Banking of data from monitoring of former mine sites in France

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Abstract

The important responsibilities incumbent upon the French State regarding post-mining are organised in a structured manner. The competent arm of central government (France's Ministry of Environment) deals with sovereign functions while other aspects are devolved to regional divisions. The operational aspects have been entrusted to BRGM which has created a special department for the purpose, the DPSM (Mine Safety and Risk Prevention Department).

The main duties of this department are: to act as principal agent for safety engineering works; for operations following expropriation; for surveillance of mining facilities under the Mining Code and Environment Code; and for management of the post-mining information system, including management of mining archives and support for mining intelligence.

Former mine sites monitored under the surveillance requirement comprise a varied range of elements: about 3,000 mine shafts, 5,000 mine entrances, 600 spoil heaps, 100 pumping and lifting stations, etc. These are subject to phenomena that need to be monitored via thousands of measurement and observation points: water levels and quality, CH_4 levels, pumping rates, etc.

The collection and storage of this information is a crucial question for the long- and medium-term study of the phenomena (rising water tables, methane levels in reservoirs, etc.). This is both a scientific issue (understanding the phenomena) and an economic one (optimising monitoring costs).

The means of instrumentation, often inherited from former mine operators, are multiple. The data are not all systematically made secure, nor long-term protected nor available to third parties (scientific community, government authorities, etc.).

To improve this situation, the DPSM has introduced a DATABANK initiative to set up a Post-mining Information System to collect and compile all of the technical information from monitoring. This project is based on three main functional axes: Harmonisation of the technical means of instrumentation (sensors, supervisors, etc.) for remote-acquisition, field data entry (via PDA type terminals); Setting up of a Distributed Geographic Information System based on a central databank on which all of the collected data converges, regardless of collection mode; Design of a scientific and technical reference system describing the monitored assets (all former mine sites, elements monitored, phenomena studied, etc.).

This presentation looks at the steps taken by the DPSM to set up the Information System and at the results, both to-date and expected at completion of the project.

1 The initial situation

The important responsibilities incumbent upon the French State regarding post-mining are organised in a structured manner. Sovereign functions are handled by the competent arms of central government while other aspects are devolved to regional divisions. The operational aspects have been entrusted to BRGM which has created a special department for the purpose, the DPSM (Mine Safety and Risk Prevention Department).

The main duties of this department are: to act as principal agent for safety engineering works; for operations following expropriation; for surveillance of mining facilities under the Mining Code and Environment Code; and for management of the post-mining information system, including management of mining archives and support for mining intelligence.

Acting on behalf of the state, the DPSM therefore manages the "the mining legacy" when former operators can no longer be traced. In fulfilling this duty, the department addresses technical problems of very different origins, depending on local circumstances. This diversity stems from history and from the wide range of technologies encountered from mining basin to mining basin and from extracted substance to extracted substance. Most former operators had data acquisition systems centralised at the level of a facility or mining basin. These means were, however, of the industrial type and, when they became too cumbersome to maintain as facilities closed, they were replaced by less costly equipment using conventional media for communication, thereby making data concentration more difficult. In addition, since the implementation of surveillance, a wide variety of sensors may be used for a single type of measurement. Controllers are of different makes and data are collected in different ways: automatic, semi-automatic or manual. There is also little or no centralisation of data collected.

In addition, managers of surveillance, tasked with drafting the reports that represent the deliverables required by administrative departments, obtain data via a range of channels (sub-contractors in charge of facilities, colleagues) in a variety of forms (hardcopy, pdf file, Excel file, etc.). Data are often re-entered locally to allow correlation between them and to provide coherent analyses to the requiring parties. This is laborious work and the results often remain on agents' desks, with no benefit for the DPSM.

The difficulties in accessing information and lack of analytical tools do not encourage effective use of data or scientific enquiry. In addition, the data communicated to administrative bodies often lack value-added: a groundwater level may be at a given value, but how does that relate to other measurement points? How is the groundwater level behaving, what is the trend? What is the phenomenon being observed? How can we explain it? Does it correlate with other information (e.g. meteorological data)? Should we develop mathematical models for better understanding of the observed behaviour?

2 A post-mining information system

The DPSM is tasked, amongst things, with the management of a post-mining information system and is very aware of the importance of sound management of post-mining data to underpin the department's other missions.

In fact, DPSM has been confronted with the diversity of information, of documents and of existing databases since the start of its mission. It has built an infrastructure allowing overall centralisation and federation of the existing elements.

