LIFE Project Number

LIFE10 ENV/FI/000062 ASROCKS

FINAL Report

Covering the project activities from 01/09/2011 to 31/08/2014

Reporting Date

30/11/2014

Guidelines for Sustainable Exploitation of Aggregate Resources in Areas with Elevated Arsenic Concentrations

Project Data

Project location	Finland
Project start date:	01/09/2011
Project end date:	31/08/2014 **Extension date:** -
Total Project duration (in months)	36 months
Total budget	
Total eligible budget	
EU contribution:	
(%) of total costs	
(%) of eligible costs	

Beneficiary Data

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Table of contents

1. List of key-words and abbreviations

GTK	Geologian tutkimuskeskus, (Geological Survey of Finland)
TTY	TTY-säätiö (TTY foundation)
SYKE	Suomen ympäristökeskus (Finnish Environment Institute)
TTL	Työterveyslaitos (Finnish Institute of Occupational Health)
YM	Ympäristöministeriö (Ministry of the Environment)
ELY	Elinkeino-, liikenne- ja ympäristökeskus (Centre for Economic Development, Transport and the Environment)

2. Executive Summary

In the European Union, the volume of aggregate production is as high as three billion tons and the number of employed exceeds 200 000. Aggregates are used in road and railroad construction and in the foundations of infrastructure and buildings. They form the basis for concrete and asphalt production. In Finland, the annual revenue from aggregate production is 500 M€.

The main objective of the ASROCKS project was to develop guidelines for the exploitation of natural aggregate resources, crushed bedrock, sand and gravel, in areas with high arsenic concentrations in bedrock and soil.

Arsenic is a toxic and carcinogenic substance. Residents can be exposed to arsenic using potable water from drilled bedrock wells or via arsenic-rich dust. Certain ecosystems may be vulnerable to arsenic-rich surface waters.

During the project it appeared that ASROCKS is the forerunner in the world to develop guidelines for aggregate production in arsenic-rich areas even though regions with high arsenic contents in bedrock and soil have been reported in Europe, Asia and America. In some localities like Bangladesh high arsenic content in drinking water and rice have caused serious health problems.

To our relief, the ASROCKS project found no problems in the studied aggregate production and construction sites in the Finnish demonstration area. Leaching tests showed that only a minor part of arsenic concentration was leached from rock, soil and aggregate products in surface water. In addition, arsenic content in dust was studied around one of the demonstration sites and the results showed that dust did not contain arsenic.

However, there are areas with higher arsenic content compared with the Finnish demonstration area especially in the Middle and Southern Europe. Therefore, the outcome of the ASROCKS project can be of importance for population health in certain localities in Europe and some other parts of the world. The guidelines and sampling and analytical procedures developed in the ASROCKS project can be modified and applied in other countries.

Because of the international importance and the pioneering nature of the findings, the ASROCKS project decided to allocate a lot of resources to dissemination activities and

publications both in Finland and in other European countries. This appeared to be a very successful decision but had also an inevitable side effect: the working hours of the permanent personnel of the ASROCKS project exceeded those of the original budget for all three beneficiaries.

The highlights of the project are:

1. ASROCKS developed the guidelines for sustainable aggregate production and construction for arsenic-rich areas, to our knowledge as the first in the world.
2. The guidelines can be modified for other countries with high arsenic levels in soil and bedrock.
3. ASROCKS was the first project in the world to investigate and develop risk management tools for arsenic in crushed rock aggregate and construction industry.
4. The methods used for the development of the guidelines were innovative: close cooperation, workshops and continued discussions between various stakeholders, companies, authorities and researchers.
5. Research institutes, universities, regional and national authorities, companies and other stakeholders participated in the project activities from the kick off meeting to the final seminar and the close cooperation will continue during the After LIFE phase.
6. Arsenic is a carcinogenic substance. People can be exposed especially via drinking water, crop and dust.

Key deliverables and outputs of the ASROCKS project include:

- The Guidelines were published in Finnish both as a printed volume and in the internet and distributed to all stakeholders and authorities.
- The Guidelines are available in English in the internet and were presented in numerous conferences and workshops in other parts of Europe for researchers, authorities and companies, and After LIFE, during the autumn 2014, for the European Aggregates Association and for the scientific community in a conference in Asia.
- Instructions for sampling, leaching tests and chemical analyses were compiled, based on comprehensive studies and comparison of different procedures and methods.
- The Layman's report was published as a comprehensive hard-cover book in Finnish. The book was sent to all municipalities and public libraries in the demonstration area and other areas with elevated arsenic content in soil and bedrock in Finland. After LIFE, the book will be distributed free of charge in various meetings and workshops in Finland.
- The English version of the Layman's report can be downloaded from the project web-pages and from Research Gate as well. After LIFE, the printed volume has been distributed in conferences and meetings abroad.
- Numerous reports and maps have been produced for different subtasks of the project (please see pages 21-22 in the Layman's report, English version).

ASROCKS project was launched 1st September 2011 and the kick-off meeting was held on 17th October 2011 in the demonstration area, in the city of Tampere. The Mid-term Report was sent 30th April 2013 and accepted by EU Life Unit on 20th June 2013. The Progress

report was sent 28th February 2014. The project was monitored four times by the members of the external monitoring team. In addition, the project has been monitored in spring 2014 by the Commission's technical desk officer, the financial desk officer and the representative of the external monitoring team.

Geological Survey of Finland (Geologian tutkimuskeskus, GTK) has acted as the coordinating beneficiary of the project. The associated beneficiaries were TTY foundation (TTY säätiö, the Technical University of Tampere), and the Finnish Environment Institute (Suomen ympäristökeskus, SYKE). Partnership agreements were signed between the beneficiaries. GTK acted not only as the administrative manager of the project but also as the action leader for every action except for the Actions 2 and 3. TTY was the leader of Action 2 and SYKE the leader of Action 3, but all beneficiaries participated actively in all actions. The core competences of the beneficiaries differ and therefore the team completed well each other.

The management structure comprised of the Steering Committee (7 meetings), the Management Board (14 meetings) and numerous project group meetings organised by the Action leaders. The project manager actively followed the progress and costs of different Actions. The Action leaders reported the progress of their actions in the Management Board meetings and a summary was presented to the Steering Committee. The stakeholders showed extraordinary interest in the project and actively participated in the Steering Committee meetings and workshops. The stakeholders provided valuable feedback and guidance for the project.

The financial monitoring team was established with the beneficiaries, chaired by GTK. An internal financial reporting system was introduced to supplement the official reporting procedures and an internal financial report was produced every three months for the project manager.

In addition to the kick off meeting, two seminars were organised for general public. Three workshops for experts, academics, industry and authorities were especially fruitful for the objectives of the project.

The networking and dissemination of the ASROCKS results were a vital part of the project. In Europe, networking with other projects included a Road Show to Slovakia, Sweden and Germany.

The guidelines established in the ASROCKS project promote the risk assessment and management of the potential adverse environmental effects caused by natural arsenic at rock aggregate production, soil extraction and constructions sites. It therefore serves the objectives of the Thematic Strategy of the Soil Protection (COM(2006)231) and the Water Framework Directive (2000/60/EY), and protection of the environment in general. The study results and guidelines of ASROCKS also increase the permitting authorities' understanding of the actual environmental impacts of elevated arsenic concentrations and provide both them and aggregate producers and constructors with the information on the tools to control and manage the risks related to arsenic. The results of ASROCKS project indicate only a minor release of arsenic from construction aggregates in the demonstration sites in Finland. However, the variable pH conditions or interaction with other materials should be considered in the future. The need for informing the total amount of arsenic in products' CE-marks or in the declaration of performance may be needed in the future in certain end uses of aggregates.

The project activities will continue After LIFE as follows:

- The ASROCKS website will be available at least until 2019. Deliverables of the project will be available for industry, authorities and for general public free of charge. "Guidelines" subpages will be updated on a regular basis. The website of the ASROCKS project is linked to the website of the Coordinating beneficiary GTK. Therefore, the web pages will be taken care of by the web page administrator of the Geological Survey of Finland.

- The guidelines developed during the ASROCKS project may be implemented into regulations of environmental authorities in Finland and other EU countries.

- The results of the ASROCKS project will be presented in conferences, and scientific publications are in preparation.

- The results of the ASROCKS project will be applied in the regional plan of the Tampere region in determining areas appropriate for exploitation of crushed rock aggregates.

- GTK, TTY and SYKE are eager to continue investigations and demonstration activities with arsenic-rich aggregate products. Cooperation with other European countries will continue.

Long-term indicators showing how successful ASROCKS really was include:

- application of the ASROCKS guidelines and other results for regulation etc. in Finland
- application of the ASROCKS guidelines and other results for regulation etc. in EU and other countries
- application of the ASROCKS instructions for sampling, leaching and analytical procedures in Finland
- application of the ASROCKS instructions for sampling, leaching and analytical procedures in other countries
- number of follow-up projects in EU and in other parts of the world
- number of publications of ASROCKS results
- number of citations to ASROCKS publications

One of the indicators reflecting the importance of the ASROCKS results for the Finnish Society is that the final seminar was opened by the Permanent Secretary of the Ministry of Employment and the Economy.

3. Introduction

In Finland, 80-100 million tons of aggregates are used annually. The consumption of aggregates per person (20 tons/person/year) is among the highest in the EU since Finland is a large country with fairly small population. Aggregates are used in the construction of roads, highways and railways. One half of the demand consists of crushed rock aggregates and the other half of sand and gravel deposits. Crushed rock aggregates are increasingly used instead

of sand and gravel. The availability of aggregates is essential for the construction and maintenance of infrastructure in a modern society.

The project region is the second largest economic and population cluster in Finland. Strongly developing infrastructure will demand significant amounts of rock aggregates in the near future. This underlines the need to develop the exploitation of the local resources to satisfy the increasing consumption without violating the environment. The results of the ASROCKS project will be applicable with some modifications to many areas in Europe with elevated As in bedrock and/or soil.

GTK has close interaction with international organizations due to present co-operation projects such as the 7FP Integrated Project ProMine, and many other active links like EuroGeoSurveys, which have supported also the ASROCKS project. Currently ongoing national projects having cooperation with ASROCKS include for example ARSENAL, 'Solutions for Arsenic Control in Mining Processes and Extractive Industry', coordinated by GTK and co-funded by TEKES (www.tekes.fi).

ASROCKS is a follow-up to several previous projects such as (1) LIFE Environment project RAMAS (LIFE04 ENV/FI/000300) ’Risk Assessment and Risk Management Procedure for Arsenic in the Tampere Region. Since the zone of high As concentrations extends to the south towards the city of Hämeenlinna, ASROCKS extended the investigations to this less studied region and provided new data from this area. (2) A national research project TAATA (2007-2009) ’Development of urban geological survey processes for the Tampere Region’ collected geochemical, geological and geophysical information to support the compilation of maps for construction planning. (3) A national research project TAPIR (2007-2009) ’National geochemical baseline database’ built up a database system for soil geochemistry. Summary data are publicly available through a web-based GIS user interface.

These projects demonstrated the presence of As problem in the demonstration area. One of the most important observations was the urgent need to establish guidelines for sustainable use of aggregates for large scale construction projects, which involve the handling of major soil and bedrock masses. Also the permitting process of new aggregate production sites was lacking adequate guiding on the risk management of potentially As bearing rock materials. The weak understanding of the causal relationship between the observed elemental concentrations and actual environmental impacts had lead to the situation where the permitting authorities may reject permit due to lacking risk assessment. There was an urgent need to establish guidelines for the risk assessment and management plan required for the permitting process. ASROCKS focused on the development of such guidelines for the different stages and different parties of the exploitation cycle. In addition, one of the most important outcomes of the ASROCKS project was the development of sampling and analytical procedures in agreement with existing EU standards.

Additional background data is presented on pages 4-6 in the English version of the Layman's report.

4. Administrative part

4.1. Description of the management system

The ASROCKS project consisted of nine Actions of which the first two concerned collecting data for risk assessment and guidelines compiling.

- The **Action 1** was a pilot phase of the project in which the focus was to delineate and characterize the areas with naturally high concentrations of arsenic, to locate the existing aggregate production sites and to select four demonstration sites from 21 pilot sites for detailed studies in Action 2. The samples of rock types, soils, aggregate products, groundwater and surface water for laboratory analyses were collected and preliminary leaching tests and laboratory analyses were carried out.
- In the **Action 2**, detailed investigations on four demonstration sites were implemented consisting of sampling from rocks, soils, waters, dust, humus, sediments and aggregate products for analyses and leaching tests.
- After that the risk assessment and management for selected demonstration sites were calculated in **Action 3** and guidelines for environment authorities and producers were compiled in **Action 4**.
- Project management, monitoring and audit were carried out in **Actions 5 and 6** respectively and the After Life plan was established in **Action 7**.
- Dissemination in **Action 8** included reports, workshops, seminars, conferences, press releases and articles in newspapers.
- Networking and co-operation with other Life projects in Finland and in other European countries in **Action 9** were abundant during the last year of the project and included oral presentations and workshops in events of different kind in several countries.

Geological Survey of Finland (Geologian tutkimuskeskus, GTK) acted as the coordinating beneficiary of the project. GTK is the national geological organization in Finland and one of the most competent European service centres in applied earth sciences. The staff exceeds 600 including qualified professionals in various aspects of geology, environmental sciences, geophysics, geochemistry and information technology, many of them with strong international background.

The associated beneficiaries were TTY foundation (TTY säätiö) and Finnish Environment Institute (Suomen ympäristökeskus, SYKE). The Earth and Foundation unit of TTY performs research which is based on engineering geology and geotechnics. The main research areas of the unit are earth structures, foundation structures and railway structures. The Finnish Environment Institute (SYKE) is the national environmental R&D centre of the environmental administration. The work carried out in SYKE covers multi-disciplinary research, expert services, administrative tasks, monitoring and information systems. GTK acted as administrative manager of the project and action leader in every action except the Action 2 and 3. TTY was the action leader in the Action 2 and SYKE in the Action 3, but both of them participated actively in other actions, too.

The management structure of the ASROCKS project comprises the Steering Committee and the Management Board as shown in the organigramme (Fig. 1). The Steering Committee

decides on high-level management issues such as amendments to the work plan, financial matters and project monitoring. The Management Board co-ordinates the project under the control of the Steering Committee in relation to technical and exploitation issues and supports of the project beneficiary in fulfilling obligations towards the European Commission.

