Rocketts Landing, Richmond, Virginia, USA, brownfield redevelopment under voluntary remediation

DAVID M. SAYRE[1] & AHMET BULBULKAYA[2]

[1] *Virginia Geotechnical Services, P.C. (e-mail: dmsayre@vgspc.com)*
[2] *Virginia Department of Environmental Quality. (e-mail: aebulbulkaya@deq.state.va.us)*

Abstract: The village of Rocketts Landing is a mixed-use commercial and residential development on neglected industrial property along the north bank of the James River in the City of Richmond and Henrico County, Virginia. The site has a history of various commercial and industrial uses since a ferry was established in 1730. In 1999 a real estate development company, Rocketts Landing, LLC, assembled a professional team to begin due diligence investigations and property acquisition. Environmental impacts from past industrial and commercial uses were a primary consideration in project planning and design. Renovation and construction activities began in the spring of 2005 and are specifically designed to address environmental impacts from past uses.

Rocketts Landing, LLC launched the project as a real estate venture to gain control of six parcels of land totalling 20-hectares. The professional team addressed due diligence, preliminary design, and real estate issues. Environmental design for the project began with risk management activities including Phase I and II Environmental Site Assessments (ESAs) and Site Characterization and Remediation Plan development under the Virginia Department of Environmental Quality's Voluntary Remediation Program. Phase I and Phase II ESAs were completed on six separate sites. The professional team worked closely with regulators in the Voluntary Remediation Program to produce a Site Characterization, a Risk Assessment, and a Remediation Plan that met program requirements and allowed for cost effective development. Innovative sampling, risk assessment, and remediation design strategies were proposed and approved.

In 2004, WVS/Rocketts Landing Construction Management LLC acquired the real estate and began final design of the project. Construction of infrastructure followed by vertical construction is scheduled to begin in 2005. Remediation activities will be completed during the construction phase on a block-by-block basis so that occupancy can be achieved prior to remediation of the entire 20-hectare site.

Résumé: Le village de Rockett Landing se caractérise par un développement à la fois commercial et résidentiel des propriétés industrielles négligées le long de la rive nord de James River dans la ville de Richmond et du comté d'Henrico en Virginie aux Etats-Unis. Le site présente un passé comprenant différents usages commerciaux et industriels puisqu'un ferry y fût établi en 1730. En 1999, une agence spécialisée pour le développement de l'immobilier, Rocketts Landing LLC, a mis en place une équipe de professionnels pour démarrer des recherches assidues et procéder à l'acquisition de propriétés. Les impacts des usages industriels et commerciaux sur l'environnement consistèrent un paramètre primordial dans la phase de planning et de conception du projet. Les activités de construction et de rénovation ont démarré au printemps 2005 avec comme principal objectif de corriger les impacts sur l'environnement liés aux utilisations passées.

Pour démarrer ce projet, Rocket Landing LLC lança une fusion immobilière afin de gagner le contrôle de six parcelles, soit plus de 200 000 m^2. L'équipe professionnelle mise en place pour l'occasion a su faire preuve d'assiduité et de professionnalisme concernant tous les problèmes liés à l'immobilier et également lors de l'élaboration des premiers plans et dessins. Les plans concernant l'environnement ont démarré avec des activités de gestion des risques, notamment en Phase I et II des Evaluations du Site Environnemental (ESAs) ainsi que lors du développement du Plan de Remédiation et des Caractéristiques du Site, conformément au Programme de Remédiation Volontaire du Département de la Qualité de l'Environnement de l'Etat de Virginie. Les ESAs des Phases I et II furent complétées sur six sites distincts. Les équipes ont travaillé en collaboration avec les régulateurs du Programme de Remédiation Volontaire afin de produire une Caractérisation du Site, une Evaluation des Risques et un Plan de Remédiation qui satisferaient les attentes du programme tout en laissant une marge pour le développement des coûts liés aux opérations. Toutes les propositions, notamment les échantillons innovants, l'évaluation des risques ainsi que les stratégies des différents plans de remédiation, furent acceptées.

En 2004, Rocketts Landing Construction Management LLC a racheté l'agence immobilière et se lança dans la concrétisation du projet. Les activités de démolition et de rénovation de nombreux sites historiques sont en cours. La construction des infrastructures suivie d'une construction verticale est prévue pour 2005. Les activités de remédiation seront terminées durant la phase de construction sur une base de bloc par bloc afin que les habitations puissent être achevées avant la remédiation de l'ensemble des 200 000 m^2.

Keywords: site investigation, risk assessment, remediation.

INTRODUCTION

Developers of The Village of Rocketts Landing in Richmond, Virginia are transforming several derelict industrial sites (Figure 1) on the banks of the James River (Figure 2) into a "new urban village" similar to many European communities. The project will be a high-density blend of residential buildings, office space, specialty stores,

restaurants, and a green recreational area along the river's edge providing public access to the river. This contrasts with recent historical trends in the United States where zoning requirements have separated residential and commercial development resulting in urban sprawl. The high-density of structures is an integral component of the innovative remedial solution where hardscape serves as the primary barrier to disrupt human exposure pathways to site contaminants. A team based approach involving the owner, professional design consultants, and local and state government officials was critical for project success. Construction is underway with a scheduled build-out of ten years. The project developer is initiating preliminary feasibility investigations on multiple adjacent parcels that would double the project area and extend the development schedule.