The first action was to create a website (http://dpsm.brgm.fr) with several important features:

- An Internet function (institutional site) relaying information to the general public and providing information on the department's missions, programmes and activities as well as on its work and results obtained.
- An Intranet function enabling DPSM agents to share information in their daily tasks.

- An Extranet function allowing others involved in post-mining (ministries, regional authorities, etc.) to obtain relevant information and data.

Amongst the main features of the website is a site map giving access to a body of information contained in geo-located databases and to a collaborative area allowing file sharing between post-mining stakeholders.

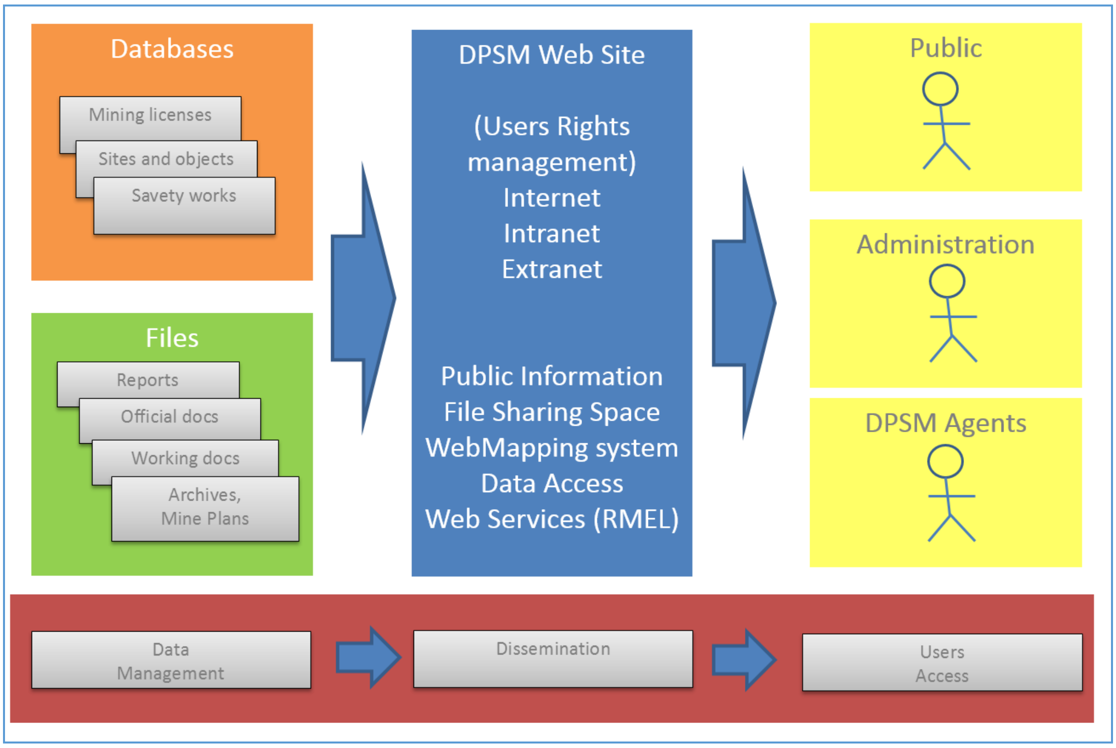

Figure 1: DPSM Web Site

The fields currently covered by the DPSM website are as follows:

- Mining licences: this base contains the licences (exploration, operation, concessions) relating to facilities and works or to technical archives. It records the technical and administrative aspects of the licences (substance sought or extracted, latest holder, administrative situation, scope, etc.).
- Surveillance: this base records the facilities under surveillance as required by France's Mining Code and Environment Code and gives brief descriptions of the their management, operation and maintenance and of the requirements applying to them.
- Works: this base provides description of the safety engineering work managed by DPSM on former mine sites, both scheduled in its annual programme or undertaken in the event of an emergency when problems are observed that require urgent intervention. The base records the nature of work performed, the place, the actors and the schedule of operations, etc.
- Technical archives: under an agreement with France's national archive department, the DPSM is responsible for collection, storage and provision of access to the technical records produced by public mining companies when they close. Each batch (box, document set or tube) is the object of an identifying data sheet.
- Mine plans: this base, linked to the archives, contains the main characteristics of plans drawn up by operators and used by DPSM in its post-mining mission. Many of these have been scanned and are downloadable.

This first step in data federation, extending over the first five years of the DPSM's activity (2006–2011), enabled grouping of access to the existing elements without profoundly changing their nature. The DPSM website provides access and dissemination to different actors. This work was performed essentially by retrieval of existing elements when the initial situation of the data allowed.