4.2. Organigramme of the project team and the project management structure

The organigramme of the project team and the project management structure is shown in Fig. 1.

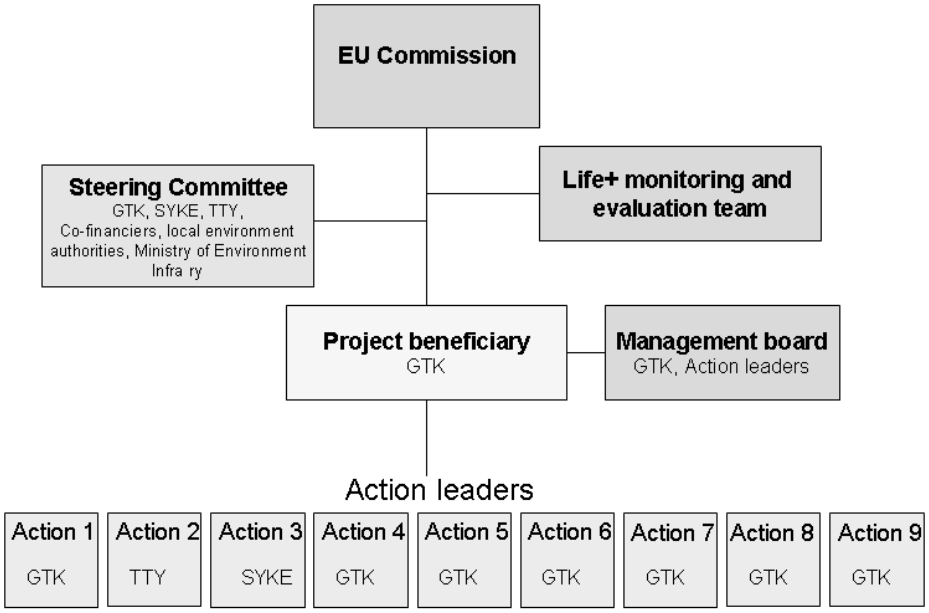

Fig. 1. Management chart of the ASROCKS project.

4.3. Project Coordinator and Steering Committee

Prof. Kirsti Loukola-Ruskeeniemi has been the coordinator of the ASROCKS project since the project proposal phase. Some changes have occurred in the assemblage of the Steering Committee of the ASROCKS project compared with the members in the first meeting on 18 October 2011 due to the fact that members have changed organizations and new stakeholders have joined in the project.

Altogether seven Steering Committee meetings were held during the project. The main focus of the meetings was to decide high-level management issues like amendments to the work plan, financial matters and monitoring of the project.

4.4. Project Manager, Management board and project group

Project manager has been responsible for the management of the operative tasks carried out in the nine Actions of the ASROCKS project. The Action leaders reported the progress and activities of the actions to the project manager. Project manager communicated with the project coordinator on daily basis. Project manager has also been responsible for arranging meetings and leading the Management Board. Mr Paavo Härmä has acted as the project manager of the ASROCKS project since April 2012.

The Management Board consisted of the Action leaders nominated at the start-up meeting on 1st September 2011 in addition to the project manager. In total, 14 management board meetings were organised during the project period

There have also been several project group meetings organized by the leaders of Actions 1, 2, 3 and 4. Altogether 16 project group meeting were held during the project duration.

4.5. Amendments to the Grant Agreement and the submitted Partnership agreements

The original project objectives and work plan were executed on schedule and according to the Grant Agreement. Two months delay on the project schedule, i.e. the extension of the field work season in the year 2012 due to climate conditions, approved by the Commission and reported in the Mid-term report, was taken by the end of 2013 as reported in the Progress report. Since then the project has again followed the original schedule and all deliverable and reports have been delivered in time. The Gantt chart of the project is shown in Fig. 2.

The tripartite Partnership agreements were signed between GTK, TTY and SYKE. The dates of the signatures are 7th May, 14th May and 16th May 2012, respectively. The agreement defined the obligations, payment scheduling and administrative issues between the beneficiaries.

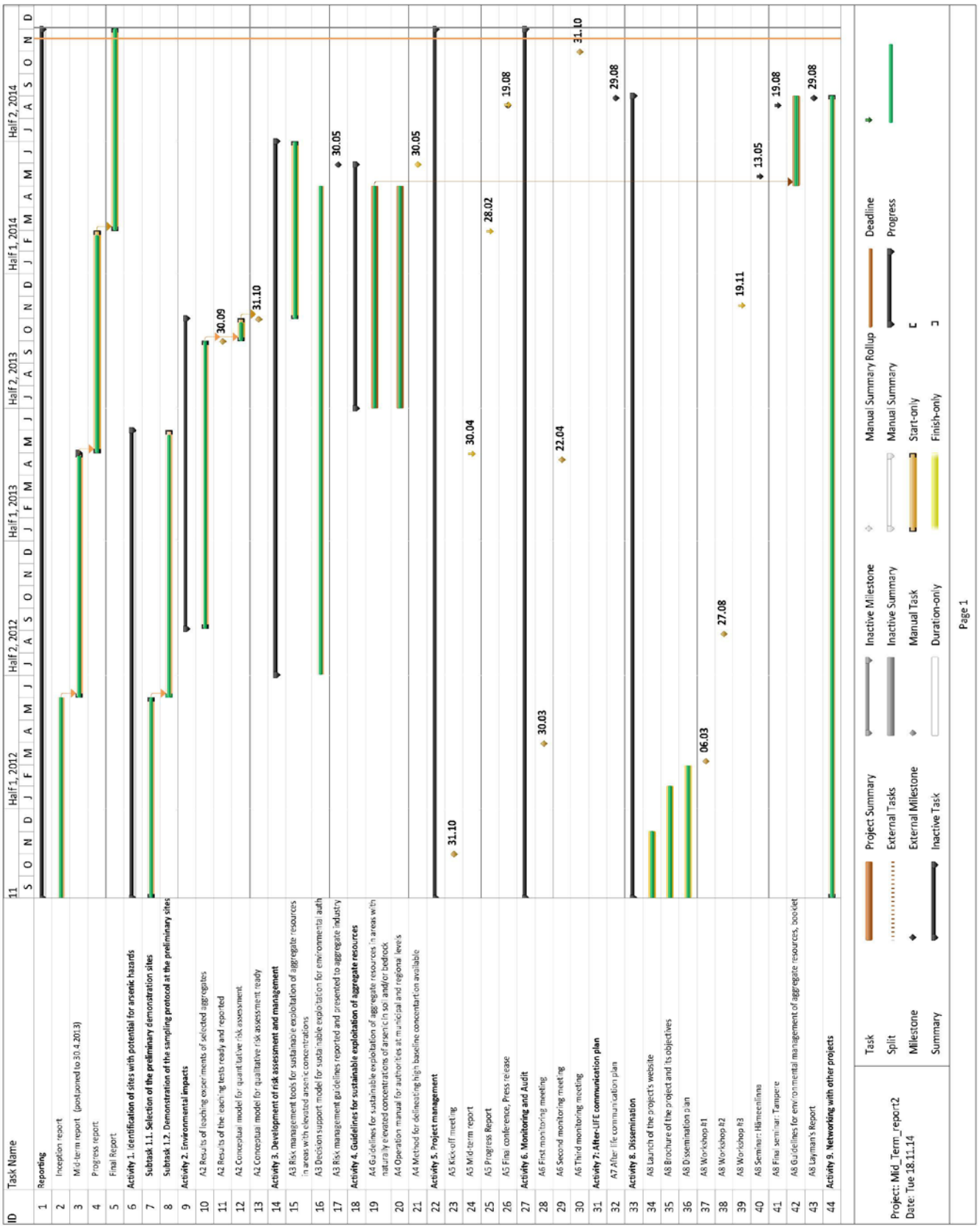

Fig. 2. The Gantt chart of the ASROCKS project.

4.6. Carbon Footprint: Comment of the EU LIFE unit in the Mid-Term report:

COMMENT: You report that the project's carbon footprint is recorded, based on the ilmastolaskuri.fi ("climate calculator") website. Kindly, briefly describe the records in the Final report and explain which factors have the largest carbon footprint.

The response:
The carbon footprint of the ASROCKS project during the whole duration of the project was recalculated at the end of August 2014. Each beneficiary calculated its own carbon foot print for the project.

The results were parallel within every calculation of three beneficiaries. The largest carbon dioxide emissions resulted from travelling by air, heating and electricity consumption. The personnel of the project were involved in the international workshops for networking and dissemination organized by the project. In addition scientists presented the project results in several conferences in Europe. Finland is one of the northern countries and winters are cold, therefore the heating and electricity consumption is high but inevitable.

4.7. Monitoring and audit

The progress of the technical actions was followed by the Project Coordinator and the Project Manager. The action leaders reported in the Management Board meetings. A summary was presented to the Steering Committee in the Steering Committee meetings. The ASROCKS project manager Mr. Paavo Härmä followed the costs of the project together with the financial team. Each of the beneficiaries had named one person responsible for the contribution of the beneficiary in the ASROCKS project. Ms Pirjo Kuula was responsible for TTY and Ms Jaana Sorvari for SYKE.

Financial monitoring

A financial monitoring team was established to carry out project's financial reporting and to ensure sound financial management of the project. The financial monitoring team consisted of addressed representatives of each of the project beneficiaries. The financial monitoring team was chaired by GTK. Team members at the end of the project were: GTK: Financial planner Sanna Matikainen, TTY: M.Sc. (tech) Terhi Ketola and SYKE: Technical coordinator Tuuli Raatikainen.

An internal financial reporting system was introduced in the ASROCKS project to supplement the official financial reporting procedures described in the Grant Agreement and its annexes. An internal financial report was produced by the financial monitoring team every three months for the project manager.

The ASROCKS project was monitored by a member of the external monitoring team, Ms. Anne-Marie Salmi from Astrale GEIE – ELLE on 30 March 2012. The external monitoring team member changed in February 2013 and since then Mr. Pekka Hänninen from Astrale GEIE – ELLE has been in charge,. The ASROCKS project was monitored by Mr. Pekka Hänninen on 22 April 2012, 17 April 2013 and 31 October 2014.

The ASROCKS project was monitored also by the Commission's technical desk officer Ms Madalinska, the financial desk officer Ms Simic and the representative of the external monitoring team Mr Hänninen in the office of one of the project partners, the Tampere University of Technology, in Tampere on 17 March 2014.

4.8. Evaluation of the management system

The management system served the goals of ASROCKS and provided support to obtain the principal objectives. There was discussion about resources between the beneficiaries since economic situation may be challenging in organisations these days and the LIFE budget structure is maybe not the best compared with some other programmes within EU. The management structure of the ASROCKS project with active cooperation with authorities and stakeholders in the Steering Committee resulted in a wider scope of the importance of the ASROCKS objectives and encouraged the large research institutes GTK and SYKE to invest own contribution for the project even more than was expected in the original budget.

The added value of the partnerships was really of great importance for the project, both between the beneficiaries since each had their own expertise, and moreover, between the stakeholders and authorities participating in the management through their active role in the Steering Committee. There were no significant deviations from the arrangements shown in the partnership agreements.

The progress of the technical actions was followed by the Project Coordinator and the Project Manager. The action leaders reported the progress of their actions in the Management Board meetings. A summary was presented to the Steering Committee during Steering Committee meetings. The progress of the Actions and related costs were actively followed.

We found the communication with the Commission and the Monitoring team most helpful and constructive with the focus on gaining the objectives of the project. The excellent expertise and long experience of the Monitoring team gave invaluable support to the management of the ASROCKS project.

5. Technical part

The main objective of the ASROCKS project was to provide guidelines for the exploitation of natural aggregate resources (crushed bedrock, sand and gravel) in an area with elevated arsenic concentrations in bedrock and soil. In addition, guidelines were developed for re-use of aggregates in selected large construction areas with elevated arsenic concentration. The demonstration area was the Tampere-Häme region in southern Finland, where arsenic (As) bearing minerals occur naturally in bedrock and soil.

5.1. Technical progress, per Actions

The ASROCKS-project was divided into four main technical actions and their content is described below.

5.1.1. Action 1: Identification of the present aggregate production areas and planned large construction sites with potential for arsenic hazards

Please see also page 8 in the Layman's report.

The objectives of the Action 1 were 1) to delineate and characterize the areas with naturally high concentrations of arsenic in bedrock and soil and 2) to locate the existing aggregate production sites and planned large construction sites within these geochemical anomalies by using available geochemical data. According to the project plan, the selection of representative production sites has been made in co-operation with stakeholders, land use planners and environmental authorities and on basis of existing data like regional geochemical databases, datasets from RAMAS and TAATA projects and other existing data (geological maps, licensing registers etc.). The sampling guidelines were developed and demonstrated in about 21 sites. Four of these sites were selected for detailed site demonstration in Action 2.

Subtask 1.1 Selection of the preliminary demonstration sites

The results of GTK's geochemical soil mapping projects were used to locate the areas with highest natural arsenic concentrations in soils. Already in 1997, Salminen and Tarvainen (1997) demonstrated that geochemical background concentrations in Finland vary regionally according to the bedrock geology and locally according to the type and genesis of overburden. GTK has carried out nationwide geochemical mapping of till in Finland on a reconnaissance scale (1 sample/300 km2) in 1983 (Koljonen 1992) and a regional scale (1 sample/4 km2) during 1984-1992 (Salminen 1995) followed by more detailed mapping projects in selected regions. These surveys provided information on the natural elemental distribution in slightly weathered subsoil of the most common soil parent material in Finland, glacial till. The nationwide datasets were used to divide Finland into geochemical provinces for the National Baseline Geochemical Database TAPIR (Jarva and others 2010).