Figure 1. The Village of Rocketts Landing site is mostly abandoned industrial property with previous environmental impacts.

Successful redevelopment of the site is possible due to changes in environmental regulations in the past 10 years. The site is being remediated with the concurrence of the Virginia Department of Environmental Quality's (DEQ) Voluntary Remediation Program (VRP). The VRP program was the result of 1995 legislation by the Virginia General Assembly. The purpose of the VRP is to encourage hazardous substance cleanups that might not otherwise take place. The program is a streamlined mechanism for site owners or operators to voluntarily address contamination at sites with concurrence from DEQ. Sites are eligible for participation in the VRP program only if they are not regulated under other programs or jurisdiction is waived. After satisfactory completion of remediation, DEQ will issue a certificate of completion. The certificate carries immunity from prosecution under State law.

This paper details the impacts of past industrial and commercial activity on the development and construction process. We discuss the site history, site characterization, risk assessment, remediation plan development, and initial construction process.

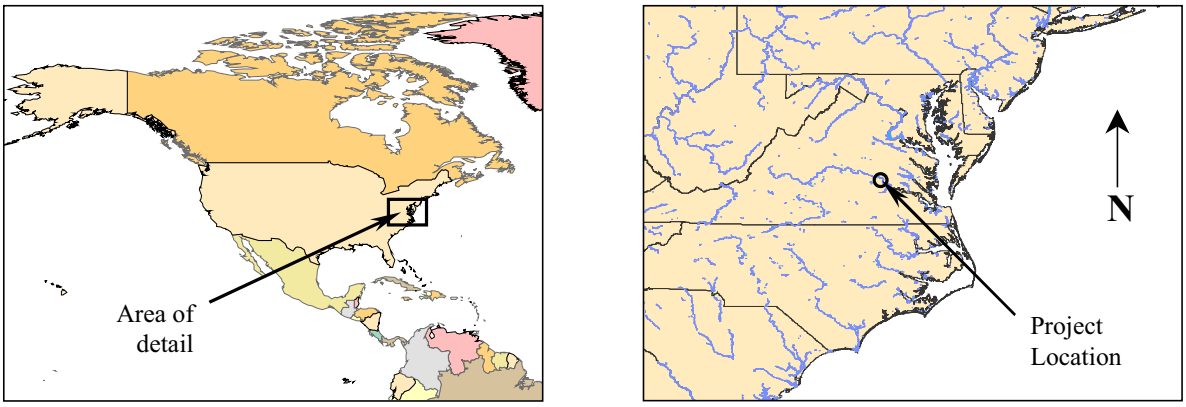

Figure 2. Site location

SITE BACKGROUND

The project site is located in the Fall Zone, an area of overlap of the Coastal Plain and Piedmont Physiographic Provinces of Virginia. The Coastal Plain is characterized by unconsolidated marine to fluvial sediments generally increasing in thickness towards the Atlantic Ocean to the east. The Piedmont is characterized by low, rounded hills composed of saprolitic soils overlying folded metamorphic and igneous bedrock.

The recorded history of Rocketts Landing began four hundred years ago when British explorers sailing the James River from Jamestown were halted by the falls. The falls remained a major obstacle to the transportation network for two and a half centuries. William Rocketts established a ferry at the site in 1730. Rocketts Landing became Richmond's first deep water landing as ocean going vessels transported people and goods to and from this inland port. Rocketts Landing was described as a busy port by 1773 when the population of Richmond was 600. Industrial development began with rope making, tobacco warehousing, and taverns documented from 1776 to 1781. The first steamboat arrived at Rocketts Landing in 1815 and by 1860 three hundred ocean going vessels were arriving each year. Research of past industrial activities on the project site provided a time line when various industrial activities began:

- 1867 Sugar refining
- 1870 Brewing
- 1876 Glass manufacturing
- 1884 Cooperage (Richmond Cedar Works established. The Cedar Works would become a major industrial operation using steam powered equipment to produce wooden cooperage items)
- 1895 Super phosphate fertilizer production
- 1905 Tobacco industry (Kentucky Tobacco Product Company)
- 1910 Coal fired electrical generation (Richmond Street Car Powerplant)
- 1917 Scrap metal operations
- 1920 Petroleum bulk storage
- 1925 Nicotine extraction (Tobacco By-Products and Chemical Corp)
- 1945 Metal working, type unkown (Richmond Metal Products)
- 1969 Equipment and machinery salvage
- 1972 Steel furniture manufacturing (American Furniture and Fixture Company)
- 1982 Chemical warehousing and production of asphalt cement additives (Raschig Chemical Corporation)

The port of Rocketts Landing began to decline by 1870 as newly constructed railroads carried freight directly to coastal ports such as Newport News. The port's importance decreased again when automobile and truck transportation became prevalent. From the 1950's to 1970's the area became mostly abandoned. Remaining residences and commercial buildings, that were once located close to the industrial concerns, were demolished wholesale during urban renewal efforts in the 1970s. By the late 1990s, the 20-hectare site was supporting one petroleum bulk storage facility, a chemical company warehouse and small processing area, a restaurateur's warehouse and meat packaging operation, a warehouse for bulk foods and containers, and several small tenants including a raft company, a rowing club, upholstery shop, embroidery shop, and cabinet makers shop.