However, if there is one subject that could not be integrated during this first stage it is that of observations and measurements from surveillance. Solutions were considered against the diversity of technical means of collection and of the associated human organisation.

3 - Organisation of collection of observations and measurements

Beyond "descriptive" information, the operation or surveillance of facilities such as water pumping stations, treatment plants or mine water monitoring produces large amounts of data from observations and measurements. Historically, this information was collected by official agents who processed it to draft the legally required reports constituting the official deliverables required of operators by the administration.

The initial data therefore remain scattered over agents' workstations, unexploited and therefore often impossible to disseminate or to be used by other parties (for example for scientific research).

To remedy this situation, the DPSM aims to create a single databank (LTDB) on which all of the collected information will converge, whether from measuring instruments (water levels, CH_4, etc.) or observations (condition of a pipe, flow in an outfall, etc.), whether collected automatically or recorded visually and whether uploaded automatically or transferred manually.

The ideal situation is a measurement point with automatic data transmission but, naturally, this is not always possible for reasons of cost and availability of communication networks.

In general, data are routed as shown in the figure below.

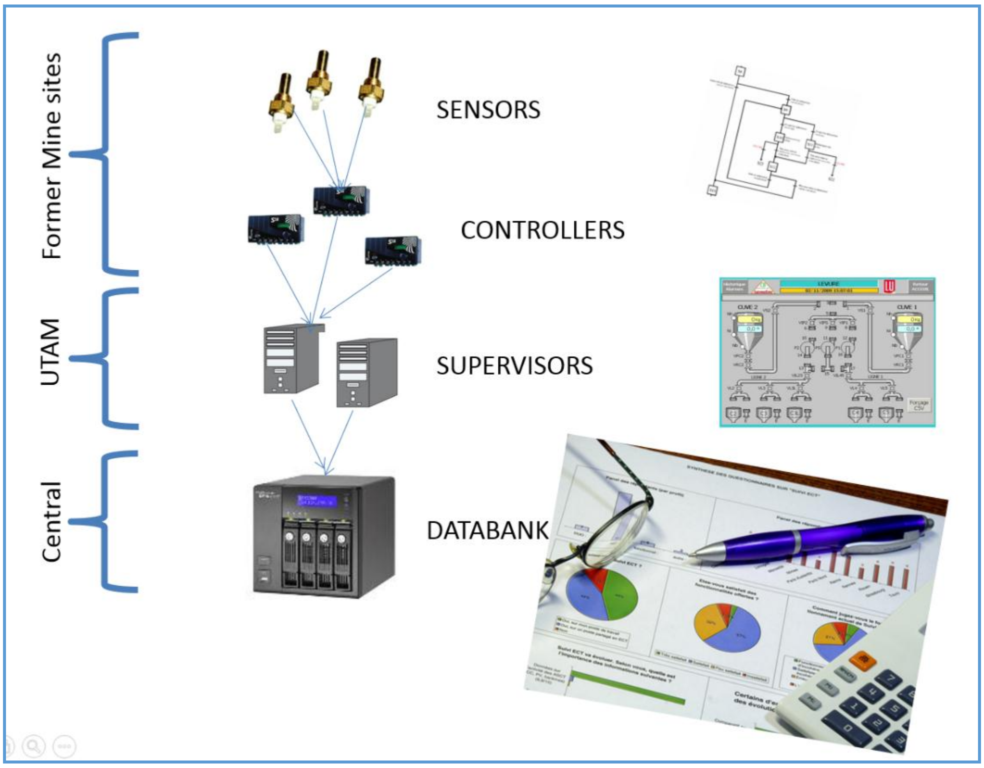

Figure 2 : Dataflow from the sensor to the databank

At site level, sensors are connected to controllers ensuring local storage. When resources permit, these data can then be transmitted to a supervisor, providing each UTAM (territorial post-mining unit) with real time display of the sites for which it is responsible. And lastly, all of the data are deposited in a storage databank, ensuring their long-term safekeeping and availability for analysis.

The table below gives an indication of the number of sites monitored and the number of variables (measurement points).

Table 1 Indicators

Item	Number of instances
controllers in place	**150**
automatic variables (T°, CH_4, etc.) (transmitted and stored into the databank)	**5000**
manual variables (collected and uploaded into the databank)	**12000**

A special effort was made to equip the monitored sites with automatic means, even if the majority of variables are still obtained via human observation in the field, or from manual reading of measurements.