The demonstration area of the ASROCKS project belongs to the geochemical arsenic province number 4 in the TAPIR database which is available for general public in the internet

(http://projects.gtk.fi/Taustapitoisuusrekisteri/index.html). The delineation of the arsenic province 4 was tested with the national rock geochemical dataset (Rasilainen and others 2007). All the rock samples with elevated arsenic concentration in the southwestern Finland were situated within the arsenic province 4. More detailed pedogeochemical mapping was used to test the shape of the arsenic province 4 near Tampere (data described by Hatakka and others 2010) and in the Häme region (data described by Tarvainen 2010). The detailed pedogeochemical datasets proved that the delineation based on nation-wide data was applicable also in regional scale. Thus arsenic province number 4 of the National Baseline Geochemical Database was the basis for making the first deliverable of the ASROCKS project, "Map of areas with elevated natural concentrations of arsenic in bedrock and soil in the Tampere-Häme region" (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

Selection of the preliminary demonstration sites

The process for choosing preliminary demonstration sites began with the lists of recommended production sites provided by the aggregate producers, stakeholders, land use planners and environmental authorities to the ASROCKS project. In addition, the operative aggregate excavation permits in every municipality located in the demonstration area were searched from the KITTI database (the aggregate accounting system http://geomaps2.gtk.fi/Kiviainestilinpito/ maintained by GTK) to find all producers to be able to cover the whole project area. Geological maps of Quaternary deposits (less than 10 000 years old soil) were used to find the location of sand and gravel deposits where gravel excavation is possible. Häme and Pirkanmaa Centres for Economic Development, transport and the environment gave information about gravel excavation permits in the ASROCKS demonstration area. For choosing the construction sites, the proposals were provided from the Nokia, Tampere, Pirkkala and Hämeenlinna municipalities in the project area.

For the selection of the demonstration sites, information was also sought about the permits for the extraction of sand and gravel and crushed rock aggregates, and constructions in the regions of Tampere (Pirkanmaa) and Kanta-Häme. Environmental monitoring activities as well as chemical analyses for As concentration and environmental assessments related to the permits were recorded. The data were collected from several databases maintained by the environmental administration of Finland, i.e. AHJO, POVET, MATTI and VAHTI databases. These data were complemented by environmental impact assessment reports available in the internet and by consulting regional permitting authorities in Pirkanmaa and Kanta-Häme.

Preliminary version of the 'List of aggregate production sites, major earthworks and selected potential construction sites in the Tampere – Häme region' (Deliverable #4, deadline 31.1.2012: http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html) was presented to the Management Board on 5 March 2012 and to the Steering Committee on 6 March 2012. Members of the Steering Committee gave valuable additional information on the suggested sites during the workshop organised prior to the Steering Committee meeting, and the preliminary list was accepted by the Steering Committee.

It was challenging to select the demonstration sites. There were many potential sites and limited information was available from the permitting authorities. Therefore the final selection from the most potential sites was done on the basis of results of a field study. Most potential demonstration sites according to available data were visited by the project geologists and research assistants by the end of April 2012 for the final decision of the preliminary

demonstration sites (Fig. 3). As a result, 10 crushed rock aggregate sites, 7 gravel and sand excavation sites and 4 construction sites were chosen for the preliminary demonstration sites.

Fig. 3. An aggregate production site in the Tampere-Hämeenlinna area in Finland. The candidates for the ASROCKS demonstration sites were visited by the geologists and research assistants in spring 2012 for the final decision of the preliminary demonstration sites.

Sampling plan for the selected demonstration sites – The instructions for the sampling of bedrock, soil, water and aggregate products

Instructions for soil and aggregate product sampling were based on GTK's geochemical soil sampling procedure and in addition, specific instructions for aggregate product sampling by Mäkinen and Westerholm (2007) were followed when applicable. The method for aggregate product sampling for leaching tests was based on the standard EN 932-1. The methods for water sampling in the ASROCKS project were based on GTK's geochemical water sampling instructions (e.g. GTK's Standard Operating Procedures of groundwater research, Paukola et al. 1999 and Lahermo et al. 2002).
The sampling plan and instructions (Deliverable Action 1 by the end of March 2012: http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html), including the descriptions of the quality assurance systems and safety instructions for the 21 preliminary demonstration sites were completed at the end of March 2012.

Subtask 1.2 Demonstration of the sampling protocol at the preliminary sites

The sampling guidelines generated in Subtask 1.1 of the Action 1 were demonstrated in selected sites in the beginning of field work season in summer 2012 (Table 1 and Fig. 4). It was followed by chemical analysis and leaching tests. The results were used for identification

of potential pathways and selection for sites for investigations of detailed demonstration sites of Action 2.

Fig. 4. Soil sampling in the Marjamäki demonstration site. The guidelines for sampling were demonstrated in the beginning of the field work season in summer 2012.

Fig. 5. Surface water sampling close to a demonstration site. Total and dissolved concentrations of arsenic and metals were determined for surface water and ground water samples.

The chemical analysis of rock, soil and aggregate product samples included three types of analysis:
1) chemical analysis of the total element concentrations by XRF method,
2) chemical analysis of the semi-total concentrations using hot aqua regia extraction and
3) chemical analysis of more easily leachable element concentration by acid ammonium acetate – EDTA extraction.

Total and dissolved concentrations of the metals were determined for surface and ground water samples (Fig. 5). Portable field XRF instruments were used to select soil, bedrock and aggregate product samples for chemical analyses in laboratory.

Table 1. Sampling dates and number of rock, soil, aggregate product and water samples of the 21 sites analysed in Action 1. In addition to samples mentioned in this table, field duplicate samples were collected for quality assurance.

Name of the Site	Sampling date	Rock	Soil	Product	Water
501 Sotkian Takamaa, Akaa	22.-25.5.2012	6	3	7	2
502 Kanervavuori, Forssa	21.5.2012	6	2	5	1
503 Rappumäki, Humppila	22.-25.5.2012	5	1	4	1
504 Juhanila, Hattula	31.5.-4.6.2012	5	3	2	2
505 Marjamäki, Lempäälä	5.-8.6.2012	6	4	8	2
506 Patavuori, Valkeakoski	1.-7.6.2012	5	3	7	1
507 Nokia, Nokia	25.5.-5.6.2012	6	4	15	0
508 Lamminsivu, Nokia	30.5.-8.6.2012	4	2	8	1
509 Pitkäkallio, Lempäälä	23.-24.5.2012	8	2	8	2
510 Takamaa, Ylöjärvi	24.-29.5.2012	8	2	3	1
521 Kantokylä, Pälkäne	6.6.2012	3	3	5	1
522 Saari, Kangasala	1.-6.6.2012	2	4	9	0
523 Levonmäki, Humppila	23.-24.5.2012	1	4	9	1
524 Myllymäentila, Jokioinen	22.5.2012	0	4	0	1
525 Markkola, Urjala	31.5.2012	1	6	10	2
526 Kerälänvuori, Hattula	28.5.2012	0	3	1	1
527 Mustilahti, Valkeakoski	28.5.2012	1	2	1	1
541 Koivisto, Pirkkala	5.6.2012	3	3	0	2
542 Harjuniitty, Nokia	29.5.2012	4	4	0	3
543 Siiri, Hämeenlinna	4.6.2012	5	4	0	1
544 Vuores, Tampere	30.5.2012	4	4	0	3
Quality control samples		4	5	7	3
Total (= **300** samples)		**87**	**72**	**109**	**32**

Leaching tests in the Action 1

The ten crushed rock aggregate product samples for leaching tests are presented in Table 2. The main purpose of the product sampling for the leaching test was to select the finest grading

fraction of the products available at the production site (Fig. 6). The leaching tests were performed according to standard EN 12457-3 during June and July 2012. The chemical analyses of the leachates were performed by the laboratory of Ramboll Analytics Ltd during June and July 2012.

Table 2. Ten crushed rock aggregate product samples selected for the leaching tests in Action 1.

Site	**Product type**
501 Sotkian Takamaa, Akaa	0/11 mm
502 Kanervavuori, Forssa	0/4 mm
503 Rappumäki, Humppila	0/32 mm
504 Juhanila, Hattula	0/16 mm
505 Marjamäki, Lempäälä	0/3 mm
506 Patavuori, Valkeakoski	0/4 mm
507 Nokia, Nokia	0/4 mm
508 Lamminsivu, Nokia	0/3 mm
509 Pitkäkallio, Lempäälä	0/3 mm
510 Takamaa, Ylöjärvi	0/11 mm

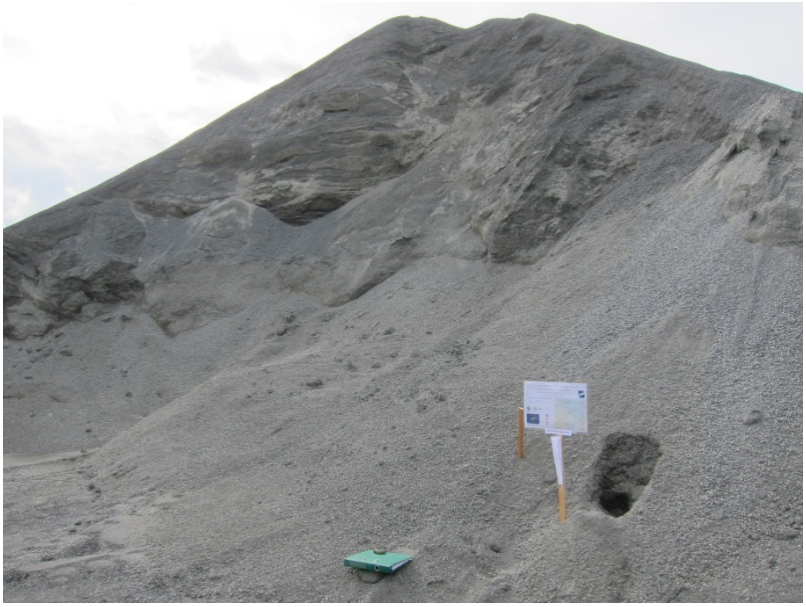

Fig. 6. The main purpose in the product sampling for the leaching test was to select the finest grading fraction of the products available at the production site.

Results of the Action 1

The first deliverable of the ASROCKS project, “Map of areas with elevated natural concentrations of arsenic in bedrock and soil in the Tampere-Häme region” was published as planned in 30.11.2011. The final demonstration sites, 10 crushed rock aggregate sites, 7

gravel and sand excavation sites and 4 construction sites were chosen for the preliminary demonstration sites in April 2012.

The sampling plan and instructions, including the descriptions of the quality assurance systems and safety instructions for the 21 preliminary demonstration sites were completed at the end of March 2012 as scheduled (Deliverable Action 1 by the end of March 2012: http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html). The sampling guidelines generated in Subtask 1.1 of the Action 1 were demonstrated in selected sites in the beginning of field work season in summer 2012. It was followed by chemical analysis and leaching tests. The results were used for identification of potential pathways and selection for sites for investigations of detailed demonstration sites of Action 2.

The deliverable "Description of selected 21 demonstration sites" which was given in the archive report (Tarvainen et al. 2013: http://tupa.gtk.fi/raportti/arkisto/3_2013.pdf) ran ahead of the scheduled time in the mid of January 2013. The last deliverable of Action 1, "General Guidelines for Sampling Procedures in Aggregate Production Sites and Sampling Plans" was published at the end of May 2013. After this, Action 1 was completed.

Based on the geochemical analytical results on bedrock, soil, aggregate products and water samples collected in the preliminary demonstration phase, four sites were selected for more detailed studies and demonstrations. The four demonstration sites were selected on the basis of higher than average natural arsenic concentrations in soil and bedrock and the leaching properties of arsenic compounds. Results of the Action 1 demonstration sites (field measurements, observed main transport pathways, chemical analysis and leaching test results) were presented to the Management Board on 23 August 2012 and to the Steering Committee on 27 August 2012. The following four sites were selected for detailed demonstration for Action 2:

1) Marjamäki site, Lempäälä municipality (crushed rock aggregate production)
2) Nokia site, Nokia municipality (crushed rock aggregate production)
3) Koivisto site, Pirkkala municipality (construction site)
4) Harjuniitty site, Nokia municipality (construction site)

Deliverables of Action 1

The following deliverables were disseminated during Action1:

1) Map of areas with elevated natural concentrations of arsenic in bedrock and soil in the Tampere-Häme region
2) List of aggregate production sites, major earthworks and selected potential construction sites in the Tampere-Häme region
3) Sampling plan for selected 21 demonstration sites
4) List of selected detailed demonstration sites for Action 2
5) Description of selected 21 demonstration sites
6) General guidelines for sampling procedures in aggregate production sites and sampling plans.

The deliverables are able to be downloaded from the WebPages of the ASROCKS project (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

All the work and the deliverables planned for Action 1 were carried out and finished in scheduled time and the deliverable "Description of selected 21 demonstration sites" was completed even earlier than planned in the proposal phase to provide data for the next phase of the selection of the demonstration sites as soon as possible.

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5.1.2. Action 2: Environmental impacts at detailed demonstration sites

Please see also pages 10-13 in the Layman's report (English version).

The objective of Action 2 was to characterise the environmental impacts at detailed demonstration sites. The task was divided into two subtasks: (1) Transport pathways and detailed sampling and (2) Leaching tests. The two deliverables planned for Action 2 were completed in due time.

The aim of the sampling was to obtain reliable and comprehensive data for risk assessment and risk management to be carried out in Action 3. Some of the sampling methods were tested in Action 2 in order to have more detailed information for the general guidelines for sampling procedures in aggregate production sites. The potential pathways of arsenic and other harmful elements to surface water and groundwater were investigated by hydrological mapping of the

demonstration sites. The main field work and sampling campaign in Action 2 were carried out during 20 September – 30 November 2012. Water, soil and product samples were selected for geochemical and mineralogical analysis for environmental monitoring purposes. The chemical analytical data gathered during Actions 1 and 2 were studied and processed. The results of soil and product samples were processed with IBM-SPSS statistical software during July and August 2013.

Subtask 2.1. Transport pathways and detailed sampling

The field work and sampling campaign in Action 2 were carried out during 20 September – 30 November 2012 (Fig. 2). The samples were collected according to same methods as in Action 1 with some exceptions. The soil and product samples in Action 2 were taken as composite samples (with more than six subsamples). For product samples three different sampling methods were tested: 1) SFS-EN 932-1, 2) Six subsamples 3) 30 subsamples (multi-increment sampling). The detailed description of sampling methods is published in the *General guideline of sampling procedures* (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html). The results from the sampling method comparison indicate that the multi-increment sampling method gives lowest scattering of the total As when 0/3 material is analysed. However, the sampling method affects only marginally the total As when single sized material without fines is analysed.

In the Nokia Harjuniitty and Pirkkala Koivisto demonstration sites humus samples were taken as composite samples (5 subsamples) with a humus sampler.

Fig. 7. The ASROCKS field work team is collecting a crushed rock aggregate product sample in the Nokia demonstration site during Action 2.

