the sum reported from the Geological Survey of Sweden, since so many establishments are not included. The industrial statistics from Statistics Sweden have not been used in this study.

The statistics about deliveries of aggregates reported by the Geological Survey of Sweden are shown below. Sand is not separately reported in the statistics from the Geological Survey of Sweden, but as sand and gravel. Sand is reported in some of the production permits, but not in such a way that it is possible to say how much sand that has been produced. ”Other” mostly consists of stone from separate crushing plants and building work.

Produced aggregates 1990 - 1997, tons

	1990	1991	1992	1993	1994	1995	1996	1997
Sand and gravel	69 800 000	63 300 000	53 100 000	51 894 719	43 491 820	44 554 125	33 348 664	26 269 964
Crushed bedrock	25 100 000	24 900 000	22 600 000	25 962 197	28 591 786	32 347 777	30 714 438	28 987 805
Moraine				2 040 830	3 189 112	2 635 486	1 653 060	2 625 084
Other	5 100 000	4 500 000	5 900 000	5 779 020	7 614 163	7 647 720	4 669 437	3 676 805

(Surrounded data can not be singled out)
Source: Geological Survey of Sweden



Produced aggregates
Source: Geological Survey of Sweden

The Swedish market for aggregates has lately decreased in consequence of a low activity of building and construction. An increase has been noticed for the year 1998 and there is a tendency of change from sand and gravel to crushed stone.

During 1997 there was an extraction of 62 million tons of aggregates and about 9 million tons qualified industrial minerals (of which 7 million tons were limestone and dolomite). The market value of the deliveries of aggregates is calculated to about three thousand millions SEK. In general crushed stone is more expensive than sand and gravel from natural deposits. The price is usually in the interval 30 - 80 SEK per ton. There is a tax of 5 SEK per ton for sand and gravel from natural deposits, but not for crushed stone. There is also a cost for the transport. Transports of sand and gravel are usually done with lorries and are excepted to be about half of the total transported goods by lorries in the country.

Aggregates are used in a lot of different areas. Building and maintenance of roads and railways, concrete and filling are some examples. Other areas of use are filter sand for water cleaning, sanding against slipperiness, sandpaper etc. The producers of material from pits are asked to estimate how the deliveries are distributed on main areas of use (roads, concrete, filling and other uses). The year 1997 answers were received from 86 percent of the extraction companies. Assuming the received answers are representative, the consumption can be described as in the table below.

The total deliveries distributed as percentages on consumption areas, percent

Area of use	1990	1991	1992	1993	1994	1995	1996	1997
Roads	52	51	53	61	60	61	57	51
Concrete	15	16	14	10	10	11	12	11
Filling	17	17	18	14	16	14	15	15
Other uses	16	16	15	15	14	14	16	24

In ”other uses” industrial minerals are included
Source: Geological Survey of Sweden

In 1997 the delivery to roads etc. was estimated to 51 percentage of the total delivery. The delivery of concrete, 11 percent, and to filling (ground, levelling etc.) about 15 percent. ”Other uses” was 24 percent and include industrial minerals (among other things to the lime industry at Gotland). It is difficult for the producers to estimate where the deliveries are used so the data should be interpreted with caution.

In the table below, industrial mineral has been excluded. The table shows the use of the aggregates sand, gravel and crushed stone.

Distribution of aggregates on areas of use, million tons (uncertain data)

	1990	1991	1992	1993	1994	1995	1996	1997
Roads	57	52	48	57	56	59	46	35
Concrete	16	16	13	9	9	11	10	8
Filling	19	17	16	13	15	14	12	10
Other uses	8	7	5	6	3	3	2	9

”Other uses” excluding industrial minerals
Source: Geological Survey of Sweden

2.2 Production of concrete

One of the areas of use for sand, gravel and crushed stone is in the production of concrete. Concrete consists of about 75 percent of the these materials[1]. The information on quantity of concrete produced in Sweden differs between different sources. In the table and the text below, four different sources are presented.

Production of concrete an average year in the beginning of the nineties according to different sources (Calculations and sources: see annex 2 - production of concrete)

	Source	Production of concrete, tons	...gives amount of sgs, tons
1	Geological Survey of Sweden (recalculated)	16 400 000	12 300 000
2	Jacobson & Widmark	8 800 000	6 500 000
3	Swedish Ready-mixed Concrete Association (recalculated), Swedish Pre-cast Federation / SEPA[1)]	9 700 000	7 300 000
4	Statistics on production of cement (recalculated) [1)]	11 690 000	8 770 000

[1)] Swedish Environmental protection Agency

According to the Geological Survey of Sweden, about 10 - 15 million tons of sand, gravel and crushed stone were used to produce concrete every year 1990 - 1995. To produce one ton of concrete, 750 kg sgs is needed. An average of 12.3 million tons sgs for production of concrete per year gives an average production of concrete at 16.4 million tons.

In a study on material in the construction sector by the consultant firm ”Jacobson & Widmark”[2], the use of concrete in the construction of buildings, roads etc. an average year[3] is estimated to be 8 450 000 tons (and the use of ”light”-concrete; 338 000 tons). If we convert this into quantity of used sand, gravel and crushed stone, we will get the result 6.5 million tons.

The year 1993 about 6 million tons ready-mixed concrete (concrete delivered in flowing form to the working site for casting in moulds) and about 2 million tons pre cast concrete products were produced, according to the Swedish Ready-mixed Concrete Association and the Swedish Pre-cast Federation. Together this gives a production of 8 million tons. We have information on ready-mixed concrete for each year 1989 - 1998. If we use this information for 1990 - 1995 and assume that the

[1] See ”Assumptions”.
[2] Kartläggning av materialflöden - inom bygg- och anläggningssektorn (Material flows in the construction sector), SEPA Report 4659, Jacobson & Widmark, 1996.
[3] Average year: see section 2.3 about ”The construction industry”.

production of pre cast are constant on 2 million tons (information on other years than 1993 have not been available), we will get an average production of concrete of about 9 700 000 tons.

Production of ready-mixed concrete

Year	m^3	**tons** (assumed density: 2.4 tons/m^3)[1)]
1989	4 800 000	11 500 000
1990	5 000 000	12 000 000
1991	4 200 000	10 100 000
1992	3 300 000	7 900 000
1993	2 300 000	5 500 000
1994	2 100 000	5 000 000
1995	2 300 000	5 500 000
1996	1 800 000	4 300 000
1997	2 000 000	4 800 000
1998	2 200 000	5 300 000

[1)] Different kinds of aggregates gives different weight, but the average is about 2,4 tons per m^3 concrete. (Personal communication, Sandahl)
Source: Swedish Ready-mixed Concrete Association

If we use information on production and import of cement (se table below), we can calculate how much concrete that should have been produced if all the cement were used for concrete. (In the production of concrete, 15 percent of the weight is cement.) If we calculate an average for 1990-1995, we will get an average production of concrete of about 11 690 000 tons.