In 1999, a Richmond area developer with experience in rehabilitating historic structures assembled a team of investors to acquire property in the Rocketts Landing area to revitalize this community. The investors formed Rocketts Landing, LLC to implement the project. Rocketts Landing, LLC assembled a design team including, in addition to Rocketts Landing, LLC, architectural, civil engineering, environmental, legal, and real estate professionals. Rocketts Landing, LLC identified multiple parcels of interest and negotiated various purchase contracts or options with the parcel owners. The design team began a series of investigations to complete due diligence and assess the feasibility of developing each site. The design team recognized that environmental impacts were potentially the most challenging aspect of redeveloping the sites due to their industrial history. The team's early investigations focussed largely on environmental and economic issues.

SITE CHARACTERIZATION

The environmental consultants conducted site characterization on a parcel-by-parcel basis to allow Rocketts Landing, LLC to make risk based decisions to purchase or reject each parcel on an individual basis.

Environmental due diligence

The Phase I ESA process evolved to address liability issues created by the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) enacted in 1980. Potential purchasers of property perform Phase I ESAs to avoid liability for past environmental contamination of the property. The innocent landowner defense may apply if the owner has conducted due diligence investigations including "all appropriate inquiry into the previous ownership and uses of the property consistent with good commercial or customary practice". A Phase I ESA is conducted to permit formulation of an opinion regarding the potential for hazardous materials to exist at a site at levels likely to warrant mitigation pursuant to regulations of the State or Federal pollution control agency. The Phase I ESA consists mainly of records review and a site reconnaissance. Sampling and analysis of environmental media is beyond the scope of a Phase I ESA. The design team assumed, based on limited knowledge of the various parcels at the beginning of the project, that Phase I ESAs would identify recognized environmental conditions resulting in the need to complete Phase II ESAs. The Phase II ESA involves sampling and chemical analysis of environmental media to confirm the nature of environmental impacts on the site suggested by the results of the Phase I assessment. The professional team recommended completion of Phase II ESAs at each of the parcels.

The environmental consultants developed the Phase II ESA sampling and analysis plan to investigate the nature of potential environmental impacts. Environmental media were analyzed for a variety of compounds based in part on professional judgment, Phase I ESA research, cost, and Rocketts Landing, LLC's risk tolerance. The environmental consultants designed several monitoring wells at each site. Drilling subcontractors installed the monitoring wells using typical industry practices. A field geologist screened soil samples for volatile organic compounds with a photoionization detector as the boreholes were advanced. The geologist collected one soil sample from each borehole for chemical analysis. The site geologists developed and purged the wells prior to sample collection. The site geologist preserved and shipped the groundwater sample from each well to a chemical analytical laboratory for analysis of total petroleum hydrocarbons gasoline and diesel range organics (EPA SW846 Method 8015m), volatile organic compounds (EPA SW846 Method 8260), semivolatile organic compounds (EPA SW846 Method 8270), pesticides (EPA SW846 Method 8081), herbicides (EPA SW846 Method 8151), polychlorinated biphenyls (PCBs, EPA SW846

Method 8081) and 8 RCRA metals (arsenic EPA Test Method 206.2, barium, cadmium, chromium, lead, selenium, silver EPA Test Method 200.7, mercury EPA Test Method 245.1). The site geologist designated the soil sample with the highest photoionization detector reading for chemical analysis for total petroleum hydrocarbons gasoline range organics, total petroleum hydrocarbons diesel range organics, volatile organic compounds, semivolatile organic compounds, and 8 RCRA metals. The assessments were designed as a screening tool. Based on site research in the Phase I ESA, the professional team did not think that pesticides, herbicides, and PCBs were highly probable contaminants. Several surficial soil samples were collected at each site and analyzed for the same "soil" parameters listed above.

The environmental consultants compared the concentrations of detected analytes to risk based concentrations (RBCs) for residential properties as prepared by the United States Environmental Protection Agency (EPA). Some volatile organic compounds, semivolatile organic compounds, and metals exceeded the RBCs. Investigations at the site confirmed a release of hazardous constituents to the environment. The team interpreted this to be a result of various long-term industrial uses of the various parcels. Specific issues related to environmental impact and preliminary recommendations are summarized in Table 1.