In general, the samples in Action 2 were analyzed with the same methods as in the Action 1. Humus samples were extracted using ammonium acetate-EDTA and HNO_3-digestion. The organic stream sediment samples were extracted using ammonium acetate-EDTA-, acid ammonium oxalate –extraction and HNO_3-digestion. For the minerogenic stream sediment samples ammonium acetate-EDTA-, acid ammonium oxalate and aqua regia –extractions were used. From some soil samples, the grain size distributions were determined.

Hydrological mapping was carried out in each detailed demonstration site. The catchment areas were delineated on topographic maps, runoffs of the streams in the production sites and their surroundings were measured or assessed, and some altitudes of stream water levels and ground were measured.

In the Pirkkala Koivisto construction site three test excavation of bedrock by blasting was carried out on 6 November 2012 to get the material for geochemical analyses and leaching tests. Also samples of rock powder were taken and analyzed from the same sites. Rock core samples were taken in the Pirkkala Koivisto site by diamond drilling on 28 – 30 November 2012 for geochemical and mineralogical purposes in order to test different sampling methods and to find out the average As content from heterogeneous rock type. The drilling operation was carried out by Pöyry Finland according the contract made after the limited tender.

Table 3. Number and type of analysed geochemical samples of the four demonstration sites in Action 2. In addition, field duplicate samples of soil and blind samples of water were taken. K_d = Soil – soilwater distribution coefficient.

Sample type	**Nokia, Harjuniitty**	**Nokia, Nokia**	**Lempäälä, Marjamäki**	**Pirkkala, Koivisto**	**Quality assurance samples**	**Total**
Soil	8	1	4	11	2	26
Humus	4	6	6	0	0	16
Stream sediment	2	3	1	0	0	6
Surface water	5	6	7	2	2	22
Rock powder	6	9	11	11	0	37
Product	0	19	21	2	0	42
Groundwater	1	1	0	1	1	4
K_d	4	5	5	4	0	18
Vadose water	4	4	0	0	0	8
Mineralogy	4	0	2	4	0	10
Grain size distribution	1	0	0	7	0	8
Rock	8	5	5	13	0	31
Leaching test	1	4	3	3	1	12
Total	48	63	65	58	6	240

Several samples of rock powder were also taken from three other sites (Nokia Nokia, Marjamäki and Harjuniitty) by a drill hammer. At these points, pieces of rock sample were taken by a conventional geologist hammer to compare the reliability and correspondence of these sampling methods and differences in As content of the samples comparing to each other.

Subtask 2.2. Leaching tests

The sample types and the test matrix for the leaching tests are presented in detail in Table 4. In each site two duplicate aggregate samples were taken. The rock samples from Koivisto were crushed using a laboratory crusher, because no aggregate product samples were available from a construction site. This sampling methodology presents a normal procedure, when an aggregate production site or a construction site is evaluated in order to analyse the technical and mechanical quality of the aggregate.

All the leaching tests were performed by the TTY laboratory and the chemical analyses of the leachates were performed by the laboratory of Ramboll Analytics Ltd. Half of the samples of the Marjamäki site and all the samples of Koivisto and Harjuniitty sites were analysed with applicable leaching tests during the reporting period 28 February - 30 November 2013. Table of all the Action 2 leaching test samples and test methods is presented below (Table 4).

A supplementary sampling in the Nokia demonstration site was performed in September 2013. Chemical analyses of three aggregate samples for leaching tests were conducted in the laboratory of Labtium Ltd in November 2013. The aim of the analyses was to examine the effect of a long sample storage time (one year) on the leaching results. The results were added in the leaching test deliverable in January 2014 (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

Detailed survey of leaching behaviour of arsenic based on literature was carried out as a bachelor's thesis at TTY. The thesis, in Finnish, was delivered to the project partners through the project extranet.

Table 4. Number and type of the leaching test samples and test methods used. The numbers in the table presents the amount of parallel samples for each test method.

Site/sample type	**EN 12457-3**	**CEN/TS 14405**	**EN 1774-3**	**CEN/TS 14497**
Nokia 0/4 mm	2	2	1 *)	2
Nokia 4/8 mm	2	2	2	NA **)
Nokia 0/16 mm	2	2	NA *)	NA **)
Nokia soil	1	1	NA *)	1
Marjamäki 0/3 mm	2	2	NA *)	2
Marjamäki 3/6 mm	2	2	2	NA **)
Marjamäki 0/56 mm	2	2	NA *)	NA **)
Koivisto 0/4 mm	1	1	NA *)	1
Koivisto 4/8 mm	1	1	1	NA **)
Koivisto soil	1	1	NA *)	1
Harjuniitty soil	1	1	NA *)	1
Total	17	17	6	8

*) The test EN 1744-3 is not suitable for fine aggregate and soil samples

**) The test CEN/TS 14497 is not applicable for coarse aggregate products

The leaching tests were started immediately after the sampling in the four demonstration sites was finished. The leaching tests were finished according to planned schedule by the end of August 2013.

A supplementary sampling in the Nokia demonstration site was performed in September 2013. Chemical analyses of three aggregate samples for leaching tests were conducted in the laboratory of Labtium Ltd in November 2013. The aim of the analyses was to examine the effect of a long sample storage time (one year) on the leaching results.

Detailed survey of leaching behaviour of arsenic based on literature and former tests results was carried out as a bachelor's thesis at TTY. The thesis, in Finnish, was delivered to the project partners through the project extranet.

Results of the leaching tests in Action 2

With the four types of leaching tests conducted, the leaching of arsenic from rock aggregates and soil samples was mainly less than 0.5 mg/kg. No clear correlation between the leaching and the total amount of arsenic was found. In the leaching tests that are most common in Finland, EN 12457-3 and CEN/TS 14405, the amount of arsenic leached was less than 1 – 2 % of the total amount of arsenic in the samples. The simplest and shortest leaching test EN 1744-3 gave similar and very small results for all products despite the total As content. The leaching of arsenic from fine rock aggregate samples, particle sizes 0/3 mm and 0/4 mm, depended on the pH value of the leaching liquid: the amount of arsenic leached was higher in the pH values 4 and 9 than in the neutral pH 7. It was recognized that there is a need to further evaluate the relation between the leaching behaviour of arsenic and the mineralogy of the samples. The results of the Action 2 leaching tests were published as a deliverable report in the end of September 2013 (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

Conceptual model

In autumn 2013, constructed generic conceptual models (CM) for quarries and construction sites were defined to complete Action 2. The CMs were documented in the deliverable published by the end of October 2013 (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html). The definition of worst case scenarios, i.e. the situations with the highest possible risks to human health, ecosystem(s) or the quality of the environment to be considered in the case-specific risk assessments, were discussed.

Air quality measurement

A pilot survey of air quality was carried out at the Nokia demonstration site during 1 – 9 July 2013 and a follow-up measurement during 18-31 March 2014 in order to evaluate the impact of dust to the environment of a demonstration site. Air Quality Expert Services of the Finnish Meteorological Institute designed the surveys and was responsible for the sampling campaign as well. Dust particles less than 10 micrometers were collected to filters according to reference method EN 12341:1999 and the arsenic concentrations were measured from dust particles.

Arsenic concentrations in measurements in 2013 varied in the daily samples from 0.135 ng/m^3 to 0.621 ng/m^3. Detection limit of the applied method was 0.002 ng/m^3. Target value for arsenic for 1 year averaging period is 6 ng/m^3. This pilot study gave a preliminary estimate of arsenic level in dust during summer period when large volumes of aggregate products are transported from the site.

A supplementary air quality measurement was carried out at the Nokia demonstration site in a two week period at the end of March 2014. The supplementary measurement was needed to evaluate the effects of the crushing process on the air quality. Air Quality Expert Services of Finnish Meteorological Institute was responsible for the sampling campaign. The results of the supplementary air quality measurements indicate that the arsenic concentration as well as the amount of dust was higher during the ongoing crushing process. The average arsenic content of dust particles was 18.8 ng/m^3.

The preliminary air quality measurement has been reported (Saari, H., Vestenius, M. & Pesonen, R. 2013). The supplementary measurement has been also reported (Saari, H., Vestenius, M., Lovén, K. & Pesonen, R. 2014).

Deliverables of Action 2

The following deliverables were disseminated:

1) Results of leaching experiments of selected aggregates
2) General and site-specific conceptual model for qualitative risk assessment

The deliverables are able to be downloaded from the WebPages of the ASROCKS project (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

5.1.2.1. Air Quality: Comment of the EU Life unit in the Progress report:

Task 2; Conducting the air quality survey has been relevant regarding the project's objectives. The possible impact on the occupational health could be discussed in the final report. Please justify this additional intervention in the Final report.

The response:

In the project proposal, on page C1/6, the methods employed for Action 2 include investigation of potential pathways of arsenic. Additional samples from soils, *rock dust* and water will be collected and analysed for further investigation of the recognized potential pathways.

Action 3 is described in the project proposal on page C1/8. According to the Action description, the decision support tool will be mainly based on the case studies at the selected sites in our study area. Based on the outcome from Action 1 and Action 2 the key areas were first identified according to the geological setting and the type of aggregate source, exploitation procedure and surrounding environmental setting (*including potential*

contamination routes and receptors). Further in the chapter *Methods employed* it is said that the sampling, sample treatment and analysis methods to be used during this project are carefully explained, such as … *analysis of quarrying dust.*

During the ASROCKS project, the potential pathways of arsenic to the surrounding environment were identified while constructing the conceptual model. Transport mechanism of arsenic bearing dust was recognized as one of the potential pathways. This potential pathway was studied using two kinds of samples: short-term emissions of dust was studied by two air quality survey periods in the Nokia demonstration site and long-term environmental release was estimated by using humus samples from three detailed demonstration sites. Dust sampling of the two air quality survey periods were carried out by the Finnish Meteorological Institute.

The arsenic concentrations in humus layer were not significantly higher than the arsenic concentrations in humus in regional geochemical baseline mapping. Thus no long-term accumulation of arsenic containing dust in the environment was observed. The first short-term air quality measurement was carried out in summer time on the edge of one production area. In summer time, aggregate material is transported by heavy vehicles from the production areas. The arsenic concentrations in summer time dust were very low, however. Arsenic concentrations were higher in air quality measurements near the crushing and sieving site in late winter/early spring. This could explain some elevated arsenic concentrations in fine grained (dust) sediments of puddles within the production area. However, the results of a short air quality measurement time cannot be compared to air quality target value. The short time results were reported also to the representative of occupational health institute of the project steering committee for further evaluation.

5.1.3. Action 3: Development of risk management procedure at detailed demonstrations sites

Please see also pages 14-15 in the Layman's report (English version).

The work of Action 3 was launched as planned by conducting a brief survey on the risk management practices (part of Subtask 3.1) related to the production of crushed rock aggregate (internal document). This document provides background information for the development of the risk management procedure to be developed in the project (Subtask 3.2). The study was focused on the most relevant European countries and was conducted as a literature survey and by interviewing key experts. After the finalization of the CMs (see Subtask 2.1), the construction of a decision support model for aggregate production areas with high natural arsenic content was started. The CMs provided the basis for case-specific risk assessments for the four model sites. A presentation on Action 3 activities in the ASROCKS project was given in an international conference for scientific audience in April 2013 (AquaConsoil, Barcelona).

Subtask 3.1. Survey and testing of available risk assessment and management methods

Literature data was compiled in order to identify available and potential risk assessment methods that could be used to assess the risks at the four model sites.

Instead of testing the existing risk management procedures, it was considered more feasible and practical to collect information on their functionality and any problems and shortcomings as well as on their development needs. This information was collected in the workshop in November 2013 (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html). The main results of this workshop were documented in a memo that was first sent to all participants for comments and then published in project's www pages. The results served as a starting point for Subtask 3.3 (see below) and Action 4.

Subtask 3.2. Development of a model risk assessment and risk management procedure

The risk assessment work was launched by defining the risk assessment methodology. The results from site studies that were generated in Action 2 were also compiled and studied. These site data and literature data related to the environmental fate and (bio)availability of environmental arsenic were used to identify and prioritize the most relevant and significant transport routes, exposure pathways and receptors, taking into account the worst case scenarios defined in Subtask 2.1. This work was published as Chapter 2.3.2 of the Guide book (Lehtinen et al. 2014: http://tupa.gtk.fi/julkaisu/opas/op_059.pdf) in Finnish and in the report:

Jaana Sorvari and Heli Lehtinen (2014) Preliminary risk assessment for rock aggregate production and construction sites - Building a Conceptual Site Model and defining worst case scenarios. The report is available from the ASROCKS project web pages (http://projects.gtk.fi/ASROCKS) in English.

Transport to and via surface water proved to be the most relevant transport route at the production sites. Transport through fractured zones can also be an important transport route particularly in quarries. This transport route mainly relates to the natural phenomenon and not to the quarrying activity per se, which is in focus in the ASROCKS project. Prediction of such transport would also require additional site data and the use of specific methods and expertise that were not available in ASROCKS. Results from the leaching tests (Action 2) showed that leaching from soil and products to groundwater is not a significant arsenic transport mechanism. Therefore, there was no need for more detailed studies on the mobilization of arsenic due to disturbance of the rock or soil matrix as a potential source of environmental and health risks. At the construction sites located in arsenic anomaly areas, potential human exposure through surface soils and air dust were identified as worst case scenarios.

It appeared useful to assess mass balances of arsenic via different transport pathways and mechanisms (surface runoff, erosion, leaching). Site data was complemented with literature data in order to generate these data for the Nokia-Nokia demonstration site. Due to the low arsenic concentrations, it was considered unnecessary to conduct any quantitative assessment using groundwater transport models.

In addition to the stakeholder workshop, information on the available risk management tools was also sought from the literature. These include different guidelines, such as BAT (Best Available Technology) guidelines and technical means to limit emissions, among others. Based on the results from the survey on risk management tools, there is an evident lack of ecotoxicity-based trigger values for arsenic concentrations in surface water. In the stakeholder workshop, the aggregate producers also called for more uniform permit procedures in the municipalities. They also need better justification for the requirements of site studies at the

planning stage of production and construction sites. Workshop attendees shared a common concern of a missing strong preventive RM strategy, which would require more detailed arsenic surveys already in the land use planning phase. Besides aggregate production and construction, there is a need for guidance concerning the safe use of aggregate products and waste rock.