Production and import of cement, thousand tons

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Production of cement	2 260	1 980	1 586	1 325	1 289	1 375	1 262	1 149	1 328
Import of cement	119	110	120	120	120	120	142	148	130
Cement total	2 379	2 090	1 706	1 445	1 409	1 495	1 404	1 297	1 458
...gives the production of concrete	15 860	13 933	11 373	9 633	9 393	9 967	9 360	8 647	9 720

Source: Viktiga materialflöden (Important material flows), Rapport 4384, SEPA

The differences between the information from the different sources have not been further analysed in this study. The Geological Survey of Sweden have announced that the information on use of the material is uncertain and this could be one explanation.

In the input and output tables in annex 3, we have, to be consistent on the input side, chosen to use the information from the Geological Survey of Sweden. (Other input information is from the Geological Survey of Sweden.) On the output side, the result from Jacobson & Widmark is used. Using this data we will get a data gap on almost 6 million tons between the amount of gravel etc. that are delivered to production of concrete and the amount of concrete produced. If we had used the same information both on the input and output side concerning production of concrete, the gap would had occurred some where else in the tables.

Another source that we tried to use is the official statistics of production at Statistics Sweden. However, this statistics is difficult to use when we want to look at the production of concrete. In the classification of goods, concrete, cement etc. are aggregated, and the production of concrete is not possible to single out. The information in physical terms is also incomplete.

Below some statistics for production in 1995 are shown. The total for concrete in section 38 according to HS-nomenclature (chemical products) is about 3.1 million tons (here some other products, cement etc., are included). In section 68 (goods of concrete etc.) it is not possible to single out the goods of concrete from other goods included in the same group. The total are about 2.6 million tons.

Production 1995

HS[1]	Good	ton
381600	Cement, fire resistant masonry mortar, fire resistant concrete and similar fire resistant manufactures (excluding products on the basis of graphite or other kind of carbon)	42 282
382300 (502)	Concrete mixes	3 093 408
681011	Blocks and bricks for buildings, of cement, concrete or artificial stone, also reinforced	313 294
681019	Tiles for roof, floor, walls, garden and such goods of cement, concrete or artificial stone, also reinforced (excluding blocks and bricks for buildings)	504 823
681091	Prefabricated elements for buildings or constructions of cement, concrete or artificial stone, also reinforced	1 587 572
681099	Goods of cement, concrete or artificial stone, also reinforced (excluding prefabricated elements for buildings or constructions and tiles, bricks and the like)	209 901

Source: Statistics Sweden

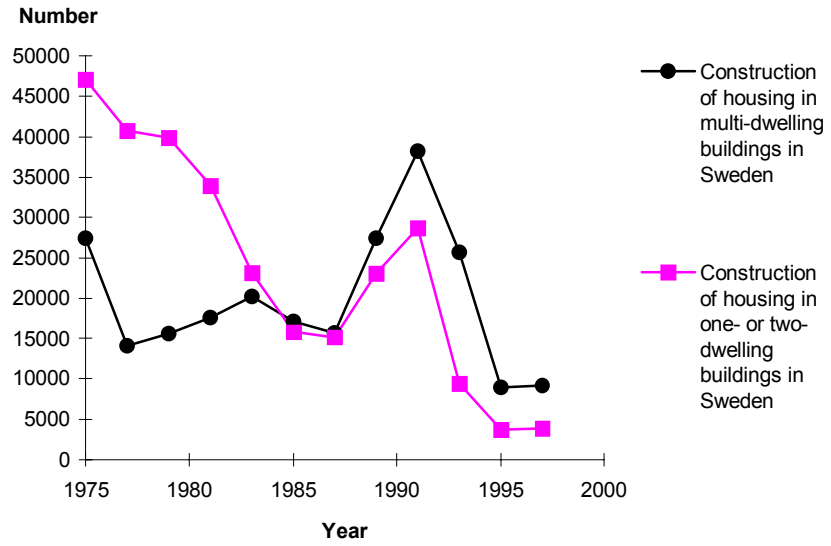
2.3 The construction industry

The construction sector is one of the largest industries, concerning several aspects - economy, employment and use of material. In 1995 the construction activities represented six percent of the GNP in Sweden and the same percentage of the employment (measured in hours)[2].

Several materials are used in construction of buildings and other infrastructure, for example minerals, wood and plastic. The largest materials, in weight, are the aggregates gravel, sand and crushed stone. The large amounts of different materials used causes impact on the environment as energy is needed for transportation and production, non-renewable natural resources are used and hazardous material are spread. Gravel is a limited resource of importance for the supply of water in Sweden (see ”Extraction and primary use”). To reduce the extraction of gravel, a larger amount of construction mineral could be recycled. An example is the possibility to use crushed concrete in production of new concrete or to use more residues as filling material. Today some recycling exists, but the use of residues could probably increase. To stimulate recycling and use of substitute materials, a tax on natural gravel exist in Sweden.

The use of material is correlated with the development in construction activities. The construction, on its part, follows the fluctuations in economy. In the last decades there have been large changes in the dimensions of the construction sector, partly due to changes in the economy. The chart below shows construction of housing in Sweden 1975-1997. The fluctuations are significant.

[1] Customs Tariffs with a Statistical Commodity List, based upon the HS Nomenclature (Harmonized Commodity Description and Coding System).
[2] Environmental accounts, Statistics Sweden.



Construction of housing in multi- and one- or two-dwelling buildings in Sweden 1975-1997
Source: Statistics Sweden

In the table below we can see the stock of real-estates measured in square meters in 1996. The total area is 653 000 000 m^2.

The stock of real-estates in Sweden, 1000 m^2

Type of building	**1996**
Multi-dwelling buildings	155 000
One- or two-dwelling buildings	227 000
Offices, shops, hotels etc.	72 000
Public administration	85 000
Industry	114 000
Total	653 000

Source: Statistics Sweden

The stock of real-estates plus other infrastructure (roads, rail-ways etc.) consists of a large amount of material, of which a large part is sand, gravel and stone. Every year more material is added to the stock and some is released from the stock, mainly as waste. There is no statistics on this today. Statistics on how much that is built (number of apartments, m^3 etc.), how large the investments are etc. exists, but to translate this into tons of different materials used is difficult. Today, statistics on construction waste is lacking (the release from stock) (see ”Residuals”). To some extent, the amounts are possible (but difficult) to estimate with the existing statistics on demolition as a base.