Table 1. Summary of environmental impacts and preliminary recommendations

Impact: Arsenic, lead, and polynuclear aromatic hydrocarbon levels are elevated across the project area from disposal of coal combustion byproducts from historical railroad, steamship, and manufacturing use. Some of the detected compounds exceed EPA RBCs. **Recommendation:** Management with engineering controls to remove exposure pathways to future site users.
Impact: Site wide groundwater contamination rendering groundwater unsuitable for potable use or irrigation. **Recommendation:** Management with administrative controls (deed restrictions prohibiting use of groundwater).
Impact: Detected petroleum contamination in soils and in groundwater. One parcel had remediated petroleum contaminated soils under a Corrective Action Plan with DEQ and some remaining soils have petroleum concentrations that exceed generally accepted action levels. **Recommendation:** Petroleum contaminated soils with Total Petroleum Hydrocarbons exceeding 1000 mg/kg should be excavated and disposed offsite. Groundwater remediation probably not necessary for petroleum contamination.
Impact: Small quantities of hazardous materials or possible hazardous waste at several properties. Included items such as "household hazardous waste". **Recommendation:** Require property owners to remove these materials, all solid waste, and leave buildings in "broom swept" condition prior to closing.
Impact: Asbestos and lead based paint in structures. **Recommendation:** Remove materials prior to demolition or remediation using certified contractor.
Impact: Waste pile largely composed of fragments of battery casings and drum carcasses. Analytical results indicate elevated levels of lead. Toxicity Characteristic Leaching Procedure analyses indicate that portions of the waste pile would be considered hazardous waste if excavated for disposal. Preliminary analysis suggested 3,500 tons of contaminated material with 500 tons that may be considered hazardous waste. **Recommendation:** Removal and offsite disposal of the waste pile. Engineering controls might be necessary after removal of the most significantly contaminated material.

Analysis indicated potential for risk to human health from exposure to on-site soils and groundwater. The design team concluded this risk could be mitigated in most cases by using engineering controls to restrict contact with soil and groundwater. Remediation of the lead contamination at a waste pile of battery casing fragments was considered necessary.

In August of 2000, Rocketts Landing, LLC requested a meeting with representatives of the DEQ. The design team presented preliminary design plans and the results of the due diligence investigations to the agency. The design team discussed entering the property in the DEQ's VRP. The DEQ reviewed the information and provided feedback to the design team. DEQ's feedback was positive, indicating that the VRP program staff thought that the site was eligible for participation in the program and that a successful remediation could be designed.

Preliminary remedial design

Rocketts Landing, LLC initiated a plan to enrol the various parcels in DEQ's VRP. A plan was developed with the involvement of VRP staff to assure that there was general agreement on project plans as they were developed. The design team developed a Conceptual Environmental Remediation Plan involving several innovative components for submission to DEQ. The conceptual plan included several key concepts that the design team felt were critical for project success:

- Utility workers have the greatest potential for exposure to site contaminants. Site characterization activities will focus along proposed utility corridors where construction workers might be exposed to environmental contaminants during site development. Site characterization will focus on soil contaminants because utility workers' exposure to groundwater will be managed with engineering controls during construction. Groundwater characterization will be accomplished primarily using existing groundwater chemical analytical data obtained during due diligence investigations.
- Future users of the site will be protected by engineering and administrative controls. DEQ's risk based screening levels for residential exposure will be accepted as preliminary remediation goals for future users. This will reduce risk assessment requirements for future residents.

- The individual parcels will be enrolled as a single site in the VRP process. DEQ will release future subparcels defined by the owner as remediation was completed. This will allow occupancy of future subparcels prior to remediation of the entire site.
- DEQ will release Rocketts Landing, LLC from responsibility to address existing contamination in the James River.

The design team submitted the Conceptual Environmental Remediation Plan to DEQ for review and met again with DEQ in July 2001. DEQ agreed with the conceptual plan and Rocketts Landing, LLC authorized enrolment of the various parcels in the VRP.

The environmental consultants prepared applications for enrolment for each parcel and the applications were submitted to DEQ. DEQ reviewed the enrolment applications and the various parcels were accepted into the program. Rocketts Landing, LLC directed the design team to proceed with the VRP process and Risk Assessment activities were initiated. The VRP risk assessment process consists of four major steps (DEQ 2000). These steps are data collection and evaluation (site characterization), exposure assessment, toxicity assessment, and risk characterization.

VRP SITE CHARACTERIZATION

The design team developed a site characterization sampling and analysis plan based on the utility grid model presented in the conceptual plan. The environmental consultants developed a due diligence sampling and analysis plan for two additional parcels to be completed simultaneously with the site characterization investigation. Additional data was developed on subsurface conditions including soil conditions and aquifer characteristics.

Contaminant characterization

Twenty-six borings were completed at various depths within the proposed utility corridors for VRP site characterization. Table 2 details the number of samples collected for various analyses in this phase of the project. Soil samples were analyzed for RCRA metals, volatile organic compounds, and polynuclear aromatic hydrocarbons (EPA SW846 Method 8310). Constituents detected in soil samples at concentrations above VRP residential screening levels for soil included two metals and four polynuclear aromatic hydrocarbons. Groundwater was characterized using sampling and analysis results from completed due diligence and site characterization investigations. Constituents exceeding VRP residential screening levels for drinking water include five metals, two pesticides, seven volatile organic compounds, and two polynuclear aromatic hydrocarbons.