Subtask 3.3. Preparation of recommendations

To get stakeholders' input to the preparation of recommendations and risk management guidelines, a workshop was organized for the representatives of aggregate producers, construction industry, environmental consultancy, and environmental authorities on 19 November 2013 in Tampere. This workshop also served for the implementation of Action 4. The workshop appeared successful, drawing over 50 participants into a whole day activity including presentations, group work and discussions. The group work was based on the open café method where groups of attendees gathered round hosted theme tables for a fixed time and then changed the theme table. The four themes discussed were the following: city planning, permits, supervision and monitoring and the acceptability of soil and rock aggregate products. The results of the workshop were reported in a separate document which was distributed to all participants and also published in the projects www-pages.

Risk management tools for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations are discussed in the report:

Heli Lehtinen and Jaana Sorvari (2014) Risk management tools for sustainable exploitation of aggregate resources in the areas with elevated arsenic concentrations. This report is available also from the ASROCKS project web pages in English (http://projects.gtk.fi/ASROCKS).

In project proposal it was planned to make a decision support model of sustainable exploitation for environmental authorities in Finnish. After having received the comments from the stakeholders it was clear that a simple decision support tree for authorities will not be the best output, because a fixed model hardly fits different geological, hydrological and other environmental conditions. The decision support model was carried out as two reports describing the risk assessment approach and management options and they are able to download in the web-pages of the project in English. In addition for that the project produced a guide book in Finnish that will serve both the authorities and the producers:

Lehtinen, Heli (toim.); Härmä, Paavo; Tarvainen, Timo; Backman, Birgitta; Hatakka, Tarja; Ketola, Terhi; Kuula, Pirjo; Luoma, Samrit; Pyy, Outi; Sorvari, Jaana; Loukola-Ruskeeniemi, Kirsti. 2014. Kiviainesten otto arseenialueilla. Opas kiviainesten tuottajille, maarakentajille ja viranomaisille. Geological Survey of Finland, Guide 59. 68 p.
(http://tupa.gtk.fi/julkaisu/opas/op_059.pdf).

For the compiling of the guide book, additional information on the weakness zones in bedrock in four demonstration sites was needed urgently. Therefore a short study of these issues was executed and as a result of that, an archive report disseminated
(http://tupa.gtk.fi/raportti/arkisto/53_2014.pdf).

5.1.4. Action 4: Guidelines for the sustainable exploitation of aggregate resources

Please see also pages 16-18 in the Layman's report.

The aim of the Action 4 was to provide instructions for the sustainable exploitation of aggregate resources with elevated arsenic concentrations. The guidelines and instructions developed in Action 3 (subtask 3.3) were generalized to be applicable for other similar areas in Finland and in Europe. The Ministry of the Environment has issued specific guidance (Environmental Administration Guidelines 1/2009) on the sustainable use of soil material already in 2009. While these guidelines were not updated during the life time of the ASROCKS project, the project decided to prepare new separate guidelines for sustainable exploitation of aggregate resources and for construction in areas with elevated arsenic concentrations. Detailed instructions were prepared in Finnish in Action 3 and more generalised guidelines were published in English in Action 4. Both guidelines are available from the project website.

The workshop organized within Action 3 for the representatives of aggregate producers, construction industry, environmental consultancy, and environmental authorities on 19 November 2013 in Tampere served also for the implementation of Action 4. The purpose of the workshop was to get the stakeholders' input to the preparation of recommendations and risk management guidelines. Two shorter meeting were arranged with stake holders in the beginning of 2014.

The company operating at the detailed demonstration site of Marjamäki applied for further environmental permit during the ASROCKS project. The final guidelines were not ready by the time the company was preparing the application. However, some of the analytical results of the project could be used in the application process. In the future the new guidelines will be useful for all producers in areas of elevated arsenic concentrations for environmental permitting.

The first planned activity of Action 4 was chemical characterization of aggregates. After the preparation of the ASROCKS project plan the Construction Products Regulation (CPR) had been developed to cover also aggregate products. According to the CPR, the CE marking of an aggregate product includes information on its technical properties *and the dangerous substances it can contain*. The test methods and the need for testing of dangerous substances in a construction product are still under development at the European level. Nevertheless, the basic principle will be that all those construction products from which dangerous substances might be released to soil, groundwater or surface water shall be tested. The leachability of hazardous substances will be tested as a part of the CE marking process in the future. This means that aggregate products will also be tested. Thus the ASROCKS project did not prepare separate classification of aggregate products but the products were characterized using different leaching tests. The project compared leaching test methods that could be applied in the CE marking. The European test methods for leaching are under validation. One of the leaching tests is quite similar to the method used in the ASROCKS project. There are no national or European threshold values for the interpretation of the leaching test results.

The second expected result was a method for delineating regions with high baseline concentration of arsenic. The study area of the ASROCKS project is an example (Fig. 8). General guidelines were published in English in the project website.

Tarvainen, T. 2014. Methods for delineating regions with high baseline concentration of arsenic. ASROCKS-project (Guidelines for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations) LIFE10 ENV/FI/000062 ASROCKS. Downloaded from http://projects.gtk.fi/ASROCKS_ENG/guidelines/arsenic_regions/

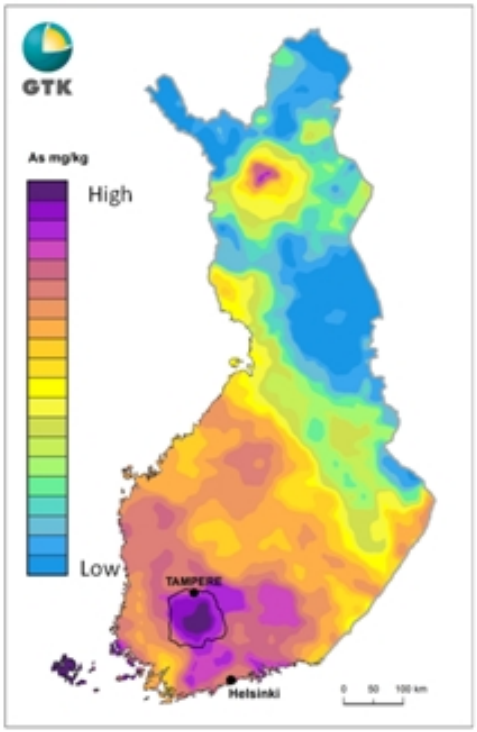

Fig. 8. Delineation of the ASROCKS demonstration area in southern Finland. In the Tampere-Hämeenlinna area, glacial till contains higher baseline concentrations of arsenic than in other parts of Finland.

The last expected result was the generalized guidelines applicable for whole Finland and similar areas in other parts of Europe. According to the results of the ASROCKS demonstration sites, the most important questions to address when a new aggregate production site or construction site is being set up are as follows:

- Is the new site located within an arsenic province, i.e. in the geological region with naturally elevated arsenic concentrations?
- What are the rock types at the site?
- Is there any information on elevated arsenic concentrations at the site or in its surroundings?
- What is the direction of surface water runoff from the site?
- Are there any valuable natural resources or protected ecosystems or species in the surroundings?
- Are there any private household wells or important groundwater aquifers nearby (within 300–500 m)?
- What is the planned land use and would this involve playgrounds or residential areas?

Generalized guidelines in English were developed for aggregate production (http://projects.gtk.fi/ASROCKS_ENG/guidelines/aggregate_production/) and for construction (http://projects.gtk.fi/ASROCKS_ENG/guidelines/construction/) in areas with elevated arsenic concentration.

Reports

Three detailed instruction reports can be downloaded from the project guideline website in English:

Jaana Sorvari & Heli Lehtinen. 2014. Preliminary risk assessment for rock aggregate production and construction sites. Building a Conceptual Site Model and defining worst case scenarios. ASROCKS-project (Guidelines for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations) LIFE10 ENV/FI/000062 ASROCKS. Downloaded from http://projects.gtk.fi/ASROCKS_ENG/guidelines/construction/

Heli Lehtinen & Jaana Sorvari. 2014. Risk management tools for sustainable exploitation of aggregate resources in the areas with elevated arsenic concentrations. ASROCKS-project (Guidelines for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations) LIFE10 ENV/FI/000062 ASROCKS. Downloaded from http://projects.gtk.fi/ASROCKS_ENG/guidelines/construction/

Tarja Hatakka, Birgitta Backman, Timo Tarvainen, Paavo Härmä, Terhi Ketola, Pirjo Kuula & Jussi Reinikainen. 2014. Sampling and Analysis. Guidelines for aggregate production and construction sites in areas with elevated arsenic concentrations. . ASROCKS-project (Guidelines for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations) LIFE10 ENV/FI/000062 ASROCKS. Downloaded from http://projects.gtk.fi/ASROCKS_ENG/guidelines/construction/

5.1.4.1. Action 4 (Task 4) Comment of the EU Life unit in the Mid-Term report:

The forthcoming guidelines (Task 4) for the sustainable exploitation of aggregate resources will be largely based on the experiences from the test area and might thus be very specific to the site or to the region. Please elaborate on this issue, i.e. how the applicability of the guidelines beyond the project area can be assessed and will there be e.g. site constraints affecting applicability.

The response:

The ASROCKS demonstration sites were well-chosen as general examples of aggregate production in areas with elevated arsenic concentrations. They presented two kinds of land use: aggregate production and construction. It was possible to demonstrate applicability of different sample materials, various sampling techniques, analytical methods and leaching tests as well as risk assessment in arsenic containing environment.

The ASROCKS project developed two sets of guidelines: one in Finnish (both web based version and a printed guide book) and one in English (available from the ASROCKS project web pages). Both language versions provide instructions for delineation of arsenic containing areas, detailed mapping and sampling on aggregate production or construction sites, suggestions for analytical methods and leaching tests and for preliminary risk assessment for rock aggregate production and construction sites (Building a Conceptual Site Model and defining worst case scenarios). These instructions are written in a general way applicable in various geographical and geological conditions. Examples are given from the ASROCKS demonstrations sites. However, some good practices are depending on national laws and regulations. Thus the Finnish version of the guidelines is more detailed and tailored to local regulations while the English version gives more general approach that can be applied together with knowledge of local requirements. Being generic, the guidelines are also applicable in other countries even if the policy instruments and administrative organization differ from those in Finland.

5.1.4.2. Task 4: Operation manual: Comment of the EU Life unit in the Progress report:

Task 4; The Operation manual, developed within this task, should be given appropriate publicity in the After-LIFE communication plan (Task 7) and in the remaining dissemination activities.

The response:

Operational manual, the 'Guidelines' book has been mentioned in the After-LIFE communication plan as an item that will be possible to implement as official guidelines for local environment authorities in the future. In the final seminar in Tampere, the guidelines publication was delivered to every participant and it is available for downloading in the web pages of the project. The After-LIFE Communication plan is a downloadable deliverable (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html.

The guidelines established in the ASROCKS project promote the risk assessment and management of the potential adverse environmental effects caused by natural arsenic at rock aggregate production, soil extraction and constructions sites. It therefore serves the objectives of the Thematic Strategy of the Soil Protection (COM(2006)231) and the Water Framework Directive (2000/60/EY) , and protection of the environment in general. The study results and guidelines of ASROCKS also increase the permitting authorities' understanding of the actual environmental impacts of elevated arsenic concentrations and provide both them and aggregate producers and constructors with the information on the tools to control and manage the risks related to arsenic. The results of ASROCKS project indicate only a minor release of arsenic from construction aggregates. However, the variable pH conditions or interaction with other materials should be considered in the future. The need for informing the total amount of arsenic in products' CE-marks or in the declaration of performance may be needed in the future in certain end uses of aggregates.

5.2. Dissemination actions

5.2.1. Objectives

The ASROCKS aimed at making a significant impact on the sustainable exploitation of aggregates in a region, where various critical environmental and economic issues, fears etc., complicate the situation. Therefore, the dissemination of the results was a vital part of the ASROCKS project. Major efforts were made to inform and train the authorities in different levels, industrial parties and researchers in national and international forums.

Related to the deliverable "Evaluation of dissemination" (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html), a Webropol enquiry was sent to the major stakeholders and environmental authorities of the project region to find out the success of dissemination through deliverables, WebPages and newspapers and other media. According to the enquiry the dissemination of the ASROCKS project had been successful.

The Steering Committee serves as an important floor for dissemination given the fact that all major stakeholders nominated their member to the Steering Committee and participation to ASROCKS meetings and workshops was very active.

5.2.1.1. Dissemination plan

A revised dissemination plan was one of the deliverables in the original project plan. It was completed in March 2012 and accepted by the Steering Committee on 6 March 2012. The schedule of workshops and seminars was updated to match the schedule of Action 2. The dissemination activities have followed this plan accordingly except for the schedule for final seminar in Tampere which was organised in August 2014. The permission for the change of date from May to August 2014 was accepted by Technical Desk Officer Izabela Madalinska during the Monitoring Meeting in Tampere, Finland in March 2014. The seminars for the general public were organized to distribute and share the demonstration results of the project for local people. The seminars is shown are summarized in Table 5 below.

Table 5. The seminars for general public.

Schedule	**Category**	**Audience**	**Number of participants**
May 2014	Local/regional Place: Hämeenlinna city	General public	25
August 2014 *The final seminal of the ASROCKS project*	National Place: Tampere city	General public	60

5.2.2. Dissemination: overview per Activities

Please see also page 19 in the Layman's report.

The dissemination activities are summarized in Table 6. Dissemination in Actions 1 and 2 focused on producing reports and maps and other deliverables according to the original work plan. Results of chemical analysis and detailed descriptions of four demonstration sites were delivered to aggregate producers, to each company the data concerning their own production area. The report containing instructions for sampling and analytical procedures is also important for dissemination. In Actions 3 and 4 main products for dissemination were the guidelines (handbook) both as a printed report and in the www-pages, in Finnish as well as in English.

Steering group and management board meetings, excursions, press releases, questionnaire to stakeholders and activities summarized in the After Life dissemination plan were the main dissemination means for Actions 5 and 7. However, the principal dissemination actions of the ASROCKS project took place in the course of Actions 8 and 9 which include www-pages, brochures, workshops, evaluation of dissemination, notice boards and poster and oral presentations in seminars and conferences of different kind.

5.2.2.1. Kick-off meetings

Kick-off meeting of the ASROCKS project was held on 17th of October, 2011 at Pirkkala municipality in the demonstration area. In the meeting 18 researchers and other participants from the three beneficiaries were present to answer questions of stakeholders, press and local community. Press and TV were present and articles in newspapers and TV interviews were published.