In a well performed study on these matters by the consultant-firm Jacobson & Widmark[1], made for the Swedish Environmental Protection Agency, some estimations have been made. From construction statistics and expert knowledge, statistics is recalculated into flows of material within the construction sector. We have used results from this study, because it is, as far as we can see, the best attempt done in Sweden. Much more work has to bee done in this area to get more certain information about input in and waste from the construction sector.

In the study from Jacobson & Widmark, they have divided the information into different material groups. Of interest for this study on sand, gravel and crushed stone is their material groups: aggregates (sand/stones etc.), concrete and asphalt. They have studied housing and other

[1] Kartläggning av materialflöden - inom bygg- och anläggningssektorn (Material flows in the construction sector), SEPA Report 4659, Jacobson & Widmark, 1996.

infrastructure, including roads and railways but excluding for example military buildings, maintenance of houses. They have measured what they call a standard year (or as we call it further on; an average year). This is an average of five years in the beginning of the nineties (different years for different types of buildings etc. due to the existing statistics - within a seven year-period, statistics for five years is used).

The construction statistics used as a base in their study is the official building statistics from Statistics Sweden. Building statistics is used to follow up housing construction, for making forecasts of housing investments, and for market assessments. Different parties in the construction sector and building market use the Construction Index and Real Estate Price Index to regulate agreements and contracts.

2.4 Import and export

The information on import and export comes from the official foreign trade statistics at Statistics Sweden. The foreign trade statistics contains import and export of goods, accounted for in standard classification. With EU membership in 1995 the foreign trade statistics changed. Earlier it was produced with the use of tariff documents. All export and import was registered. Today, without the same custom procedures inside the European Union, the foreign trade statistics is produced by questionnaires to a sample of companies. The statistics has so far not been of sufficient quality. In this study however, only statistics until 1995 has been used.

Only statistics for import and export of aggregates (sand, etc.) has been included (HS-code 25.17.100). Some goods containing sand, gravel and crushed stone have probably been exported or imported, but statistics for these kind of goods are presented together with other goods containing other materials[1], and is therefore not possible to use in the study.

Export and import 1990-1995

Export of ”sand, gravel and crushed stone”:	1990: 1 282 740 tons
(HS: 25.17.100)	1991: 1 653 062 ”
	1992: 1 405 734 ”
	1993: 1 423 487 ”
	1994: 2 048 630 ”
	1995: 1 980 093 ”
Import of ”sand, gravel and crushed stone”:	1990: 64 500 tons
(HS: 25.17.100)	1991: 79 601 ”
	1992: 129 536 ”
	1993: 564 388 ”
	1994: 85 560 ”
	1995: 42 520 ”

Source: Foreign trade statistics, Statistics Sweden

2.5 Residuals

Large amounts of construction and demolition waste are generated in the construction sector. Today no complete statistics for this exist. In a study of waste handled by municipalities 1994, construction waste was measured[2]. Waste from construction, demolition, rebuilding and excavated material were included. The total amount was 1 460 000 tons. As this only includes the waste handled by municipals, it only represents a part of the total construction waste.

[1] Compare with the same problem in chapter 2.2 ”Production of concrete”.
[2] Waste and recovery in municipalities in Sweden 1994, Na 28 SM 9502, Statistics Sweden.

The data used in the input and output tables in annex 3 is from the study on material flows in the construction sector mentioned earlier[1]. The waste amounts are estimated from knowledge of the industry used together with statistics on housing. The total amount of waste an average year in the early nineties is estimated to 6 000 000 tons. 43 percent are reused and 40 percent goes to ”filling”. Several tons of the reused material and the material to filling probably never pass the municipal waste handling, and this can explain the differences in the result from the two sources. In the input and output tables in annex 3, the amounts from the total waste (6 million tons) that consists of sand, gravel and crushed stone are estimated to be 3 940 000 tons.

Waste from the construction sector, 1 000 tons

Source	Total	*of which to*			
		Landfill	Filling	Incineration with energy recovery	Recycling[2)]
Study on material flows in the construction sector (statistics on housing used as base)	1 460	900	[1)]	100	440
Survey on construction waste handled by municipalities in 1994	6 000	300	2 400	300	3 000

[1)] No information on filling. It is possible that responders (municipalities) has considered filling as either landfilling or recycling.
[2)] Including reuse and material recovery.

The Swedish Environmental Protection Agency, that are responsible for the official waste statistics, is planning to, in a couple of years, produce statistics on waste from the construction sector. The statistics will probably be compiled by a combination of questionnaires and estimations with statistics on housing as base. To make such estimations accurate, more information on the relation between the size of construction and demolition activities and the waste arising is needed.

Waste from other sectors; mining, manufacturing of concrete, other manufacturing; and imported and exported waste may also consist of sand etc. By looking at the waste statistics from 1993 we have not been able to find any waste types of this kind from the mining industry and the industry for manufacturing of concrete. Some recycling of concrete (crushed concrete used to make new concrete) probably exist, but we have no information on the size of this activity.

[1] Kartläggning av materialflöden - inom bygg- och anläggningssektorn (Material flows in the construction sector), SEPA Report 4659, Jacobson & Widmark, 1996.

3 Results

In this chapter results are presented. Data on input in and output from the economy is included as well as input and output between sectors within the economy. The data used is described in chapter 2 and in annex 2. We want to point out that some existing flows have not been included, either due to lack of data or that no information on the activity has been available. We also want to make clear that some of the used data is uncertain, which is also described in chapter 2.

3.1 Input and output of sand, gravel and crushed stone

Information on input and output of material is usually received from industrial input and production statistics. In this case, when the construction industry is such a large user of the material in question, data is often taken from the construction statistics. As described above, in ”Extraction and primary use”, the industry statistics on production or extraction of the natural resources in this area are incomplete. There are a large number of small businesses with few employees, not included in the statistics, but producing a large amount. Therefore statistics from the Geological Survey of Sweden is used instead to describe the input of material in the economy.

In annex 3, input and output tables are presented. The sources are described in annex 2 and the results are commented below. The statistics are calculated to show an average year between 1990 and 1995. This is done for several reasons; the information for the construction sector (input and output) collected from the study from Jacobson & Widmark is only available in this form and an average for several years will also reduce the impact of possible errors in statistics for a specific year.

The matrixes could be used for different types of analyses, for example resource or destination analyses[1]. In this study the main use of the input and output is:

- identify data gaps and shortcomings in the existing statistics - a discussion-base for continuous work in the area
- to study the direct material input and output in society (see below)
- to estimate the increase in the stock.