Table 2. Summary of sampling and analysis plan for site characterization

	Due diligence additional Parcel 1		Due diligence additional Parcel 2		Site characterization		Total Samples
	Soil	Water	Soil	Water	Soil	Water	
TPH GRO (8015m)	5	5	5	5			20
TPH DRO (8015m)	5	5	5	5			20
RCRA Metals	5	5	5	5	30	8	58
8310 Polynuclear aromatic hydrocarbons	5	5	5	5	24	8	52
8260 Volatile organic compounds	5	5	5	5	24	8	52
8151 Herbicides	5	5	5	5			20
8081 Pesticides & PCBs	5	5	5	5			20

The environmental consultants collected additional soil samples in the vicinity of the “battery pile” during the site characterization phase of investigation. The parcel owner had completed a removal action at the battery pile designed to remove all wastes exceeding the Toxicity Characteristic Leaching Procedure (TCLP) regulatory threshold for lead of 5 mg/L. The sampling and analysis plan was designed to provide data for human health risk assessment and to assess the effectiveness of the removal action.

The environmental consultants collected eight sediment samples in the James River in September 2001. These samples were collected in the vicinity of the battery pile and were analyzed for lead. The sediment sampling locations are not located on the site and the results were not used in the human health risk assessment.

Further analysis of the nature of the contamination was provided in a Risk Assessment report.

Subsurface characterisation

The western Coastal Plain of Virginia is characterized by a thin layer of sediments overlying crystalline basement. During drilling, project geologists observed the soils to be predominantly sand and gravel with intermittent layers of clay and various amounts of fill on the surface of the site. The following generalized stratigraphy was encountered during drilling.

- **Fill** is generally dark gray in color and identifiable by the presence of coal cinders, brick fragments, and other debris including granite cobble stones, wood, and building materials. Thickness ranged from 0.3 to 2.5 meters.
- **Stratum 1** consists of loose to dense, SAND and GRAVEL with very stiff fat (high plasticity) clay layers. Thickness ranged from 0 to 8.5 meters. Stratum 1 appears to be Pliocene-aged Bacons Castle Formation.
- **Stratum 2** consists of gray, brown or green-gray SAND, SILT, and fat (high plasticity) CLAY. Thickness ranged from 0 to 4 meters. Stratum 2 appears to be Cretaceous-aged Potomac Formation.

The environmental consultants performed additional measurements and analysis of aquifer characteristics. Site stratigraphy is highly variable. The subsurface sediments are generally coarse grained with numerous clay interbeds. The water table aquifer is variably located in the Bacons Castle or the Potomac Formation. The environmental consultants measured the depth to water in available wells in December 2002. The design team surveyor measured the x,y,z coordinates for these wells. This data was used to develop a groundwater contour map (Figure 3). The map shows a strong flow component perpendicular to the James River on the majority of the site.

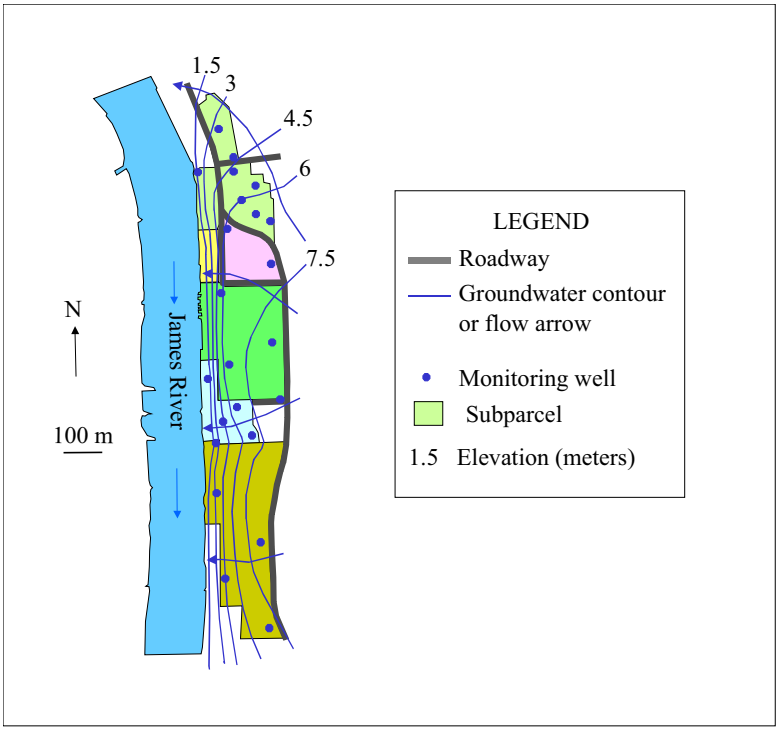

Figure 3. Groundwater contour map at The Village of Rocketts Landing December 2002 showing various subparcels assembled into the project site.

