Field Demonstration of Steam Enhanced Extraction at Alameda Point, California

Kent S.Udell, Professor, *University of California, Berkeley, California*

Gorm Heron, MSc Engineering, *Steamtech Environmental Services*

Tom Heron, geologist/Head of Department, NIRAS A/S

1. INTRODUCTION

In spring and summer 1999 US Navy carried out a full scale Steam Enhanced Extraction (SEE) project on the former Naval Air Station, Alameda, Alameda Point, San Francisco.

The site was contaminated with chlorinated solvents and oil products caused by a leakage from a waste oil tank buried on the site. The extension of the contamination was relatively moderate, and the US Navy wanted a technology demonstration with SEE to document the effect of the method.

The remediation was conducted by Berkeley Environmental Restoration Centre (BERC) lead by professor Kent S. Udell and MSC Engineering Gorm Heron. SteamTech Environmental Services supplied and operated the steam injection- and extraction system. Geologist Tom Heron, NIRAS participated in the various phases of the project.

2. SITE CHARACTERIZATION

At previous investigations and as a part of the steam remediation project, detailed investigations of the geological, hydrogeological and contamination conditions were carried out on the site. The investigation techniques used included: CPT, Laser Induced Fluorescence, GeoVis, GeoProbe/MIP, soil cores, ground water samples and soil vapor samples. Figure 1 shows an overview of the site with monitoring points, the identified NAPL zone and the treatment well layout.

2.1 *Geology and hydrogeology*

The contaminated area is paved with concrete slabs and asphalt. Under the paving 1.5 m of sandy, silty filling is found. From 1.5 – 4.0 m.b.g. the soil consist of fine-grain, silty sand. In all wells a clay layer is found from 4.0 to 4.2 m.b.g. The clay is underlain by bay mud down to al least 6.5 m.b.g. The secondary aquifer is unconfined and located in the upper sand layer. The water table is approx. 1.7 m.b.g.

2.2 *Contamination*

The area contaminated with residual NAPL is shown in Figure 1. The NAPL consists of a mixture of TCE and diesel/motor oil and has a density lower than that of water. The source of the contamination is a former under ground waste oil tank.

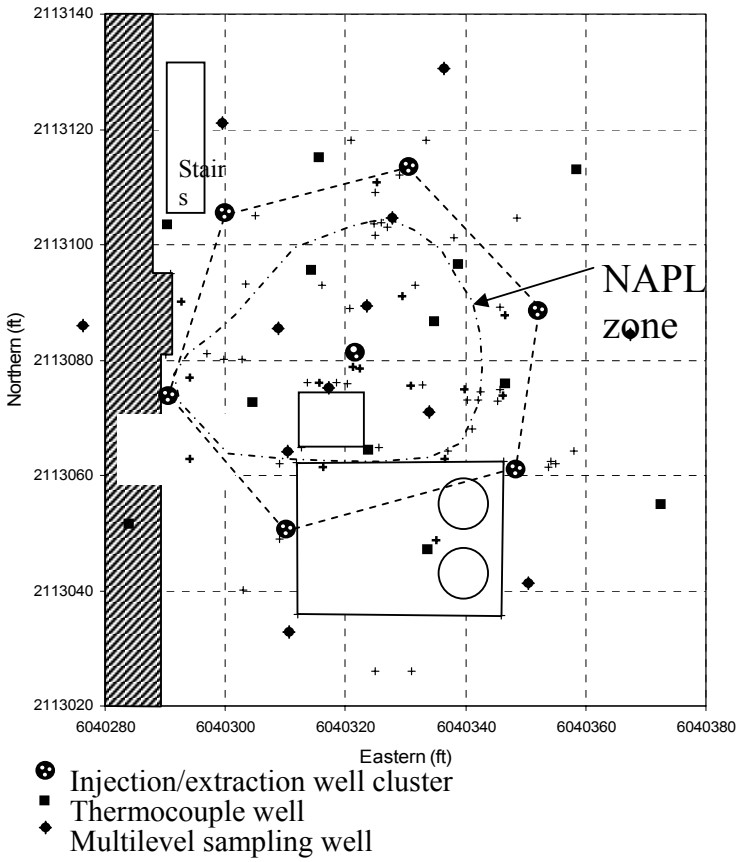
3. REMEDIATION STRATEGY

Steam was injected in two different intervals in 6 injection wells located out side the NAPL zone, as shown in Figure 1. From the central extraction well ground water, soil vapor, steam and volatilized contaminants were extracted.

The remediation strategy was to encircle the areas with residual NAPL with a “donut” of steam and hereafter mobilize the contamination towards the extraction well in the centre of the source area. After 50 days steam

temperatures were reached in most of the source zone and apparently all NAPL had been removed. Then the system was run in a cyclic mode for a duration of 20 days. The pressure cycling has been shown to dramatically reduce the dissolved contaminant concentrations.

Figure 1. Site plan with monitoring well, NAPL zone and treatment well layout. Each square is 20 by 20 feet (6 by 6 m.).



4. RESULTS AND PERSPECTIVES

From thorough investigations it was estimated that the total volume of NAPL at the site was 400 l. During the SEE demonstration 2,300 l of NAPL were removed. 84 % was removed as a separate phase. Table 1 show preliminary results of soil and ground water samples.

	Before SEE demonstration	After SEE demonstration
TCE in the groundwater (mg/L)	10-500	0.000-0.050
TCE in soil samples (mg/kg)	500-3,000	0-10
Total oil in soil samples (mg/kg)	Up to 20,000, in average 2,500	<2.000 in all samples, in average 100
Total quantity of contamination (kg)	2,000	<200
Contamination signature	Chlorinated solvents, diesel/motor oil	Heavy motor oil

Removal of more than 95% of the contaminated mass and more than 99% of the volatile constituents was achieved at the demonstration. Steam Enhanced Extraction is considered to be an extremely efficient method of quick removal of NAPL from source areas.