The data in the input and output tables is collected from several different statistics. The sources are mentioned in annex 2 and described in chapter 2. The data is in some part not sufficient and in several cases calculations have been made from assumptions. For some areas no data has been found, even thought there probably exist production or use. Never the less, we assume that we have been able to compile data for the large flows. To identify missing or inaccurate data and to work on collecting or improving this is a task for the future.

[1] Carbon Flow Analysis in Sweden, Statistics Sweden, 1996.

In the scheme below the input and output tables are commented upon:

Total input and output of sand/gravel/crushed stone (sgs) in the different sectors

	Input, ton	Output, ton	Comment
Extraction	0	88 400 000	There is a large extraction of sand, gravel and crushed stone.
Manufacturing of concrete	12 300 000	6 500 000	The input of sgs is larger than the output. This is a data gap due to difference in statistics from different sources (see more under ”Production of concrete” (2.2)). There should probably also be a small input of waste (i.e. crushed concrete), but no data on this has been found.
Other manufacturing	4 400 000	0	No output of goods containing sgs has been included (due to lack of data), which probably is incorrect and should be similar to the input.
Construction of buildings and roads etc.	64 380 000	68 600 000	A small (expressed in percent) difference between the input and output. The output is larger, more is produced than used. This could be a consequence of different data sources or a real difference, if material for example has been stored. There also, probably, should be output of waste from construction (waste from re-building are included in demolition), but no separate data on this has been found. A study made in Sweden in 1994, of one construction project, shows that 18 % (in weight) of the waste are ”cement and stone material”[1].
Demolition (and rebuilding) of buildings etc.	920 000	920 000	The input and output are the same because of the same source. The data is uncertain due to difficulties in estimation. Construction statistics are used as a base for estimations.
Demolition (and rebuilding) of roads etc.	3 020 000	3 020 000	The input and output are the same because of the same source. The data is uncertain due to difficulties in estimation. Construction statistics are used as a base for estimations.
Filling	17 410 000	0	A large input directly from extraction of sgs plus residues from demolition. It is difficult to separate filling from some activities in construction. No output has been accounted for. If ”extraction” from filled areas exist, this could been seen as inaccurate.
Landfilling	60 000	0	Input of waste in landfills and no output. The amount to landfill from demolition is uncertain due to the methods to estimate the data.
Import	-	160 000	According to the trade statistics.
Export	1 630 000	-	An export larger than the import.
Total	(104 120 000)	(167 600 000)	The total does not give any information, it contains double counting. For total input in and output from society - see below.

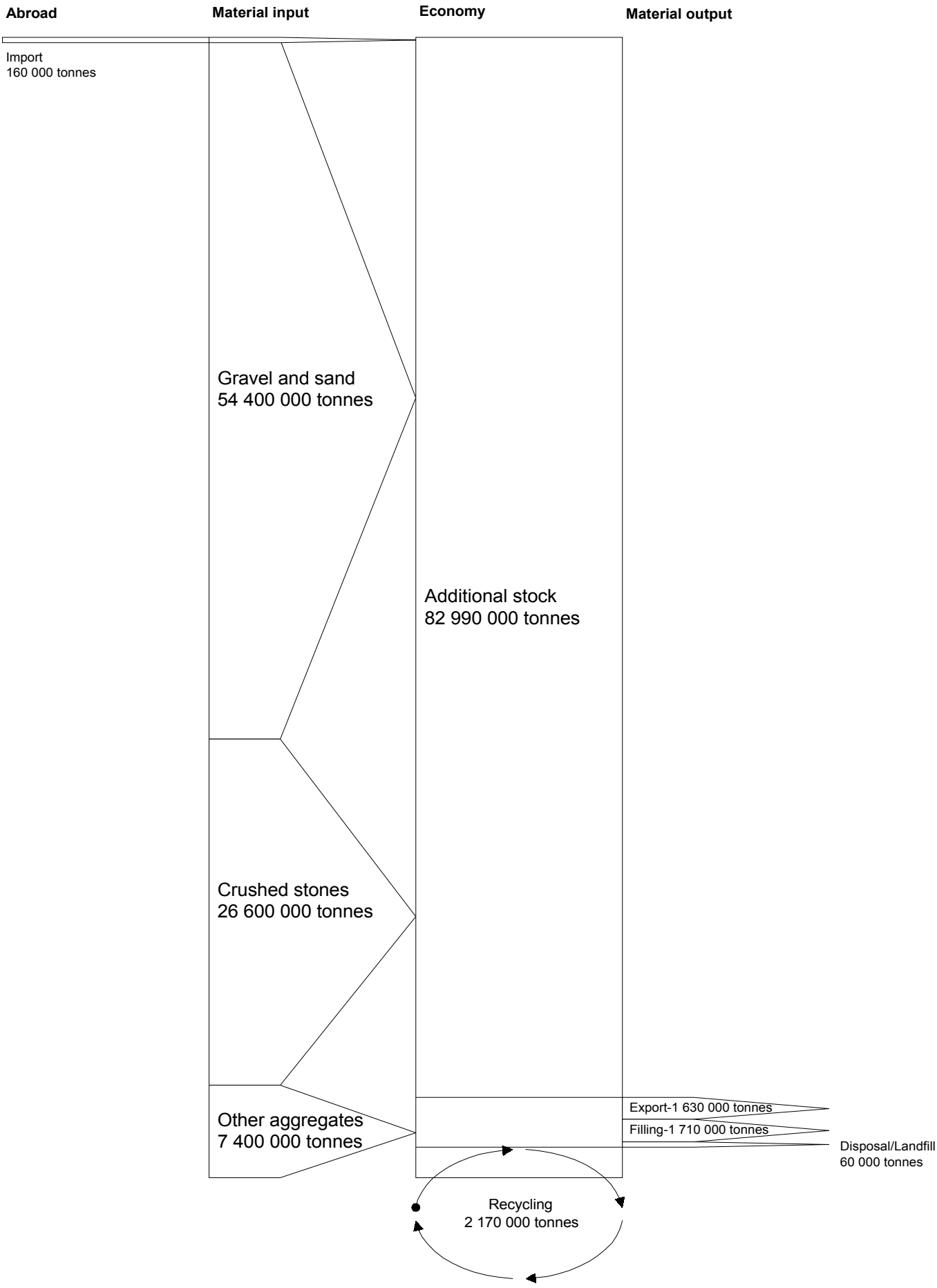
[1] Bygg- och rivningsavfall - inventering av avfallet från två byggarbetsplatser (Construction and demolition waste - inventory of waste from two construction sites), 1994, Lotta Sigfrid.