As a complement to this effort on instrumentation, and in the interests of simplified management, the existing technical means were standardised. The automatic devices now consist of only one model of controller and supervisor. Similarly, manual means of collection have been centred on use of clearly identified PDAs.

This standardisation of the technical resources was a crucial step in the evolution of the DPSM Post-mining Information System. It opened the way to centralisation of observations and measurements in a single databank.

Although convergence of observations and measurements in a single bank constituted a major advance that was completed in 2014, it also revealed that, if full benefit is to be gained from the data, the observations and measurements should be used in conjunction with well-defined and structured elements. This was not really the case with the initial databases, often limited to simple lists of objects with no relational links between them. It was in this context that a data modelling initiative was launched.

4 – Data modelling: towards a more integrated approach

After the steps federating and disseminating existing information, the DPSM organised the means for collection of observations and measurements from former mining sites. The problem then arose of restructuring of the data (data modelling) so as to be more in tune with the department's missions.

One of the information management issues encountered by the DPSM was to shift its logic from a focus on (operators') legal obligations to a more sustainable logic that will ensure long-term monitoring and comprehension of phenomena as well as encompassing environmental, social and economic aspects.

For example, although a legal obligation may simply require recording of a water level and its transmission to the competent authority, the DPSM should also integrate the history of these values, clearly identify what is observed (groundwater), analyse the trends, describe the phenomena observed and, in so far as possible, anticipate the short-, medium- and long-term consequences in the light of the current situation.

With this approach, it is sometimes necessary to define models (geological, hydrogeological, economic, etc.) to improve understanding and to develop the surveillance system to obtain better comprehension, etc.

Initially, databases were designed individually to enumerate certain entities without any real structuring. They do not therefore provide the desired support for daily management and do not advance scientific understanding of phenomena.

The new data model must encompass different aspects of surveillance, inter-relate different entities and answer scientific and technical questions such as:

- Why is object O under surveillance?
- How many objects are monitored for a heating phenomenon?
- How is groundwater G monitored?
- To which aspect of surveillance does my instrument I contribute?
- How many variables are observed for waste heap H?
- What is the historical background to groundwater level Z?
- Which objects are monitored under the Environment Code?
- What archive material do we have for well W? What drawings?

This new model must also establish a link with data for work organisation and management.

- How many operations have been carried out on concession C since year Y? For how much?
- What is the background on visits to site S? Latest report? Scheduled date for next visit?
- Which is the transfer file for facility F? Which is the latest version and what is its background history?

It was with the aim of providing answers to such arising questions that a new conceptual framework was proposed.

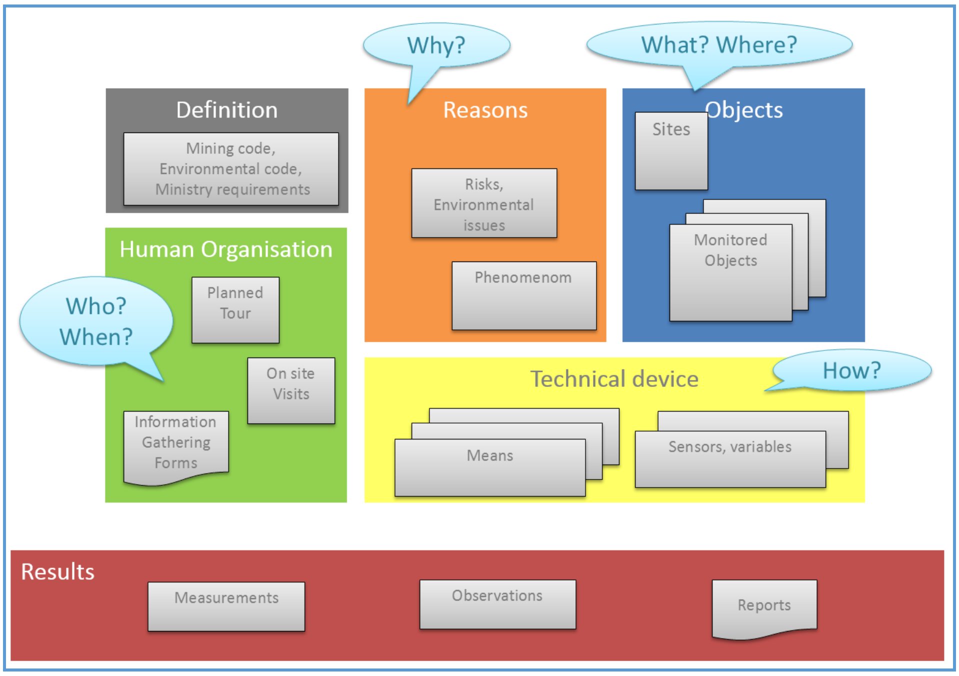

Figure 3: Informational new conceptual framework

Definition: surveillance is defined in Prefectorial Orders that enumerate the elements to be monitored by the DPSM. Surveillance ensures compliance with the Mining Code and the Environmental Code which provide the legal framework.