The environmental consultants measured hydraulic conductivity at four monitoring wells and averaged them for flow rate calculations (Table 3). The environmental consultants measured hydraulic gradients for two areas that appeared to represent minimum and maximum gradients. Measured hydraulic gradients ranged from 0.0083 to 0.1250. Calculated Darcian groundwater flow velocity on the site ranged from approximately 1.5 to 23 m/year. Assuming a porosity of approximately 30% for onsite sediments, seepage velocities were calculated at 5 to 75 m/year.

Table 3: Measured hydraulic conductivity

Well	Hydraulic Conductivity (m/s)
GMW1	1.9×10^{-7}
RMW2	1.6×10^{-5}
RMW3	4.9×10^{-7}
MW1	4.8×10^{-7}
Average	5.7×10^{-6}

Data developed in the Site Characterization Report were used as the basis for exposure assessments in the Risk Assessment.

Risk assessment

The VRP risk assessment should include an evaluation of the risks to human health and the environment posed by contaminants released to the environment. Risk assessments under the VRP generally follow the methodology described in Risk Assessment Guidance for Superfund (United States Environmental Protection Agency, 1989).

Exposure assessment

The Rocketts Landing Risk Assessment Report focused on potential human health risks most likely encountered during redevelopment of the property. DEQ agreed that post-development risks would be mitigated by planned engineering and institutional controls and, with the exception of the recreational scenario, would not need extensive analysis. The environmental consultants identified potentially complete exposure pathways for soil and ground water for human receptors. The environmental consultants performed exposure assessment for utility workers during construction and a recreational scenario for an area along the James River. Other exposure pathways were not considered because future exposures to site soils would be prevented by installation of a cover system prior to occupancy. Screening levels protective of residential receptors (DEQ Screening Levels) were used to identify constituents of potential concern (COPCs) for future site users. This information may be utilized in the future as a mechanism to identify individual areas that should be further evaluated during development for residential and commercial land use.

Utility construction workers have significant contact with soil and ground water as they complete their normal job functions. The utility construction worker may be exposed to soil through ingestion, inhalation, and dermal contact pathways during excavation activities. The utility construction worker may also be exposed to shallow ground water during excavation through dermal contact and incidental ingestion and volatiles emanating from groundwater through inhalation. Recreational receptors using the proposed recreational area along the river may be exposed to potential contamination via incidental ingestion, inhalation of fugitive dusts, and dermal contact with surface soil. The magnitude, frequency, and duration of exposure for each receptor and exposure pathway was quantitatively evaluated by estimating exposure point concentrations and calculating pathway-specific intakes.

The following is a generic equation for calculating constituent intake:

$$\text{Intake} = \frac{C \; x \; IR \; x \; EF \; x \; ED}{BW \; x \; AT} \qquad \text{(USEPA, 1989)}$$

where:

C = Constituent concentration at point of exposure (milligrams/kilogram)
IR = Intake rate (milligrams/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kilograms)
AT = Averaging time (years)

Toxicity assessment

The environmental consultants collected qualitative and quantitative toxicity information and determined appropriate toxicity values during the toxicity assessment of the risk assessment. Quantitative reference values describing the toxicity of the chemicals of concern are obtained from published sources such as Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Tables (HEAST), or the National Center for Environmental Assessment (NCEA). Toxicity values such as a Reference Dose and a Carcinogenic Slope Factor are based primarily on human and animal studies.

Risk characterization

The risk characterization phase of the Risk Assessment assigns quantitative values for both carcinogenic and non-carcinogenic effects and considers uncertainty inherent in the risk assessment process. Risks from potential carcinogens were estimated as probabilities of excess cancers as a result of exposure to chemicals from Rocketts Landing. In accordance with DEQ guidance, individual COPCs that contribute more than 1×10^{-6} to cumulative risk are considered to be contaminants of concern (COCs).

Non-carcinogenic hazards are expressed as a quotient by:

$$\text{Hazard Quotient} = \frac{CDI}{RfD}$$

where:

CDI = Chronic Daily Intake (mg/kg-day)
RfD = Reference Dose (mg/kg-day)

The sum of the hazard quotients for each chemical in a specific pathway is termed the “hazard index.” A hazard index above 1 indicates that the potential for adverse effects. The Risk Assessment concluded that non-carcinogenic COPCs at The Village of Rocketts Landing do not pose an unacceptable risk to site receptors. The carcinogenic soil risk estimates for the utility construction worker exceeded 1×10^{-6}. Arsenic and lead contributed to the exceedence. The cumulative carcinogenic ground water risk estimates for the utility construction worker exceeded $1 \times 10^{-6.}$ Hexachlorobenzene concentrations resulted in this exceedance. The carcinogenic risk estimate for the recreational adult and child receptors exceeded 1×10^{-6}. Soil constituents associated with risk greater than 1×10^{-6} for this scenario included arsenic and benzo(a)pyrene. Two ground water compounds, benzene and trichloroethene, were detected at concentrations above residential indoor air screening levels in an isolated area.