3.2 Direct material input in and output from the society

It is important to get an overview of the primary input in and output from society. This gives possibility to study the extraction of a natural resource and connect this to the stock building and to the output from society. From this, a discussion about substitutes for the natural resource or reuse of the resource could be initiated. We will by this approach see the increase in the stock of buildings for the time period the flow refers to. It would also be of interest to cover hidden flows[1], material never entering the economy, in the overview. This however is not included in this study.

In the chart on the next page, the input in and output from the society (Sweden) for an average year in the beginning of the nineties is presented. The data is from the input and output tables in the appendix. We have considered residues to filling as output from the economy, but material directly from extraction to filling as input in the economy. As mentioned above, the data on output is very uncertain.

[1] See: Resource Flows - The material basis of industrial economies, Wuppertal Institute, 1997.



Input in and output from the Swedish economy, of sand, gravel and crushed stone, an average year in the beginning of the nineties

3.3 Accumulation in society

The accumulation in society, i.e. the increase in stock, of sand, gravel and crushed stone in buildings, roads etc. is growing every year. The size of the existing stock in infrastructure in Sweden can be discussed. An accurate measure is difficult to get. We have used an estimate from the study used in other parts of our presentation (Jacobson & Widmark, 1996). According to this estimation, the total accumulation of material in buildings were 2.5 thousand million tons in 1995. The sand, gravel and crushed stones part is almost 80 percent (see table below).

Accumulation in society (measured in tons of sand, gavel and crushed stone) up to and including 1995

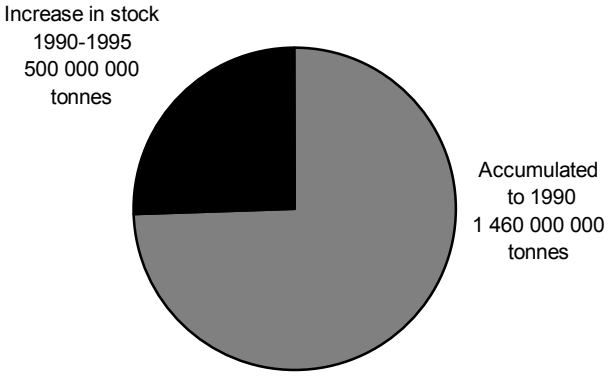
	In houses	In roads etc.	Total
Concrete	391 500 000	22 500 000	414 000 000
"Light"- concrete	15 317 000	-	15 317 000
Asphalt	-	245 904 000	245 904 000
Sand etc.	260 000 000	1 020 000 000	1 280 000 000
Total	**666 817 000**	**1 288 404 000**	**1 955 221 000**

Source: Jacobson & Widmark, 1996 - modified (see assumptions)

If we estimate the increase in stock from the statistics in the input and output tables, we will get an increase on about 500 million tons 1990-1995.

Period	Tons
1. Stock until 1995[1]	1 955 000 000
2. Increase/year 1990-1995[2]	82 990 000
3. Increase 1990-1995	497 940 000
4. Stock until 1990 (row 1 minus row 3)	1 457 060 000

[1] according to "Jacobson & Widmark" (recalculated)
[2] see 3.2



Stock of sand, gravel and crushed stone in the Swedish society up to and including 1995
(according to estimations and calculations)

According to the estimations above, the increase in stock is very large expressed in percent. If these estimates are right we will soon have doubled the accumulated material (gravel, sand and crushed stone) in Sweden from 1990. For future discussions about the accuracy in suggested size of the accumulation in society, we have put together two examples below.

- According to the estimate above there are 666 817 000 tons sand, gravel etc. in buildings (1995). From the construction statistics we know that the area of buildings in Sweden is 653 000 000 m^2 (1996). This means that there should be about one ton per square meter.
- The length of roads in Sweden is 430 000 km[1]. This should mean that there are about 3 000 tons of sand, gravel etc. in one km road if we use the total amount in roads presented above (1 288 404 000 tons). According to the National Swedish Sand, Gravel and Crushed Stone Association, there are 30 000 tons sand, gravel etc. in one km road. The amount of course depends on which type of road that is studied. The types of roads in Sweden are:
  - 15 000 km European highways and national highways
  - 83 000 km county roads
  - 330 000 km other roads and streets including forest roads

  If we only include the two first types of roads above, one km would contain 13 000 tons.

[1]Markanvändningen i Sverige (Land-use in Sweden), 1998, Statistics Sweden.

4 Conclusions and future work

This study is a first attempt at Statistics Sweden to put together material flow statistics on construction minerals. Several data sources has turned out to be useful, but a lot of improvement could still be done. To identify missing or inaccurate data and to continue the work on collecting or improving this data is an important future work. Below some examples of problems encountered and possible future work are described.

Statistics on production of aggregates can be collected from two different sources: the industrial statistics at Statistics Sweden and statistics from the Geological Survey of Sweden. The statistics from Statistics Sweden have not been used because production is only reported for industrial companies with at least 10 employees and establishments with at least 5 employees. Most of the pits for sand, gravel and crushed stone have few employees and the production accounted for in the official industrial statistics will not be the total production. From summer 1999 it is possible that statistics from the tax authority can be used instead. Also small companies are reporting in the tax-return forms. At present, Statistics Sweden investigates the quality of this data.

The statistics about production from the Geological Survey of Sweden, reported to the county administrative board from the producers, are rather good as a total for Sweden. The data collected from the producers is complemented with calculated volumes for pits that have not left information about the produced volume. Nowadays most of the counties have a discrepancy of less than one percent. Although the statistics are rather good, it could be better if all the producers reported their production volumes.

The use of the aggregates (sand, gravel and crushed stone) is more difficult to get accurate data on. The producers estimate to what purpose the aggregates are delivered. They distribute their deliveries between, in percent, road construction, concrete, filling and other uses. The Swedish Ready-mixed Concrete Association has statistics about the yearly production of ready-mixed concrete, but these figures are different from the estimate made by the producers of aggregates. Concerning concrete, different data from different sources also exists. This difference in data is needed to be further analysed.

Statistics on the use of material in the construction industry and the releases from the stock, i.e. the waste generated, could be much better. The information used in this study is from one study made in this area. It is important to, in the future, get better knowledge on the waste streams from demolition, as well as from building and re-building. This could be made as direct statistics (for example by questionnaires to the construction firms) or by estimations from the size of the construction activities. If this is to be done, much better information on the relation between construction and demolition and the waste arising is needed.

