DEVELOPING A COMPREHENSIVE CONCEPTUAL SITE MODEL: GETTING THE MOST OUT OF YOUR SITE HISTORY

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Investigating site histories and gathering site characterisation data are integral parts of the environmental site assessment process – but how should we interpret and use the information?

For a start, the information should be integrated and presented as a conceptual site model (CSM). According to ASTM International E1689-95 (2008) *Standard Guide for Developing Conceptual Site Models for Contaminated Site*s, a CSM is 'a written or pictorial representation of an environmental system and the biological, physical and chemical processes that determine the transport of contaminants from sources through environmental media to environmental receptors in the system'.

The development of a CSM comprises an iterative process of characterising site contamination on the basis of available information or data. It should be undertaken for every contaminated site, developed as early as possible within the site assessment program and progressively updated as additional information or data become available.

A preliminary CSM can, and should, be developed prior to the commencement of any intrusive site investigations. This can be undertaken as soon as an understanding of the physical layout (both current and former) of a site, as well as its historical land-use information, has been obtained, and should ideally form part of the initial site history review (also see *Developing a Comprehensive Conceptual Site Model: what should you be looking for, and where?* Remediation Australasia, Issue 8). Although its complexity will be at least partly dependent on the scale and complexity of the site, each CSM should address several fundamental areas, as outlined in this article.

Site definition and background information

The first step is to gain an understanding of current site conditions and establish:

- the boundaries of the study area, including consideration of impacts from off-site sources
- local physical characteristics, including topography, geology, hydrogeology, surface drainage patterns and possible preferential underground contaminant migration pathways
- current land-use activities for the site and immediate surrounds, and
- the location, extent and nature of existing infrastructure.

The history of the site and immediately surrounding area should be summarised, along with the ways in which site use and infrastructure have altered over time.

Since the definition of site contamination is linked to land use (e.g. residential, industrial or recreational), it is essential to consider future site development. This includes proposed site earthworks and features such as cellars, basement car parks and swimming pools that could be affected by, or could have an influence on the management of, subsurface contamination.

Sources of contamination and contaminants of potential concern

Based on an understanding of current and historical site conditions, potentially contaminating activities (PCA) can be identified and likely source areas and contaminants of potential concern (COPC) determined. A CSM should define source areas as accurately as possible, consider implications for both on- and off-site impacts, and determine the environmental media (e.g. soil, groundwater, surface water, sediments) that may have been affected. The identification of COPC, and their possible implications for the contamination of a site or its immediate surrounds, should take account of factors such as:

- the timing and duration of the identified PCA
- the period of use of any possible associated chemicals (i.e. when they were first developed and/or when their use ceased relative to the timing of the PCA), and
- the likely behaviour (e.g. mobility and persistence) of each chemical within environmental media.

Sensitive receptors

The identification of possible sensitive receptors associated with the site and the surrounding area should include both current and future receptors, the latter comprising proposed land-use activities as well as the actual site development process.

Possible human receptors may include:

- current or future site users such as residents, visitors and workers (depending on land use)
- on- and off-site construction or maintenance workers
- current or future users of surrounding residences, reserves, and commercial or industrial premises, and
- hydraulically down-gradient groundwater users who extract groundwater for purposes that could have implications for human health (e.g. potable/domestic, primary contact recreation, irrigation of home-grown produce).

Possible environmental receptors may include:

- surface water bodies located on or near the site
- groundwater environments beneath, or in the vicinity of, the site
- hydraulically down-gradient groundwater bores used to extract groundwater for purposes that could affect the environment (e.g. parkland irrigation, stock watering), and
- flora and fauna that may inhabit or migrate through the site.

Migration pathways and exposure routes

For a source to be of concern, a mechanism for contaminant release into environmental media must be present (e.g. leakage from an underground fuel storage tank into surrounding soils). Likewise, for a risk to human health or the environment to exist, we need a source, a contaminant release mechanism and a receptor as well as a migration pathway that allows the COPC to move from the source to the receptor and a point of contact between the COPC and the receptor (i.e. an exposure route). Together these factors make up an exposure pathway, which must be complete for risk to occur.

Possible migration pathways may include:

- leaching of contaminants through the soil profile to groundwater
- downward migration from one groundwater aquifer to another
- transport of contaminants via groundwater to surface water
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- volatilisation from soil and/or groundwater to air (indoor and outdoor)
- transport of contaminants by mechanical disturbance (e.g. earthworks), and
- biomagnification along food chains.

Possible exposure routes may include:

- direct contact (e.g. skin exposure) with contaminated environmental media
- ingestion of contaminated environmental media or

- ingestion of food stuffs grown or reared in contaminated media, and
- inhalation of contaminated media (e.g. vapour, dust).

In some cases a good CSM can eliminate the need for additional investigations if it shows that exposure pathways are incomplete.

Attempting to explain a CSM in words may be difficult and can also be open to misinterpretation by the reader. A figure illustrating the site setting and key contaminant migration mechanisms is a critical element of any conceptual model and represents a powerful tool for interpreting and conveying site information. If you cannot draw a conceptual model for your site, it is likely that you do not understand it.

In summary, a CSM is a highly beneficial tool that provides a foundation for the evaluation of human health and environmental risks. Furthermore, by identifying data gaps, CSMs can help users determine any additional investigation requirements. They can also assist with the development , or evaluation, of remediation or management strategies. Equally as important, CSMs facilitate communication of site contamination issues with a wide range of stakeholders, including the public.

As stated in ASTM International E1689-95, ‘a CSM should be used to enable experts from all disciplines to communicate effectively with one another, resolve issues concerning the site and facilitate the decision-making process’.