Since the Risk Assessment indicated that there are unacceptable risks, the design team proposed preliminary remediation goals (PRGs) for soil for the utility worker and recreational scenario. PRGs were not developed for groundwater because trench dewatering during excavation activities will prevent utility worker exposure.

REMEDIATION PLAN

The design team prepared a Remediation Plan to provide future Developers/Owners a step-by-step guide to implement appropriate environmental remediation for subparcels of The Village of Rocketts Landing. This plan was reviewed and approved by DEQ. As part of development and build-out of The Village of Rocketts Landing, the developer is required to consult and work with the VRP staff of DEQ and implement the procedures described in the Remediation Plan. The developer will receive Certificates of Satisfactory Completion of Remediation from DEQ for subparcels that may not have been completely remediated at the time of purchase. The Certificate will give Developers/Owners assurance that DEQ will not require future remediation provided that site conditions at the time of issuance do not significantly change from conditions reported to DEQ prior to issuance. The subparcels can be developed in any sequence and as residential or commercial property based on the developer's plans.

The overall purpose of the Remediation Plan is to enable development of the property for residential and commercial use, while also having a positive impact on the surrounding environment. The environmental improvement will be the result of the constructed environment. The Remediation Plan uses a combination of institutional controls (deed restrictions) and engineering controls to protect construction workers during site development and to protect future end users residing or working on the property.

Institutional controls

Institutional controls are required for all of the Village of Rocketts Landing development. The institutional controls include deed restrictions to:

- Prohibit groundwater use.
- Require protection of construction workers through adherence to site specific and Occupational Safety and Health Administration (OSHA) requirements.
- Require installation and maintenance of engineering controls to protect future end users.
- Bind Developers/Owners to this Remediation Plan.
- Offer an alternative remedial pathway to Developers/Owners that choose to deviate from The Village of Rocketts Landing development concept or Remediation Plan.

Institutional controls (deed restrictions) are used to prevent specific pathways of exposure related to ground water and soil. Restrictions are recorded in the applicable Circuit Court in the chain of title of all subject properties obligating successors in title to the controls and limitations. Deed restrictions incorporate by reference the final Remediation Plan and all of its requirements.

Engineering controls

Developers/Owners at the Village of Rocketts Landing must implement engineering controls to protect construction workers during site development and to protect future end users after development is complete.

Engineering controls to protect construction workers will include:

- Management of groundwater encountered during construction activities.
- Remediation (removal action) of soil in utility corridors at identified areas where specific hazards are identified in the Risk Assessment.

Engineering controls to protect future end users will include:

- The entire site will be remediated using one of the following methods:
  - Hardscaping,
  - Clean soil cover, or
  - Access control.
- Vapour mitigation for buildings will be required in the isolated areas with unacceptable risks posed by volatile contaminants.

The Remediation Plan includes a contingency plan for unanticipated hazards and a requirement for development of Health and Safety Plans for site workers.

The Remediation Plan uses the built environment (hardscape) in an innovative manner as a cap to disrupt exposure pathways to future site users. The design team proposed to use high-density occupancy to maximize hardscape and reduce remedial cost by using conventional floor slabs, pavements, sidewalks, etc. to serve as the primary barrier to disrupt human exposure pathways to site contaminants. The construction is essentially the remediation. Only limited landscape areas will be covered exclusively with soil. Several areas of the site that slope steeply to the river will be managed with access controls preventing human access to site soils.

CONSTRUCTION

After the Remediation Plan was finalised and approved by DEQ in late 2002, Rocketts Landing, LLC completed real estate transactions to acquire various subparcels and then marketed the assembled property and the conceptual master plan design to several developers in 2003 and 2004. WVS/Rocketts Landing Construction Management LLC purchased the property from Rocketts Landing, LLC in late 2004. Final environmental, geotechnical, civil and architectural design was then initiated for Phase I of the project.

Final environmental design services consisting of a variety of tasks including preliminary design coordination, development of remediation design plans, OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) training for utility construction workers, and sampling and analysis of potential imported fill material were completed to support construction activities.

Preliminary design coordination

Significant environmental design coordination was necessary between the environmental, civil, and architectural team members. Because of past impact of industrial activities on site soils, balance cut and fill was rejected in favour of minimized excavation and importation of offsite fill. Most excavated soils must be disposed of offsite at significant expense. Large quantities of select fill are available from a nearby quarry operator at transportation cost. A portion of the site will be filled prior to utility installation to allow the majority of the utilities to be placed in clean fill material rather than existing impacted soils. Foundation, floor slab and pavement design recommendations were provided using systems that minimize excavation and spoils. Construction considerations related to soil excavation, subgrade preparation, reuse of onsite soils, controlled structural fill, and general construction considerations were prepared that addressed the need to minimize excavation, avoid contaminant migration and develop an acceptable cap for the site.