A general point of view, working with material flow statistics for one particular material, is that more information on material contents in goods is needed. This has also been the case in this study. The classification of goods sometimes includes a group of several types of goods, which makes it difficult to estimate the quantity of the good or material in question. Also when one type of good corresponds to one code in the classification, difficulties exist of knowing the contents of the material in question. Another general opinion is that better physical information is needed for production of goods and input in manufacturing industries.

Lists of references

- Aggregates and industrial minerals, Year 1990 - 1996, Geological Survey of Sweden
- Aggregates, Year 1997, Geological Survey of Sweden
- Bygg- och rivningsavfall - inventering av avfallet från två byggarbetsplatser (Construction and demolition waste - inventory of waste from two construction sites), 1994, Lotta Sigfrid
- Carbon Flow Analysis in Sweden, 1996, Björn Andersson, Statistics Sweden
- Chromium and nickel in Sweden, 1995, Viveka Palm *et. al*.
- Environmental accounts, Statistics Sweden
- Foreign trade statistics, Statistics Sweden
- Grus och Makadamföreningen (National Swedish Sand, Gravel and Crushed Stone Association), Information material
- Grustäkters inverkan på grundvattnet (The influence of gravel pits on the groundwater), Report 4570, Swedish Environment Protection Agency
- Industrial metabolism. The emerging landscape of heavy metal immission in Sweden, Bo Bergback, 1992
- Industriella mineral och bergarter - en branschutredning, 1998, Geological Survey of Sweden
- Kartläggning av materialflöden - inom bygg- och anläggningssektorn (Material flows in the construction sector), SEPA Report 4659, Jacobson & Widmark, 1996
- Markanvändningen i Sverige (Land use in Sweden), 1998, Statistics Sweden
- Material flow studies at Statistics Sweden and the National Chemicals Inspectorate, 1996, Margareta Östman, the National Chemical Inspectorate, Elisabeth Bergstedt, Statistics Sweden
- Naturgrus och alternativa material (Gravel and alternative materials), 1997, Rapport 4831 Swedish Environmental Protection Agency
- Nordiska naturresurs- och miljöräkenskaper - delrapport II (Nordic environmental- and natural-resource account - part II), 1997, Nordic Council of Ministers
- Reduced emissions of carbon dioxide through changed use of materials, to be published in 1999, Statistics Sweden
- Resource Flows – The material basis of industrial economies, Wuppertal Institute, 1997
- Waste and recovery in municipalities in Sweden 1994, Na 28 SM 9502, Statistics Sweden
- Waste and renewable raw material from the industry 1993, Na 28 SM 9501, Statistics Sweden
- Verksamheten 1997/98, Swedish Ready-mixed Concrete Association
- Viktiga materialflöden (Important material flows), Rapport 4384, Swedish Environmental Protection Agency

Assumptions

The assumptions below have been used in the study:

Concrete consists of (% of weight):

Aggregates (sand etc.)	77 %
Cement	15 %
Water	8 %

Source: "Miljöbalans- Betongens positiva och negativa effekter", Cementa AB 1993

Used: Concrete contains approximately 75 % "sand, gravel, crushed stone"

"Light"-concrete:

Content: standard-cement, limestone, gypsum, sand/sandstone and water
The percentage (weight) of sand and sandstone are 45-60 %.
Source: Ytong (Swedish company)

The conversion factor for amount of sand and stone in "light"-concrete used in this study is 53 %.

Asphalt consists of (weight-%):

Stone material (crushed stones)	94 %
Bitumen	6 %

Source: Föreningen för Asfaltbeläggningar i Sverige - Swedish Asphalt Pavement Association

Used: Asphalt contain 94 % "sand, gravel crushed stone"

The input- and output tables - sources and calculations

(For description of sources - see chapter 2)
(Calculation factors and other assumptions - see "Assumptions")

Output-table

A 1	Extraction of gravel	*Source: Geological Survey of Sweden* 1990: 69 800 000 tons 1991: 63 300 000 " 1992: 53 100 000 " 1993: 51 900 000 " 1994: 43 500 000 " 1995: 44 600 000 " Average 1990-1995: 54 400 000 tons
B 1	Production of crushed stones	*Source: Geological Survey of Sweden* 1990: 25 100 000 tons 1991: 24 900 000 " 1992: 22 600 000 " 1993: 26 000 000 " 1994: 28 600 000 " 1995: 32 300 000 " Average 1990-1995: 26 600 000 tons
C 1	Production of other aggregates	*Source: Geological Survey of Sweden* 1990: 5 100 000 tons 1991: 4 500 000 " 1992: 5 900 000 " 1993: 7 800 000 " 1994: 10 800 000 " 1995: 10 300 000 " Average 1990-1995: 7 400 000 tons
D 2	Production of concrete	*For used alternative - see in the text "Production of concrete"* ***Alternative 1:*** *Source: Geological Survey of Sweden (estimated and recalculated)* 1990: 16 000 000 tons sgs used in concrete ⇒ *(/0,75) = 21 300 000 tons concrete prod.* 1991: 16 000 000 ⇒ *21 300 000 tons concrete produced* 1992: 13 000 000 ⇒ *17 300 000 "* 1993: 9 000 000 ⇒ *12 000 000 "* 1994: 9 000 000 ⇒ *12 000 000 "* 1995: 11 000 000 ⇒ *14 700 000 "* Average 1990-1995: 12 300 000 tons sgs used in 16 400 000 tons concrete ***Alternative 2:*** *Source: Jacobson & Widmark, 1996* (a study on material in the construction industry) Used in buildings etc. an average year: Concrete: 5 340 000 tons (x 0,75) = 4 005 000 tons sgs "Light"-concrete: 338 000 tons (x 0,53) = 179 140 tons sgs Used in roads etc. an average year: Concrete: 3 110 000 tons (x 0,75) = 2 332 500 tons sgs ⇒ a total of about 6 500 000 tons sgs are used in 8 800 000 tons concrete an average year. ***Alternative 3:*** *Sources:* *- Viktiga materialflöden (Important material flows), Rapport 4384,*