Kick-off meeting for LIFE+ projects 2010 was held at Riga on 14th of November, 2011. The participants in that meeting were Mr. Paavo Härmä and the project manager Jussi Mattila, who gave a presentation of the ASROCKS project.

Table 6. Overview of dissemination activities in different Actions of the ASROCKS project.

Action no	Dissemination	Number of items	Responsible organisation	Objective reached	Feedback
1	Reports Lists of selected sites Maps	3 2 1	GTK	Yes	Lists of selected demonstration sites were accepted by stakeholders. Instructions for sampling and analytical procedures were highly appreciated.
2	Reports Detailed descriptions of demonstration sites	2 4	TTY SYKE GTK	Yes Yes	Leaching test report was evaluated to be very useful. Description of sites was sent to aggregate producers, who appreciated the data.
3	Guidelines (handbook) The risk assessment and risk management report	1 1	SYKE SYKE	Yes Yes	The guidelines were very highly appreciated. A lot of useful data in guidelines (handbook).
4	Guidelines on www-pages	1	GTK	Yes	The guidelines were very highly appreciated among stakeholders and authorities. "A lot of useful data in guidelines."
5	Steering group meetings Management board meetings www-sites Questionnaire to stakeholders	7 14 1	GTK GTK GTK	Yes Yes Yes	Well organised meetings. These meeting have been important. Stakeholders were satisfied.
7	After LIFE dissemination plan	1	GTK	Yes	The feedback from the European Aggregate Producers was rewarding in October 2014. The feedback from a scientific conference in Asia was very good. The ASROCKS results raised a lot of interest.
8	Web site Brochures Dissemination plan Workshops Evaluation of dissemination Kick-off meeting, Hämeenlinna seminar Final seminar and excursion	1 2 1 3 1 1 1 1	GTK GTK GTK, TTY, SYKE GTK GTK, TTY, SYKE GTK, TTY, SYKE GTK	Yes Yes Yes Yes Yes Yes Yes Yes	About 29 visitors a month. Updated version accepted by Life unit The second workshop: very well organised Dissemination of the project has been successful Both seminars were rewarding and also media was interested (TV interviews, newspapers)
9	Oral presentations and posters in congresses and seminars Notice boards	10 4	GTK, TTY, SYKE GTK	Yes Yes	The ASROCKS results have gained a lot of international and national interest. Notice boards were erected in the detailed demonstration sites.

5.2.2.2. Final seminars

Hämeenlinna, 13 May 2014

The results of the project were presented in the southern part of the demonstration area, in Hämeenlinna to be able to distribute results also for the stakeholders and authorities in the Hämeenlinna region. The seminar was in principle open for general public as well but we sent invitations to municipalities, local authorities and companies to be able to get feedback for Action 4 and to be able to modify final deliverables accordingly for the last deliverables and for the final seminar which was organised in Tampere in August. There were 20 participants in the Hämeenlinna seminar from the invited organizations. Discussion was active and we were able to get the feedback we needed for future work (Fig. 9).

Fig. 9. Some of the participants in Raatihuone (Town Hall) in Hämeenlinna, May 2014. The seminar was targeted mainly to regional authorities and stakeholders in the southern part of the demonstration area.

Tampere, 19 April 2014

The final seminar was held in the Tampere Hall and in context of the final seminar also a press conference was organized. After the seminar, an excursion for selected demonstration sites in the area between Tampere and Hämeenlinna was organised 20th August with presentations both on the sites and in the bus. There were 60 participants in the final seminar representing all stakeholders (Fig 10), 15 participants in the press conference of which five from different media and about 30 participated in the excursion as well. TV interview and numerous newspaper articles were published.

The presentations of both Hämeenlinna and Tampere seminars can be downloaded from our web pages, http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html.

Fig. 10. The final seminar was organised in the Tampere Hall in August 2014. The importance of the ASROCKS results for the Finnish Society can be seen for example from the fact that the final seminar was opened by Mr Erkki Virtanen, the Permanent Secretary of the Ministry of Employment and the Economy.

5.2.2.3. Workshops

Three workshops were organized for stakeholders and authorities in addition to numerous internal project workshops. The three workshops are summarized in Table 7, the schedule for which was enclosed already in the Mid-term report. A workshop for the Steering Committee members and personnel of the beneficiaries participating in the Action 1 was organized on 6 March 2012. Altogether 13 participants were present in the workshop. Feedback for selecting the 21 preliminary demonstration sites was given by the stakeholders during that workshop. In addition, the stakeholders together with the beneficiary representatives provided important feedback related to the dissemination in the project, and as a result the dissemination plan was modified.

The second workshop for the Steering Committee members, stakeholders of the project, producers of the demonstration sites, and personnel of the beneficiaries was held on 27 August 2012 at the Tampere University of Technology (TTY). The preliminary results of Action 1 were presented and feedback requested for the selection of four detailed demonstration sites to the next phase of the project, Action 2. There were 22 participants in this workshop.

The third workshop was organized for the key stakeholders, i.e. representatives of aggregate producers, construction industry and environmental consultancy, and environmental authorities on 19 November 2013 in Tampere. It was a success, drawing over 50 participants into a whole day activity including presentations, group work and discussions. The group work was based on the open café method where groups of attendees gathered round hosted theme tables for a fixed time and then changed the theme table (Fig. 11). Four themes discussed were the following: city planning, permits, supervision and monitoring and the acceptability of soil and rock aggregate products.

Table 7. The three workshops for stakeholders and authorities.

Schedule	Category	Participants	Number of participants	Aim
March, 2012 *In association with the steering group meeting*	Regional	Experts, academics, industry and environmental authorities	13	To discuss future activities of the ASROCKS project. To get feedback.
August 2012	Regional	Experts, industry and environmental authorities	22	The preliminary results of Action 1 were presented and feedback requested.
November, 2013	National	Academics, experts, environmental authorities	52	To inform and to get feedback on the conceptual model for qualitative risk assessment.

The participants of the third workshop in November 2013 gave feedback for Actions 3 and 4. The feedback was very positive but it was also useful since it contained detailed suggestions for future activities. Some of the participants volunteered to participate in the actual preparation of the guidelines. **An expert group was formed** to support ASROCKS in this task including representatives from all stakeholder groups. The content of the workshop can be found in the Web pages of the ASROCKS project (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

Fig. 11. During the third workshop with stakeholders and authorities the group work was based on the open café method where groups of attendees gathered around theme tables.

Questions raised during the ASROCKS workshops for stakeholders and authorities:

Two specific questions were raised during workshops and seminars for Actions 2 and 3: Can other methods for chemical analyses be used in the arsenic studies than those applied by the ASROCKS team and can we estimate how probable high arsenic concentrations are in planned new aggregate production sites. To answer these questions, additional analyses were carried out and the results were as follows:

Alternative analytical methods

Easily mobile fraction of arsenic concentrations was evaluated using various weak extraction methods and leaching tests. The results of weak extraction methods and standard leaching tests do not always correlate positively. According to this pilot study, weak extractions based on ammonium chloride and barium chloride extractions were most promising methods for estimation of the easily mobile fraction of arsenic. The applicability should be further studied with larger number of samples that are analysed both using these two weak extraction methods and standard leaching tests. Ammonium oxalate leach can give valuable additional information if arsenic is bound to iron precipitates.

Report is available from the project web site:
Tarvainen, T., Hatakka, T., Backman, B., Ketola, T., & Härmä, P. 2014. ASROCKS-hankkeen heikkouuttomenetelmien vertailu. Geologian tutkimuskeskus. Arkistoraportti 77/2014. 13 p. (In Finnish) (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html)

Distribution of arsenic in rock types of planned new rock aggregate production sites in the Tampere region

ASROCKS-project analysed *aqua regia*-leachable arsenic concentrations in 180 rock sample from 60 areas planned for rock aggregate production in Tampere region. The arsenic concentrations are 0.80 – 115.6 mg/kg. The median value is 3.1 mg/kg. The highest arsenic concentrations are in bedrock which consists of gabbro. In 1 – 24 rock samples the arsenic concentrations were higher than the baseline values for arsenic in bedrock and soil in southern Tampere region. These samples were taken from 1 – 19 different study areas which is 1.7 – 31.7 % of the planned rock aggregate production sites studied in the project.

The report is available from the project web site:
Hatakka, Tarja; Nurmi, Heikki; Tarvainen, Timo; Backman, Birgitta; Vuokko, Jouko; Härmä, Paavo. 2014. ASROCKS-hankkeen selvitys Pirkanmaan kallioperän arseenipitoisuuksista kalliokiviaineksen tuotantoon kaavailluilla alueilla. Geologian tutkimuskeskus. Arkistoraportti 93/2014. 21 p. (In Finnish)
(http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html)

5.2.2.4. Conferences, seminars and fairs

Results of different Actions of the ASROCKS project were presented for example in following conferences, seminars and fairs:

1. ASROCKS-project has been presented for the scientific community in the 30th Nordic Geological Winter Meeting in Reykjavík in January 2012.
2. The Geology Section of VMY, Geokemian rengas and Department of Geology, University of Oulu organized a seminar "Geochemistry and ore deposit models" at the University of Oulu on 17 - 18 October 2012. The ASROCKS project had a poster in the seminar.
3. The national seminar of environmental administration on contaminated soil was arranged in SYKE in February 2013. Dr. Jaana Sorvari gave there a oral presentation.
4. GTK presented the ASROCKS project at the Environment and Infrastructure Fair (Ympäristö ja Yhdyskunta 2012 -messut) in October 2012 in Helsinki.
5. Mutku ry (The Finnish Society for Soil Investigation and Remediation) in Tampere on 20-21 March 2013. The project manager Paavo Härmä, GTK had an oral presentation of ASROCKS project and its preliminary results of Action 1.
6. Aquaconsoil conference in Barcelona 16-18 April 2013. Abstract and poster: Dr. Jaana Sorvari, SYKE
7. The 11th Finnish Conference of Environmental Sciences (FCES) in Tampere, 2-3 May 2013. Abstract and poster: M.Sc. (tech)Terhi Ketola, TTY
8. The 29th International conference for the Society for Environmental Geochemistry and Health (SEGH) in Toulouse, France on 8-12 July 2013. Dr. Timo Tarvainen gave an oral presentation in the special session for arsenic: Current issues of speciation, environmental behaviour, and human health impacts
9. The 12th SGA Biennial Meeting 2013 (Society for Geology Applied to Mineral deposits) in Uppsala, Sweden on 11-15 August 2013. Abstract and poster: Paavo Härmä, GTK
10. EuroMining-fair, 11-12 September 2013, Tampere. The results of the Action 1 leaching tests were presented by M.Sc. (tech) Terhi Ketola as a poster.
11. 31st Nordic Geological Winter Meeting in Lund, Sweden on 8-10 January 2014. The results of ASROCKS project were presented by Birgitta Backman and Tarja Hatakka
12. PANK menetelmäpäivä (PANK Method Meeting) in Helsinki on 23 January 2014. Oral presentation: M.Sc. (tech) Terhi Ketola.
13. 11th Finnish Geochemical Meeting in Espoo, Finland on 5-6- February 2014. The project manager Paavo Härmä, geologist Tarja Hatakka and senior scientist Birgitta Backman, GTK had oral presentations in the meeting.
14. Kiviaines- ja murskauspäivät (Seminar of Aggregates and crushing) in Vantaa on 13-14 February 2014. Oral presentation of ASROCKS project: M.Sc. (tech) Pirjo Kuula.
15. Mutku ry (The Finnish Society for Soil Investigation and Remediation) in Tampere on 2-3 April 2014. Poster presentation of Heli Lehtinen, Jaana Sorvari and Timo Tarvainen
16. Maa-ainespäivät (Seminar days of Aggregates) in Helsinki on 15 May 2014. The results of ASROCKS project were presented by Heli Lehtinen

5.2.2.5. Newspapers

Dissemination of the ASROCKS-project was successful and the project drew attention in the newspapers, internet, and in television both in the kick off-phase and in the final seminar. Three press releases were released, the latest one in context with the final seminar of the project held in Tampere 19th August 2014.

The following media noted ASROCKS:

- YLE (Finland's national public service broadcasting company)
  - Web-pages on 18th October 2011
  - TV news –Häme region on 18th October 2011 and 19th August 2014
- Maaseudun Tulevaisuus ("The Future of Rural Areas in Finland" newspaper) webpage
- Valkeakosken Sanomat 4th May 2012
- Ympäristö ja Terveys –magazine no. 44 (7)/2013 “More than 20 years of arsenic risk management in the Pirkanmaa region” (“Yli 20 vuotta arseeniriskien hallintaa Pirkanmaalla”).
- Helsingin Sanomat, 20th August 2014 (the leading newspaper in Finland)
- STT, 19th August 2014
- Aamulehti, 20th August 2014 (the leading newspaper in the Tampere region)
- Pohjalainen, 24th August 2014
- Rakennuslehti, 24/2014
- Pirkkalalainen, 22 October 2014

GTK’s newspaper for stakeholders, Geofoorumi, published an article of the ASROCKS project in year 2012 (1/2012). A public debate of arsenic concentrations and artificial recharge erupted in the Aamulehti newspaper in October 2012 on its pages for readers’ voice. GTK took part in that debate by sending a reply on 23 October 2012.

5.2.2.6. Notice Boards

Notice boards have been placed in the aggregate processing sites studied in the ASROCKS project, or beside the roads leading to them. They contain basic information on the aggregate processing site and the ASROCKS project. Notice boards include a reference to the project website. The financial support from LIFE+ Programme was indicated clearly in the notice boards. Examples of notice board are given in Fig. 12A and B. Some of them could by now have been damaged due to the challenging climate in winter time or even due to vandalism.

Figs. 12A and B. Examples of notice boards in the vicinity of two demonstration sites of the ASROCKS project.

5.2.2.7. The project website

The project website (http://projects.gtk.fi/ASROCKS) had an important role in distributing the files and data between beneficiaries. Also stakeholders and general public visited the site to get reports, maps and contact information. There have been 29 visits per day on average in the project website since the launching (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

5.2.2.8. Use of LIFE logo, Photographs, (e)Mailing lists, Social Media

EU Life logo or flag and the ASROCKS project's own logo were used in reports, lists, maps, presentations and in all deliverables at least on the first page of the deliverable. In addition, the sentence "With the contribution of the LIFE financial instrument of the European Union" was added in practically all outputs of the project on the first page, but in couple of cases the indication of LIFE co-funding was placed in some other page than the first page, accidently. Numerous photographs were also taken.