Remediation design plans

Remediation design plans were developed to help contractors involved in construction activities comply with the requirements of the Remediation Plan. If soils are removed from the site they will be disposed in secure (Subtitle D) landfills. The Remediation Plan requires waste characterization chemical analytical testing for soils removed from the site for disposal. The Remediation Plan requires collecting waste characterization samples for every 410 metric tons of soil to be disposed. The sampling for waste characterization is conducted prior to excavation of the soil to avoid regulatory issues related to creation of waste piles containing hazardous wastes. Soils excavated from utility trenches that are suitable for use as fill may be replaced in the trench from the area it was excavated. Many of the near-surface soils in the project area contain old construction debris (brick fragments, glass, etc.) and are unsuitable from a geotechnical perspective for use as structural fill. These soils are segregated on a visual basis and may be stockpiled for later disposal. Multiple sampling events have been implemented across the site to characterize soils for offsite disposal.

There are four areas identified in the Remediation Plan that require additional risk characterization sampling and analysis prior to excavation activities. Risk characterization samples are required on 30-meter grid spacing for the four identified areas and for excavations outside of the utility corridors.

If water accumulates in utility trenches it will be contained in onsite above ground storage tanks. The water in the tanks is analyzed for chemical parameters to determine if the wastewater meets City of Richmond pre-treatment standards. If pre-treatment standards are met the water will be discharged into the city of Richmond combined sewer for treatment at the sewage treatment plant.

HAZWOPER training

OSHA regulations require HAZWOPER training for any employees who are potentially exposed to hazardous substances during voluntary clean-up operations at hazardous waste sites. The Remediation Plan also requires this training for utility workers. The project environmental consultants provided General Site Worker (40-hour) and Supervisor (8-hour) training programs for the utility installation contractor.

Sampling and analysis of potential imported fill

If fill is brought onto the site the Remediation Plan requires final soil cover from a borrow pit source that has been analyzed and meets the DEQ requirements for clean soil. A large stockpile of fine aggregate is available at a nearby quarry. The producer considers the stockpiled material a “waste product” because it is produced by the quarry screening operation in quantities that exceed local demand. The producer offered the material to the project for the cost of transport from the quarry where it is impeding mining operations. Sampling and analysis has indicated that the material is suitable for use as clean soil cover at the site. Sampling and testing for engineering parameters was carried out simultaneously with the chemical analytical program.

Construction status

Phase I Construction will complete approximately four city blocks. The proposed project consists of a six-story office building, three seven-story condominium buildings, seven three-story townhouse complexes, a six-story parking deck and associated infrastructure. Additional phases will begin in two-year increments and consist of four city blocks each. The estimated schedule for completing the initial 20-hectare site is ten years.

Utility installation began at Phase 1 in August of 2005 (Figure 4). Renovation of two existing historic structures for residential condominiums and the owner's offices is underway. Foundation installation for the first two new condominium towers is scheduled for spring 2006.

Figure 4: Sanitary sewer installation at The village of Rockets Landing. Fill contaminated with coal combustion byproducts visible above arrow. The pipe in the foreground is 0.3 meter diameter.

Preliminary due diligence investigations are beginning on an additional 17-hectares of property north of the current project. The new parcels are known to have significant industrial pasts including port, manufactured gas plants, and petroleum bulk storage. It is anticipated that these parcels will be developed under the VRP if acquisition occurs.

Acknowledgements: Gracious thanks are extended to William H. Abeloff, Jason Vickers-Smith, and Richard Souter of WVS/Rocketts Landing Construction Management LLC.

Corresponding author: Mr David M. Sayre, Virginia Geotechnical Services, P.C., 8211 Hermitage Road, Richmond, Virginia, 23228, United States of America. Tel: 804.266.2199. Email: dmsayre@vgspc.com.

REFERENCES

ASTM STANDARD E 1527. 2000. Standard Practice for Phase I Environmental Site Assessments, American Society for Testing of Materials.

MIXON, R. B., BERQUIST, C.R., NEWELL, W.L., JOHNSON, G.H., POWARS, D.S., SCHINDLER, J.S., & RADER, E.K. 1989. Geologic Map of the Coastal Plain and Adjacent Parts of the Piedmont, Virginia. U.S. Geological Survey, Miscellaneous Investigation Map I-2033.

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY. 2000. "Voluntary Remediation Program Risk Assessment Guidance", www.deq.virginia.gov/vrprisk/.

VIRGINIA GENERAL ASSEMBLY. 1995. Code of Virginia Chapter 14 of Title 10.1, Sections 10.1-1429.1 through 10.1-1429.3, "Voluntary Remediation."

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION III. Risk-based Concentration Tables, www.epa.gov/reg3hwmd/risk/human/index.htm.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, CFR 40 136, Guidelines Establishing Test Procedures For The Analysis Of Pollutants.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. 1989. Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (*Part A*).

UNITED STATES OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION.1910.120 Hazardous Waste Operations and Emergency Response