		SEPA, 1994 / Swedish pre-cast federation *- Swedish ready-mixed association, 1997/98* The year 1993 - about 6 million tons ready-mixed concrete (concrete delivered in flowing form to the working site for casting in moulds) and about 2 million tons pre cast concrete products were produced. Together this is a production of 8 million tons. The same year 75 000 tons pre cast concrete were imported and 125 000 tons were exported. If we assume a constant production of 2 million tons pre cast and production of ready-mixed as below, we will get an average production of concrete on 9.7 million tons which corresponds to 7.3 million tons sand, gravel and crushed stone. 1990: 12 000 000 tons ready-mixed concrete ⇒ 9 000 000 tons sgs 1991: 10 100 000 tons ready-mixed concrete ⇒ 7 575 000 tons 1992: 7 900 000 tons ready-mixed concrete ⇒ 5 925 000 tons 1993: 5 500 000 tons ready-mixed concrete ⇒ 4 125 000 tons 1994: 5 000 000 tons ready-mixed concrete ⇒ 3 750 000 tons 1995: 5 500 000 tons ready-mixed concrete ⇒ 4 125 000 tons 1993: 2 000 000 tons pre cast concrete ⇒ 1 500 000 tons Average: 9 700 000 tons concrete ⇒ 7 300 000 tons	
F 4	Production of buildings	*Source: Jacobson & Widmark, 1996* Concrete: 5 340 000 tons (x 0,75) = 4 005 000 tons sgs ”Light”-concrete: 338 000 tons (x 0,53) = 179 140 tons sgs Sand/Stones: 916 000 tons = sgs Total: 5 100 140 tons (rounded: 5 100 000 tons)	average year
G 5	Production of roads etc. (incl. asphalt)	*Source: Jacobson & Widmark, 1996* Concrete: 3 110 000 tons (x 0,75) = 2 332 500 tons sgs Asphalt: 7 660 000 tons (x 0,94) = 7 200 400 tons sgs Sand/Stones: 53 924 000 tons = sgs Total: 63 456 900 tons (rounded: 63 500 000 tons)	average year
H-K 1	Waste from extraction	From the waste statistics made in Sweden, we have not been able to find any indications that waste consisting of the materials in question should arise.	
H-K 2	Waste from production of concrete	From the waste statistics made in Sweden, we have not been able to find any indications that waste consisting of the materials in question should arise.	
H-K 4-5	Waste from construction of buildings and roads etc.	We have not been able to find any information on waste (of the material in question) from construction of new objects. A study made in Sweden in 1994, of one construction project, shows that 18 % (in weight) of the waste are ”cement- and stone material”[1].	
H 6	To reuse from demolition of houses	*Source: Jacobson & Widmark, 1996* Sand/Stones: 144 000 tons = sgs (rounded: 140 000 tons)	average year
I 6	To material recovery from demolition of houses	*Source: Jacobson & Widmark, 1996* Concrete: 192 000 tons (x 0,75) = 144 000 tons sgs ”Light”-concrete: 9 000 tons (x 0,53) = 4 770 tons sgs Total: 148 770 tons (rounded: 150 000 tons)	average year
J 6	To ”filling” from demolition of houses	*Source: Jacobson & Widmark, 1996* Concrete: 720 000 tons (x 0,75) = 540 000 tons sgs ”Light”-concrete: 54 000 tons (x 0,53) = 28 620 tons sgs Sand/Stones: 16 000 tons = sgs Total: 584 620 tons (rounded: 580 000 tons)	average year
K 6	To landfills from demolition of houses	*Source: Jacobson & Widmark, 1996* Concrete: 48 000 tons (x 0,75) = 36 000 tons sgs ”Light”-concrete: 27 000 tons (x 0,53) = 14 310 tons sgs Total: 50 310 tons (rounded: 50 000 tons)	average year

[1] Bygg- och rivningsavfall - inventering av avfallet från två byggarbetsplatser (Construction and demolition waste - inventory of waste from two construction sites), 1994, Lotta Sigfrid.

H 7	To reuse from demolition of roads etc.	*Source: Jacobson & Widmark, 1996* Asphalt: 1 620 000 tons (x 0,94) = 1 522 800 tons sgs Sand/Stones: 340 000 tons = sgs Total: 1 862 800 tons (rounded: 1 860 000 tons)	average year
I 7	To material recovery from demolition of roads etc.	*Source: Jacobson & Widmark, 1996* Concrete: 6 250 tons (x 0,75) = 4 700 tons sgs Sand/Stones: 20 000 tons = sgs Total: 24 700 tons (rounded: 20 000 tons)	average year
J 7	To ”filling” from demolition of roads etc.	*Source: Jacobson & Widmark, 1996* Concrete: 100 000 tons (x 0,75) = 75 000 tons sgs Asphalt: 1 080 000 tons (x 0,94) = 1 015 200 tons sgs Sand/Stones: 40 000 tons = sgs Total: 1 130 200 tons (rounded: 1 130 000 tons)	average year
K 7	To landfills from demolition of roads etc.	*Source: Jacobson & Widmark, 1996* Concrete: 18 750 tons (x 0,75) = 14 050 tons sgs (rounded: 10 000 tons)	average year
A-C 10	Import of stones, gravel and sand	*Source: Statistics Sweden* (HS: 25.17) 1990: 64 500 tons 1991: 79 601 ” 1992: 129 536 ” 1993: 564 388 ” 1994: 85 560 ” 1995: 42 520 ” Average 1990-1995: 161 017 tons (rounded: 160 000)	

Input-table

Cell	Information	Source and calculations	Year
A-C 2	Use of Sand/ Gravel/Stones in concrete	*Source: Geological Survey of Sweden* 1990: 16 000 000 tons 1991: 16 000 000 ” 1992: 13 000 000 ” 1993: 9 000 000 ” 1994: 9 000 000 ” 1995: 11 000 000 ” Average 1990-1995: 12 300 000 tons (see also ”output-table” and chapter 2.2 ”Production of concrete”)	
A-C 3	Use of Sand/ Gravel/Stones in ”other”	*Source: Geological Survey of Sweden* 1990: 8 000 000 tons 1991: 7 000 000 ” 1992: 5 000 000 ” 1993: 6 000 000 ” 1994: 3 000 000 ” 1995: 3 000 000 ” Average 1990-1995: 5 300 000 tons We assume that 900 000 tons of ”other” goes directly to construction of buildings etc. (according to A-C 4 below) and the rest goes to other manufacturing. ⇒ ”to other excluding to buildings etc.”: 4 400 000 tons	
A-C 4	Use of Sand/ Gravel/Stones in buildings etc.	*Source: Jacobson & Widmark, 1996* Sand/Stones: 916 000 tons = sgs (rounded: 900 000 tons)	average year
A-C 5	Use of Sand/ Gravel/Stones in roads etc. (incl. in asphalt)	***Alternative 1:*** *Source: Jacobson & Widmark, 1996* Sand/Stones: 53 924 000 tons = sgs Asphalt: 7 660 000 tons (x 0,94) = 7 200 400 tons sgs Total: 61 124 400 tons (rounded: 61 120 000 tons) ***Alternative 2:*** *Source: Geological Survey of Sweden* 1990: 57 000 000 tons 1991: 52 000 000 ” 1992: 48 000 000 ” 1993: 57 000 000 ” 1994: 56 000 000 ” 1995: 59 000 000 ” Average 1990-1995: 54 800 000 tons ⇒ Figure used: 54 800 000 tons (alt 2) We use alt. 2, but we can see that the difference between the two alternatives are relatively small (about 1 percent)	average year
A-C 8	Use of Sand/ Gravel/Stones as filling material	*Source: Geological Survey of Sweden* 1990: 19 000 000 tons 1991: 17 000 000 ” 1992: 16 000 000 ” 1993: 13 000 000 ” 1994: 15 000 000 ” 1995: 14 000 000 ” Average 1990-1995: 15 700 000 tons	
D 4	Use of concrete in buildings	*Source: Jacobson & Widmark, 1996* Concrete: 5 340 000 tons (x 0,75) = 4 005 000 tons sgs ”Light”-concrete: 338 000 tons (x 0,53) = 179 140 tons sgs Total: 4 184 140 tons (rounded: 4 180 000 tons)	average year
D 5	Use of concrete in roads etc.	*Source: Jacobson & Widmark, 1996* Concrete: 3 110 000 tons (x 0,75) = 2 332 500 tons sgs (rounded: 2 330 000 tons)	average year
F 6	Input of buildings in the demolition sector	*Source: Jacobson & Widmark, 1996* H 6+I 6+J 6+K 6 (output table) = 920 000 tons sgs	average year