There are over a hundred names in the (e)mailing lists of the project. The invitation to the final seminar of the project was sent to 150 persons in August 2014. There is a link to the Twitter in the web pages of the ASROCKS project (Fig. 13). All three project beneficiaries and some of the stakeholders have a link to the project web page in their own web pages.

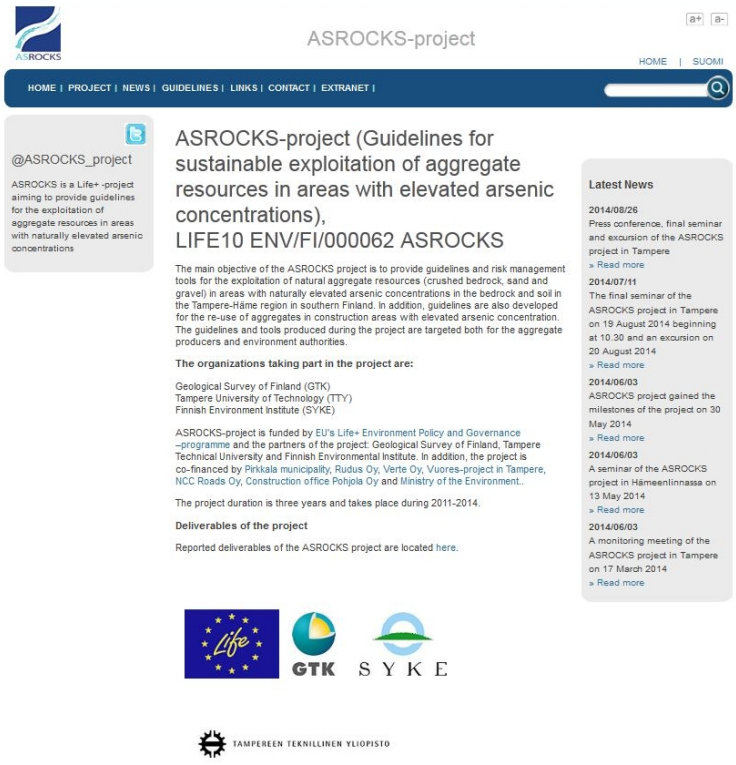

Fig. 13. A link to Twitter is placed in the www-pages of the ASROCKS project.

5.2.3. Deliverables and reports

Please see also pages 21-22 in the Layman's report. The deliverables disseminated during the project period are as follows (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html):

- Map of areas with elevated natural concentrations of arsenic in bedrock and soil in the Tampere-Häme region, 30.11.2011 (Action 1)
- Launch of the project's web-site, 30.11.2011 (Action 8)
- Brochure on the project and its objectives, 31.1.2012 (Action 8)
- List of aggregate production sites, major earthworks and selected potential construction sites in the Tampere-Häme region, 31.1.2012 (Action 1)
- Dissemination plan, 28.2.2012 (Action 8)
- Questionnaire to major stakeholders, 30.10.2012 (Action 8)
- Sampling plan for selected 20 demonstration sites, 31.3.2012 (Action 1)
- List of selected detailed demonstration sites for Action 2, 31.8.2012 (Action 1)
- Evaluation of dissemination 31.3.2013 (Action 8)
- Description of selected 21 demonstration sites, 31.5.2013 (Action 1)
- General Guidelines for Sampling Procedures in Aggregate Production Sites and Sampling Plans, 31.5.2013 (Action 1)
- Results of leaching experiments of selected aggregates 30.9.2013 (Action 2)
- General and site-specific conceptual models for qualitative risk assessment 31.10.2013 (Action 2)

- Decision support model of sustainable exploitation for environmental authorities, 30.4.2014 (Action 3)
- Guidelines for the sustainable exploitation of aggregate resources in areas with naturally elevated concentrations of arsenic in soil and/or bedrock, 30.4.2014 (Action 4)
- Operation manual for authorities at municipal and regional levels, 30.4.2014 (Action 4)
- Risk management tools for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations, 30.6.2014 (Action 3)
- Guidelines for environmental management of aggregate resources, booklet, 31.8.2014 (Action 8)
- Layman's report, 31.8.2014 (Action 8)
- After-life communication plan, 31.8.2014 (Action 8)

The main printed products, 'Guidelines' published in the Guide series of the Geological Survey of Finland, and the Layman's Report in Finnish, published in the Special Publications series of the Geological Survey of Finland, were distributed due to the dissemination scheme of the Geological Survey of Finland publication series, in addition to the dissemination specific for the ASROCKS project (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html). They are also available for downloading free of charge from the web-page http://hakku.gtk.fi in addition to the ASROCKS web-pages.

5.2.4. Networking with other projects

The project had active networking with many ongoing projects. For example, the networking with the project “SOUTH-EAST FINLAND - RUSSIA ENPI CBC PROGRAMME 2007-2013: Efficient use of natural stone in the Leningrad region and South-East Finland”. The objectives of ASROCKS –project have been disseminated in the meetings of this project.

The ASROCKS project had vivid connections with the project of ABSOILS (LIFE09ENV/FI/000575) “Sustainable Methods and Processes to Convert Abandoned Low-Quality Soils into Construction Materials” which demonstrates conversion of abandoned and low-quality soils - such like soft clays - into construction materials. Both ASROCKS and ABSOILS projects deal with natural constructions materials and both projects have demonstration sites located in Finland. Experts from both projects met at the Geological Survey of Finland on 27 March 2013 and presented the preliminary results. Another meeting was like an After Life meeting in the workshop of ABSOILS on 11-12 September 2014 where project manager Paavo Härmä kept an oral presentation of ASROCKS project.

ASROCKS had also close cooperation with ARSENAL, 'Solutions for Arsenic Control in Mining Processes and Extractive Industry' which is coordinated by GTK and co-funded by TEKES (www.tekes.fi).

There are over a hundred names in the (e)mailing lists of the project. The invitation to the final seminar of the project was sent for almost 150 persons or organisations in August 2014. There is a link to the Twitter in web pages of the ASROCKS project (Fig. 13). Every project beneficiary has a link to the project web page in their own web pages.

Networking in Europe

Please see also pages 5 and 19 in the Layman's report.

The networking and dissemination of the demonstration results have been a vital part of the ASROCKS project. We have presented ASROCKS results and discussed with authorities in different levels, industrial parties and researchers in national and international forums. The ASROCKS project communicated with aggregate producers also through UEPG (European Aggregates Association) and had contacts to the countries where high arsenic content soil and bedrock may pose a problem in aggregate production.

The personnel of the ASROCKS project visited three countries in Europe to distribute the results of the project (in addition to conferences). Please see the travel reports of the presentations, workshops and discussions in Bratislava, Slovakia on 15-16 May 2014, in Uppsala, Sweden on 26 May 2014 and in Freiberg, Germany on 15-18 June 2014. The travel reports of the trips are presented in the web-pages (http://projects.gtk.fi/ASROCKS_ENG/project/travelreports.html).

The results of the ASROCKS were introduced in the UEPG committee meetings, in Brussels, Belgium on 8-9 October 2014, an activity belonging to After Life communication and networking. The ASROCKS results and especially the map of arsenic in soil in Europe (Fig. 14) raised concern and some of the representatives decided to begin to solve the case in their country.

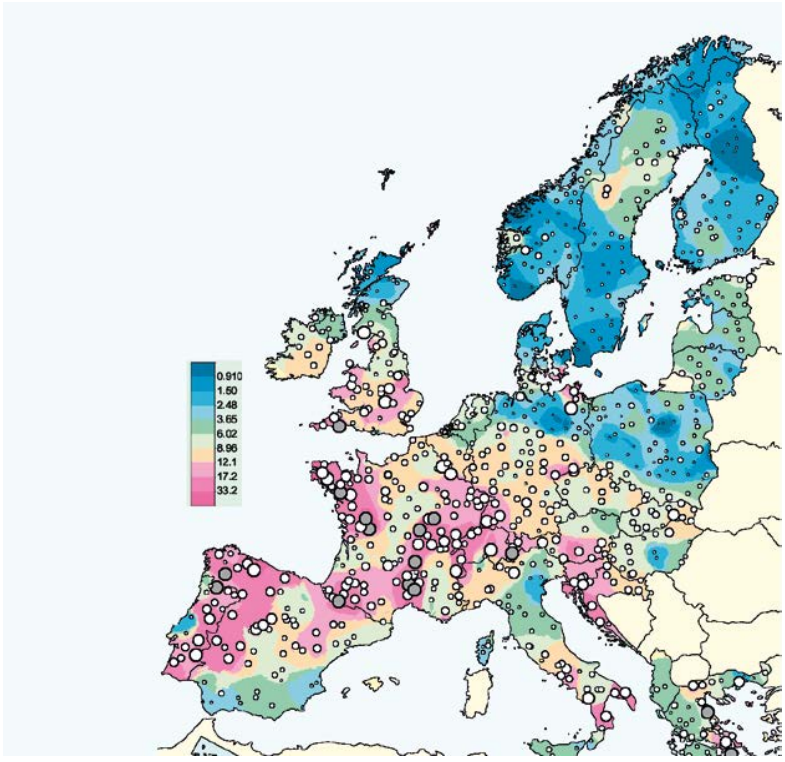

Fig. 14. Arsenic concentration in soil in Europe. Red values represent high and blue values low arsenic values. The concentrations are higher in average in south than in north due to the natural differences in bedrock. The same trend can be seen in groundwater values.

5.2.4.1. Action 7: Comment of the EU Life unit in the Mid-Term report: After-LIFE

Concerning the networking with other projects, please maintain this activity and elaborate on parallels and synergies as appropriate in the final deliverables and in the After-LIFE communication plan.

The response:

The project had active networking with many other projects in Finland and beyond it in other European countries. In Finland, close connections have been with the projects: ABSOILS (LIFE09ENV/FI/000575), ARSENAL and the project of the ENPI CBC PROGRAMME 2007-2013.

In Europe, networking with other project was realised during the road shows carried out in three European countries (Slovakia, Sweden and Germany). For example the personnel of the project became acquainted with the EU Life projects in Germany (GREENLAND) in Slovakia (Geohealth). In addition the contacts and networking in congress and seminar in different European countries, like France, Spain, Denmark and Sweden were very successful and new ideas were received. As an After-LIFE dissemination activity, the results of Action 3 were presented in the form of an abstract and poster by Dr. Jaana Sorvari in the NORDROCS 2014, 5th Nordic Joint Meeting on Remediation of Contaminated Sites in Stockholm, Sweden 15-18 September 2014. In addition, the results were presented by Dr. Jaana Sorvari in the International Conference on Contaminated Land, Ecological Assessment and Remediation (CLEAR) in Chuncheon, Korea, 5-8 October 2014. Since natural arsenic is a wide and well-known issue in Asia, the presentation rouse interest in several participants from Taiwan, Korea and Thailand, among others. As a follow-up to this conference an extended abstract has been submitted to for the consideration of a full paper to be published in the special issue of The Environmental Geochemistry and Health (EGAH).

Networking is an ongoing process and the meetings where the results of the ASROCKS project will be performed are listed in the After-LIFE Communication plan of the project.

Please see also page 23 in the Layman's report for the After-LIFE activities.

5.2.4.2. Action 7: Comment of the EU Life unit in the Progress report:

The After-LIFE communication plan could be addressed also especially to the stakeholders like municipal and regional authorities as well as aggregate business contractors.

The response:

The successful cooperation and contacts between local and regional decision makers, environment authorities on different level and aggregate producers will be maintained. Also the dissemination and networking beyond the usual sphere of stakeholders and beyond Finland will be kept up after the finishing of the project. The results of the

ASROCKS project will be applied in the regional plan of the Tampere region when the areas appropriate for exploitation of crushed rock aggregates will be determined (http://maakuntakaava2040.pirkanmaa.fi/poski).

5.2.4.3. Actions 7-9 (Task 7-9) Comment of the EU Life unit in the Progress report:

Overall, the Tasks 7-9 make one entity to publicise and give visibility for the project's results and recommendations. For the time being the dissemination and networking activities have been rather modest, mainly because the tangible, practical results, relevant for outsiders, have been missing. The completion of the Task 4 provides the project with good and comprehensive material, which together with the earlier produced visual material and photos can be effectively used to give the results publicity beyond the project's technical sphere. Additionally, based on the Soil Thematic Strategy, the Commission published a policy report on the implementation of this strategy and ongoing activities on 13 February 2012 (COM(2012) 46). This report provides an overview of the actions undertaken by the European Commission to implement the four pillars of the Strategy, namely awareness raising, research, integration, and legislation. Please elaborate the results in view of this report. Further, the Water management plans, now completed based on the Water Framework Directive, might also provide a good reference regarding the arsenic related hazards in surface waters.

The response:

How ASROCKS supports the implementation of the objectives set in the EUs thematic strategies for the protection of the environment and construction product regulation

Starting point of ASROCKS project

The environmental risks of the exploitation of bedrock are mainly regulated by the environmental permit procedure while construction activities are controlled through municipal building code or environmental regulations, and planning ordinances. So far, the potential environmental and health risks of natural arsenic arising from construction or aggregate production activities at arsenic anomaly areas have not been specifically addressed at any stages of decision-making and permits also lack for adequate guiding on the risk management of arsenic. At the same time, the knowledge of potential risks caused by arsenic has raised significant concern both among the public and environmental authorities. Due to this concern, construction projects as well as permit processes related to the extraction of rock and soil material at regions with known arsenic anomaly areas have been delayed and permit applications have also been rejected in some cases due to insufficient information about the risks. It was therefore clear that there was an urgent need for information about the extent of arsenic problem as well as for risk assessment and risk management guidelines that would enable the sustainable soil extraction, aggregate production and construction activities in those cases where elevated concentrations of naturally occurring arsenic is present. Moreover, there was a need to understand the link between the elemental concentrations of arsenic in

bedrock or soil and the factual adverse impacts in the surrounding environment that such concentrations may have.