Reasons for surveillance: issues and hazards are identified to establish risks, and the phenomena to be monitored (rise in water table, heating, collapse, etc.) are stipulated.

Objects under surveillance: waste heaps, shafts, pumping stations, etc. are examples of objects under surveillance. Categories of types of objects are established. Each object is geo-located and described in terms of its type.

Human organisation: surveillance relies partly on human organisation. The agents organise rounds of site visits. They collect data and information that are subsequently entered into the information system.

Technical device: the technical resources (piezometer, inclinometer, etc.) used for surveillance must be clearly described. They constitute the points of measurement or observed variables.

Results: the results of surveillance are given formal expression in surveillance and site visit reports. These documents are drafted on the basis of on-site observations and recorded measurements.

The aim of the data modelling exercise is to provide structured information. For the different entities, it will provide sets of data sheets (complete, summarising, emergency management, etc.) and will, primarily, allow dynamic querying of the system to obtain answers to a variety of questions that will be of help with daily surveillance or scientific work.

Software tools, dedicated for use by the different actors, are being developed and remain to be produced from 2015 onwards. The value-added from these tools depends, of course, on the relevance of the concepts modelled, but also on the careful design of user interfaces. To ensure this, they will be based on a methodology established to, on the one hand, underpin the logic behind the organisation of work and to, on the other hand, ensure effective entry of the necessary data and information into the system.

5 – Data banking: towards a methodological basis

A large part of the DPSM's surveillance activity relies on human intervention. The information system, if it is to be understood and accepted by actors, must be in tune with their daily work and must clearly be of service to them. This will only be possible if the system is well supplied with relevant information and data. As the agent entering data into the system is not necessarily the person who will benefit from it, it is necessary, in terms of data banking, to clearly define "who does what, when and how". This banking methodology must be given formal expression and must be fully integrated into the overall surveillance management framework, so as to be a task that is clearly identified in actors' minds.

The surveillance life cycle can be represented schematically as a series of steps, as shown below:

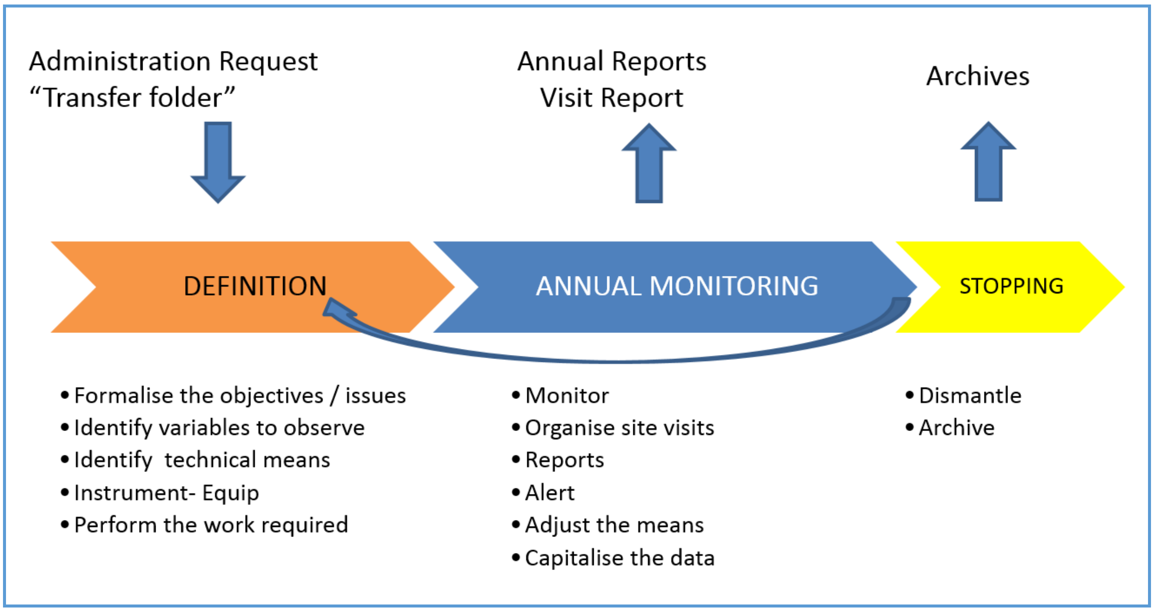

Figure 4: Surveillance life cycle key stages

The **definition phase** for surveillance is the most important one as it allows the reasons for the surveillance to be identified, a conceptual model of the phenomenon monitored to be developed, and the means of surveillance to be defined and put in place. From the site instrumentation and data banking standpoints, it allows the following questions to be answered clearly: what are the variables to be observed, with what frequency and with what degree of accuracy? How will the information be gathered?

The **monitoring phase** is an iterative process generally organised on an annual basis and within which field visits must be organised, the gathered information capitalised upon, the situation with regard to forecasts analysed and, if necessary, the established models and means of surveillance adjusted. The deliverable from these activities is generally a document of the "annual surveillance report" type. For various reasons relating to system evolution, it may be necessary to adjust what was established when defining the surveillance or even to terminate it.

Within the annual cycle, each site visit must be prepared in advance, to ensure that subsequent uploading of data to the databank is effective.

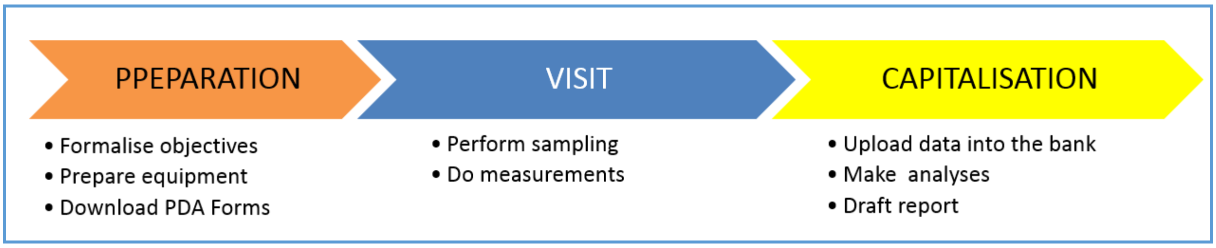

Figure 5: Organisation of a mine site visit

In the preparatory phase for a site visit, in line with the models developed, an idea should be framed of what will be found on site in terms of evolution of phenomena. For each measurement, agents go to the site with the latest values obtained (background history) and with an idea of the new value expected. Measuring instruments and data gathering means will be clearly identified. Once on site, the work is carried out. Data gathering is made easier by the use of electronic forms that can be used on-line (i.e. when there is an Internet connection) or off-line. In the latter case, the documents are loaded into a PDA when preparing the site visit, to be uploaded to the observations and measurements databank at the capitalisation stage.

The **stopping phase** comes as the result of a decision made jointly with the relevant administrative authorities. From the data banking point of view, all of the data must remain accessible but must be fixed and archived in compliance with the obligations and rules of the establishment.

This methodological aspect of data banking will be fully integrated into the overall surveillance methodology and, for each instance of surveillance, will be the responsibility of the person in charge (i.e. project manager).

Conclusion

Almost from its inception the DPSM was aware of the importance of effective management of post-mining information and equipped with the necessary resources to address the diversity of existing situations and to prepare for future issues.

In an initial period, between 2006 and 2011, the focus was on convergence of existing elements belonging to the different former operators. The creation of a databank for all of the observations and measurements arising from surveillance also came under consideration. By 2013 this thinking enabled identification of the avenues to be explored in terms of IT and technical resources, and also in terms of structuring of the data describing the mining heritage under surveillance. The data modelling exercise, concentrated mainly in 2014, identified the basic concepts (sites, phenomena monitored, variables, measurement, etc.) that provide the static description of the elements under the DPSM's responsibility and which are the corner stone of the information system.

The resulting new applications, developed for the various actors involved in surveillance, will be founded on methodological bases for surveillance management that will not only foster acceptance of the applications but will also ensure effective banking of the data. The first applications, to be deployed in 2015, cover the description of the heritage to be monitored, the associated surveillance and the link between all of the banked data.

Development of the DPSM Information System is already enabling more effective data gathering and better dissemination. In the future it will better address structuring of the descriptive, operational and scientific aspects, thereby providing the DPSM with more efficient post-mining management tools allowing the department's staff to focus on higher value-added tasks.