G 7	Input of roads in the demolition sector	*Source: Jacobson & Widmark, 1996* H 7+I 7+J 7+K 7 (output table) = 3 020 000 tons sgs	average year
H 2-3	Use of waste in production of concrete	Crushed concrete could be used to produce new concrete, but this is not yet done to any large extent. We have not been able to find any statistics on this.	
H-I 4-5	Use of waste in buildings, roads etc.	Found information so far: From different sources we know that recycled waste from concrete is often used in roads. Asphalt-waste is also used in roads. Crushed concrete could be used to produce new concrete, but this is not yet done to any large extent. But these data is not sufficient. We have to assume that the main part of residues from construction is used in the same sector. We put together the sectors for construction of buildings and roads and add the data in H6-H7 and I6-I7 from the output table.	average year
J 8	Residuals for/to filling	= Total output	
K 9	Residuals for/to landfill	= Total output	
A-C 10	Export of stones, gravel and sand	*Source: Statistics Sweden* (HS: 25.17.100) 1990: 1 282 740 tons 1991: 1 653 062 ” 1992: 1 405 734 ” 1993: 1 423 487 ” 1994: 2 048 630 ” 1995: 1 980 093 ” Average 1990-1995: 1 632 291 tons (rounded: 1 630 000)	

Annex 3-The input-output tables

Output of sand/gravel/crushed stone an average year in the beginning of the nineties, ton

		1	2	3	4	5	6	7	8	9	10	11
		NACE 10-14	NACE 26	NACE 15-37 (excl. 26)	NACE 452 a[1]	NACE 452 b[2]	NACE 45110 a	NACE 45110 b	Filling	Landfilling	Import	Total
	Good (mesured in sgs)	Extraction	Manufacturing of concrete etc.	Other manufacturing	Construction of buildings etc.	Construction of roads etc. (incl. asphalt)	Demolition/re-building of buildings etc.[3]	Demolition/re-building of roads etc.[3]				
A	Gravel and sand[4]	54 400 000	-	-	-	-	-	-	-	-	160 000	88 560 000
B	Cruched stones[4]	26 600 000	-	-	-	-	-	-	-	-		
C	Other aggregates[4]	7 400 000	-	-	-	-	-	-	-	-		
D	Concrete	-	6 500 000	-	-	-	-	-	-	-	-	6 500 000
F	Buildings etc.	-	-	-	5 100 000	-	-	-	-	-	-	5 100 000
G	Roads etc. (incl. asphalt)	-	-	-	-	63 500 000	-	-	-	-	-	63 500 000
H	Residuales for reuse	-	-	-	?	?	140 000	1 860 000	-	-	-	2 000 000
I	Residuales for recykling	-	-	-	?	?	150 000	20 000	-	-	-	170 000
J	Residuales for filling	-	-	-	?	?	580 000	1 130 000	-	-	-	1 710 000
K	Residuales for landfilling	-	-	-	?	?	50 000	10 000	-	-	-	60 000
L	Total	88 400 000	6 500 000	-	5 100 000	63 500 000	920 000	3 020 000	-	-	160000	167 600 000

Input of sand/gravel/crushed stone an average year in the beginning of the nineties, ton

		1	2	3	4	5	6	7	8	9	10	11
		NACE 10-14	NACE 26	NACE 15-37 (excl. 26)	NACE 452 a[1]	NACE 452 b[2]	NACE 45110 a	NACE 45110 b	Filling	Landfilling	Export	Total
	Good (mesured in sgs)	Extraction	Manufacturing of concrete etc.	Other manufacturing	Construction of buildings etc.	Construction of roads etc. (incl. asphalt)	Demolition/re-building of buildings etc.[3]	Demolition/re-building of roads etc.[3]				
A	Gravel and sand[4]	-	12 300 000	4 400 000	900 000	54 800 000	-	-	15 700 000	-	1 630 000	89 730 000
B	Cruched stones[4]	-					-	-		-		
C	Other aggregates[4]	-					-	-		-		
D	Concrete	-	-	-	4 180 000	2 330 000	-	-	-	-	-	6 510 000
F	Buildings etc.	-	-	-	-	-	920 000	-	-	-	-	920 000
G	Roads etc. (incl. asphalt)	-	-	-	-	-	-	3 020 000	-	-	-	3 020 000
H	Residuales for reuse	-	?	?	2 000 000		-	-	-	-	-	2 000 000
I	Residuales for recykling	-	-	-	170 000		-	-	-	-	-	170 000
J	Residuales for filling	-	-	-	-	-	-	-	1 710 000	-	-	1 710 000
K	Residuales for landfilling	-	-	-	-	-	-	-	-	60 000	-	60 000
L	Total	-	12 300 000	4 400 000	64 380 000		920 000	3 020 000	17 410 000	60 000	1 630 000	104 120 000

[1] Construction of buidings, part of NACE 452

[2] Construction of roads and other infrastructure

[3] Realise from stock

[4] Primary output, not processed

? = No data found (re-building are included in demolision)

☐ = data includes all the surrounded cells