Thematic Strategy of Soil Protection (COM(2006)231)

The overall objective of the Thematic Strategy of the Soil Protection (COM(2006)231) is to prevent further degradation of soil and preserving soil functions. The ASROCKS project studied the realization of this objective by investigating whether the extraction of rock and soil material or construction at arsenic anomaly areas causes deterioration of soil quality and soil contamination. The main objective of the ASROCKS project was to reveal the extent of this problem and thereby raise the awareness of all stakeholders (public, authorities, constructors, aggregate producers). Furthermore, any needs for additional risk management actions and guidance were identified. The studies conducted in ASROCKS showed that neither the soil extraction nor rock aggregate production has caused significant deterioration of soil quality. Owing to these results, the concern on the risks of arsenic at aggregate production sites and construction sites will be significantly mitigated. On the other hand, ASROCKS highlighted that some site-specific studies are always needed particularly when planning, continuing or extending the aggregate production activities. Hence, the aggregate producers' and constructors' awareness of the need for risk management was also raised. This enables adequate management of arsenic related risks in the future, particularly since ASROCKS also provides guidance and recommendations for the practical risk management actions. All stakeholders' awareness on the environmental effects of arsenic in rock and soil extraction and construction, as well as on the assessment of the potential effects and risk management needs, was also increased through workshops, seminars, press conferences and written material (popularized book; leaflets; guidelines for authorities, constructors and aggregate producers). The results of the project were also presented in several international conferences and road show visits to countries with known natural arsenic problem.

Water Framework Directive (2000/60/EY) and Water management plans

The Water Framework Directive (WFD) sets chemical-specific standards for groundwater and surface water quality. These standards support the classification and monitoring of water quality. Exceeding of the quality standard can change the classification of a water body from the category "good" to the category "satisfactory". Based on the WFD, a national quality standard for arsenic in groundwater has been set in Finland (5 µg/l). It is forbidden to exceed this quality standard. This quality standard also forms the basis for the determination of acceptable emissions to the water bodies and it is also applied when defining the prerequisites and provisions of an environmental permit. The ecological status of surface waters can be defined for parts of water bodies that are bigger than ditches, for streams, river routes or lakes. Thus, the quality standards are not to be applied in the case of a ditch or a rivulet.

The ASROCKS project included a survey on the current regulatory framework and practices related to construction and extraction of rock and soil material. Although the regulatory framework per se seems to support adequate management of any environmental risks related to these activities, some shortcomings that aggravate the implementation of risk management actions in practice, also came up. The most important shortcoming is the lack of quality guidelines for arsenic in surface water since arsenic has not been defined as a national priority

substance as per the Water Framework Directive. At the same time, in the planning related to surface water formation, arsenic is defined as a locally significant chemical that causes harm to the aquatic environment. In the definition of the ecological state of surface waters, arsenic needs to be considered based on its known biological effects. Even though at the rock aggregate production sites studied in ASROCKS, the arsenic load caused by runoffs fall on small ditches or streams that are generally not considered ecologically important, a question was raised whether there would be cases where the runoff would end up in protected water ecosystems. Thinking about the adequacy of risk management at other quarry sites it was suggested to consider the derivation of national, ecologically based water quality standards for arsenic. Thus, ASROCKS was able to provide input for the development of national regulations that would enhance the implementation of WFD.

Construction Product Regulation

Construction Products Regulation (the CPR) is to ensure reliable information on construction products in relation to their performances. This is achieved by providing a “common technical language", offering uniform assessment methods of the performance of construction products. Construction works as a whole and in their separate parts must be fit for their intended use, taking into account in particular the health and safety of persons involved throughout the life cycle of the works.

The essential characteristics in which the content and release of arsenic is included are hygiene, health and the environment and sustainable use of natural resources. The construction works have to be designed and built in such a way that they will, throughout their life cycle, not be a threat to the hygiene or health and safety of workers, occupants or neighbours, nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition. The release of dangerous substances into ground water, marine waters, surface waters or soil and also the release of dangerous substances into drinking water are the essential processes to be evaluated. Also the requirement for the use of environmentally compatible raw and secondary materials in the construction works is related to arsenic.

The European standardization is focusing to harmonize the requirements and evaluation methods for these essential characteristics. The CEN/TC 351 (Construction products: Assessment of release of dangerous substances) is developing horizontal standardized assessment methods relating to the release of regulated dangerous substances to soil surface water, ground water and indoor air. The intended conditions of use of the product will be an essential starting point in the evaluation. At the moment the test methods developed for leaching properties evaluation are under development but very similar to percolation test used is ASROCKS project. Although ASROCKS project concentrated on aggregate production sites the leaching tests were performed with product samples and therefore the results are usable when the need for aggregate leaching tests is evaluated.

Summary

The guidelines established in the ASROCKS project promote the risk assessment and management of the potential adverse environmental effects caused by natural arsenic at rock aggregate production, soil extraction and constructions sites. It therefore serves the objectives of the Thematic Strategy of the Soil Protection (COM(2006)231) and the Water Framework Directive (2000/60/EY) , and protection of the environment in general. The study results and guidelines of ASROCKS also increase the permitting authorities' understanding of the actual environmental impacts of elevated arsenic concentrations and provide both them and aggregate producers and constructors with the information on the tools to control and manage the risks related to arsenic. The results of ASROCKS project indicate only a minor release of arsenic from construction aggregates. However, the variable pH conditions or interaction with other materials should be considered in the future. The need for informing the total amount of arsenic in products' CE-marks or in the declaration of performance may be needed in the future in certain end uses of aggregates.

5.3. Evaluation of Project Implementation

Evaluation of the project implementation is shown in Table 8. In this table, the success and failures of the methodology applied, the results of actions conducted and the cost-efficiency of actions are discussed.

Table 8. Evaluation of project implementation in the main technical tasks (Actions).

Task	**Foreseen in the revised proposal**	**Achieved**	**Evaluation**
Action 1: 1) Map of areas with elevated natural concentrations of arsenic 2) List of aggregate production sites, 3) Sampling plan for selected 20 demonstration sites, 4) List of selected detailed demonstration sites for Action 2 5) Description of selected 21 demonstration sites 6) General Guidelines for Sampling Procedures	These first two tasks formed the basis for demonstration and sampling phase General sampling plan in proposal Basis for Action 2 Information and dissemination for aggregate producers Detailed sampling plan for producers	Yes, achieved and on time Yes Yes Yes Yes Yes	There were many suitable sites for demonstration, and selection for the representative sites was essential. A good sampling plan was very important to be able to organise sampling on time. Results were visible immediately. Many possible sites, we had to be able to select the best ones for the ASROCKS objectives. Results visible immediately. Completed ahead of schedule, results visible immediately Sampling plan was more detailed than the previous one (no 3)
Action 2: 7) Results of leaching experiments 8) General and site-specific conceptual models for qualitative risk assessment	Leaching with one (or two) methods General conceptual model	Yes Yes	Took more time than expected, more leaching methods had to be tested than originally proposed, results visible immediately Site-specific model
Action 3: 9) Decision support model of sustainable exploitation 10) Risk management tools for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations,	A decision support model, a support tree Tools for risk management generally	Yes Yes	Decision support tree for authorities was not considered very useful, instead two reports describing the risk assessment approach and management options were produced, both can be found in web pages
Action 4: 11) Guidelines for the sustainable exploitation of aggregate resources in areas with naturally elevated concentrations of arsenic 12) Operation manual for authorities at municipal and regional levels	Guidelines: report or handbook Guidelines, manual for authorities	Yes Yes	Executed as web pages in the project web site, results will be seen After LIFE. A guide book that serves both the authorities and the producers, results will be seen After LIFE

The original project objectives and work plan were executed on schedule and according to the Grant Agreement.

Effectiveness of dissemination activities was evaluated in Mid-term phase of the project at the beginning of 2013. Communication during the ASROCKS project between beneficiaries, stakeholders and aggregate producers has been based on the project web pages and e-mail conversation. In addition, seminars, workshops and meetings have been arranged. The web pages have been supplemented with an extranet, where the beneficiaries have been able to read and download project's documents from. To evaluate the dissemination of information during the first half of the project, a questionnaire was sent to the stakeholders and the aggregate producers via Webropol. The results showed that the dissemination was successful. The general public was informed in the national media; radio, television, newspapers and web. The project's web pages, excluding the extranet, are open for general public. Evaluation of dissemination is reported as a deliverable (http://projects.gtk.fi/ASROCKS_ENG/project/deliverables.html).

5.4. Analysis of long-term benefits

During the project it appeared that ASROCKS is the forerunner in the world to develop guidelines for aggregate production in arsenic-rich areas even though regions with high arsenic contents in bedrock and soil have been reported in Europe, Asia and America. In some localities like Bangladesh high arsenic content in drinking water and rise have caused serious health problems.

The ASROCKS project found no problems in the studied aggregate production and construction sites in the Finnish demonstration area. Leaching tests showed that only a minor part of arsenic concentration was leached from rock, soil and aggregate products in surface water. In addition, arsenic content in dust was studied around one of the demonstration sites and the results showed that dust did not contain much of arsenic.

However, there are areas with higher arsenic content compared with the Finnish demonstration area especially in the Middle and Southern Europe. Therefore, the outcome of the ASROCKS project can be of importance for population health in certain localities in Europe and some other parts of the world. The guidelines and sampling and analytical procedures developed in the ASROCKS project can be modified and applied in other countries. The networking and dissemination of the ASROCKS results were a vital part of the project. In Europe, networking with other projects included a Road Show to Slovakia, Sweden and Germany.

<u>The highlights of the project are:</u>

1. ASROCKS developed the guidelines for sustainable aggregate production and construction for arsenic-rich areas, to our knowledge as the first in the world.
2. The guidelines can be modified for other countries with high arsenic levels in soil and bedrock.

3. ASROCKS was the first project in the world to investigate and develop risk management tools for arsenic in crushed rock aggregate and construction industry.
4. The methods used for the development of the guidelines were innovative: close cooperation, workshops and continued discussions between various stakeholders, companies, authorities and researchers.
5. Research institutes, universities, regional and national authorities, companies and other stakeholders participated in the project activities from the kick off meeting to the final seminar and the close cooperation will continue during the After LIFE phase.
6. Arsenic is a carcinogenic substance. People can be exposed especially via drinking water, crop and dust.

Key deliverables and outputs of the ASROCKS project include:

- The Guidelines were published in Finnish both as a printed volume and in the internet and distributed to all stakeholders and authorities.
- The Guidelines are available in English in the internet and were presented in numerous conferences and workshops in other parts of Europe for researchers, authorities and companies, and After LIFE, during fall 2014, for the European Aggregates Association and for the scientific community in a conference in Asia.
- Instructions for sampling, leaching tests and chemical analyses were compiled, based on comprehensive studies and comparison of different procedures and methods.
- The Layman's report was published as a comprehensive hard-cover book in Finnish. The book was sent to all municipalities and public libraries in the demonstration area and other areas with elevated arsenic content in soil and bedrock in Finland. After LIFE, the book will be distributed free of charge in various meetings and workshops in Finland.
- The English version of the Layman's report can be downloaded from the project web-pages and from Research Gate as well. After LIFE, the printed volume has been distributed in conferences and meetings abroad.
- Numerous reports and maps have been produced for different subtasks of the project (please see pages 21-22 in the Layman's report, English version).

5.4.1. Environmental benefits

Relevance to the EU legistive framework

The guidelines established in the ASROCKS project promote the risk assessment and management of the potential adverse environmental effects caused by natural arsenic at rock aggregate production, soil extraction and constructions sites. It therefore serves the objectives of the **Thematic Strategy of the Soil Protection (COM(2006)231)** and the **Water Framework Directive (2000/60/EY)** , and protection of the environment in general (please see chapter 5.2.4.3. above for more details).

CE marks of products

The guidelines of ASROCKS increase the permitting authorities' understanding of the environmental impacts of aggregate production and construction with the information on the tools to control and manage the risks related to arsenic. **The need for informing the total amount of arsenic in products' CE-marks or in the declaration of performance** may be needed in the future in certain end uses of aggregates in Europe.

5.4.2. Long-term benefits and sustainability

Benefits for the LIFE + Environment Policy and Governance

ASROCKS project opened a new challenge waiting to be solved: risk management of arsenic in construction and aggregate production industry.

Long-term social benefits

If the potential arsenic problem in aggregate industry and construction will be solved, the risks to population health will be evaluated and controlled.

Continuation of the project actions by the beneficiary or by other stakeholders

- The ASROCKS website will be available at least until 2019. Deliverables of the project will be available for industry, authorities and for general public free of charge. "Guidelines" subpages will be updated on a regular basis. The website of the ASROCKS project is linked to the website of the Coordinating beneficiary GTK. Therefore, the web pages will be taken care of by the web page administrator of the Geological Survey of Finland.

- The guidelines developed during the ASROCKS project may be implemented into regulations of environmental authorities in Finland and other EU countries.

- The results of the ASROCKS project will be presented in conferences and scientific publications are in preparation.

- The results of the ASROCKS project will be applied in the regional plan of the Tampere region in determining areas appropriable for exploitation of crushed rock aggregates.

- GTK, TTY and SYKE are eager to continue investigations and demonstration activities with arsenic-rich aggregate products. Cooperation with other European countries will continue.

Replicability, demonstration, transferability, cooperation

There are areas with higher arsenic content compared with the Finnish demonstration area especially in the Middle and Southern Europe (please see Fig. 14 above). Therefore, the outcome of the ASROCKS project can be of importance for population health in certain localities in Europe and some other parts of the world.

Best Practice lessons

The guidelines and sampling and analytical procedures developed in the ASROCKS project can be modified and applied in other countries.

Innovation and demonstration value

ASROCKS was the first project in the world to investigate and develop guidelines for arsenic in rock aggregate and construction industry. The methods used for the development of the guidelines were innovative: close cooperation, workshops and continued discussions between various stakeholders, companies, authorities and researchers. Research institutes, universities, regional and national authorities, companies and other stakeholders participated in the project activities from the kick off meeting to the final seminar and the close cooperation will continue during the After LIFE phase.

Long-term indicators of the project success

- application of the ASROCKS guidelines and other results for regulation etc. in Finland
- application of the ASROCKS guidelines and other results for regulation etc. in EU and other countries
- application of the ASROCKS instructions for sampling, leaching and analytical procedures in Finland
- application of the ASROCKS instructions for sampling, leaching and analytical procedures in other countries
- number of follow-up projects in EU and in other parts of the world
- number of publications of ASROCKS results
- number of citations to ASROCKS publications