Geology and Hydrogeology of the Marbledale Quarries;

Town of Eastchester, New York and Vicinity

[Deep Unlined Quarries Filled with Chemical Wastes]

Photos of the down-gradient contaminant receptor area in the Bronx River

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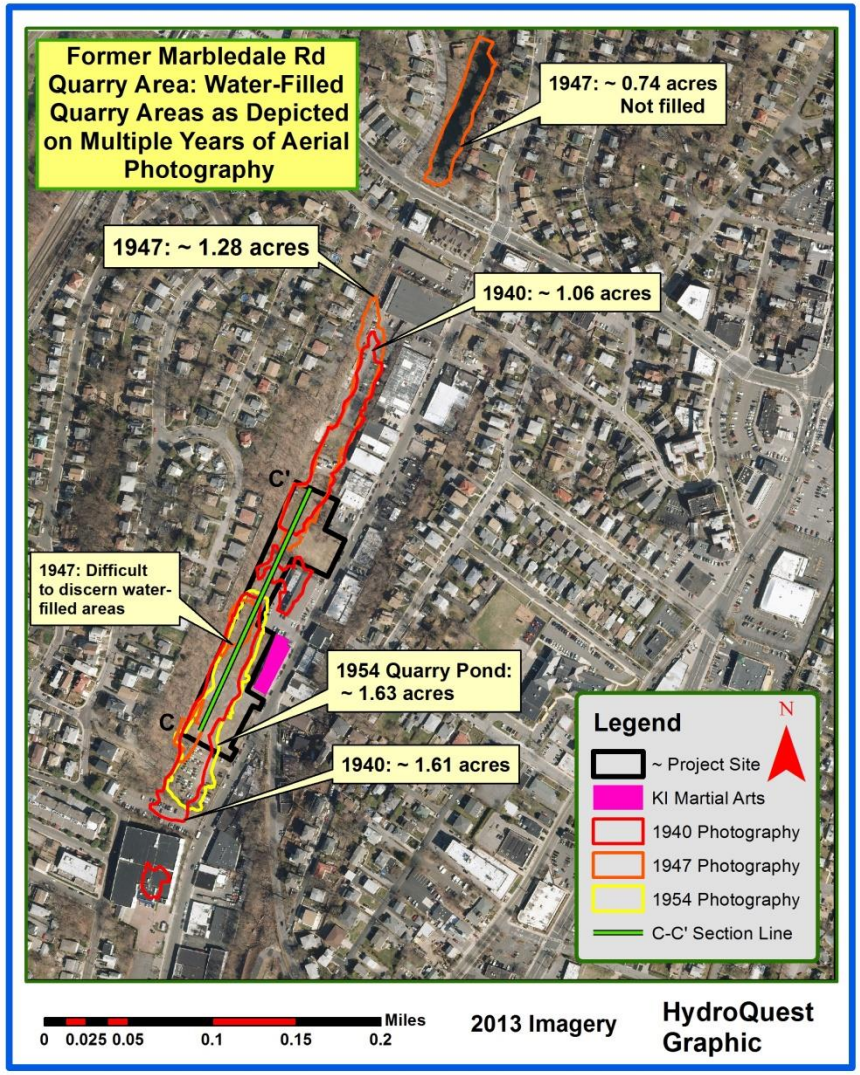
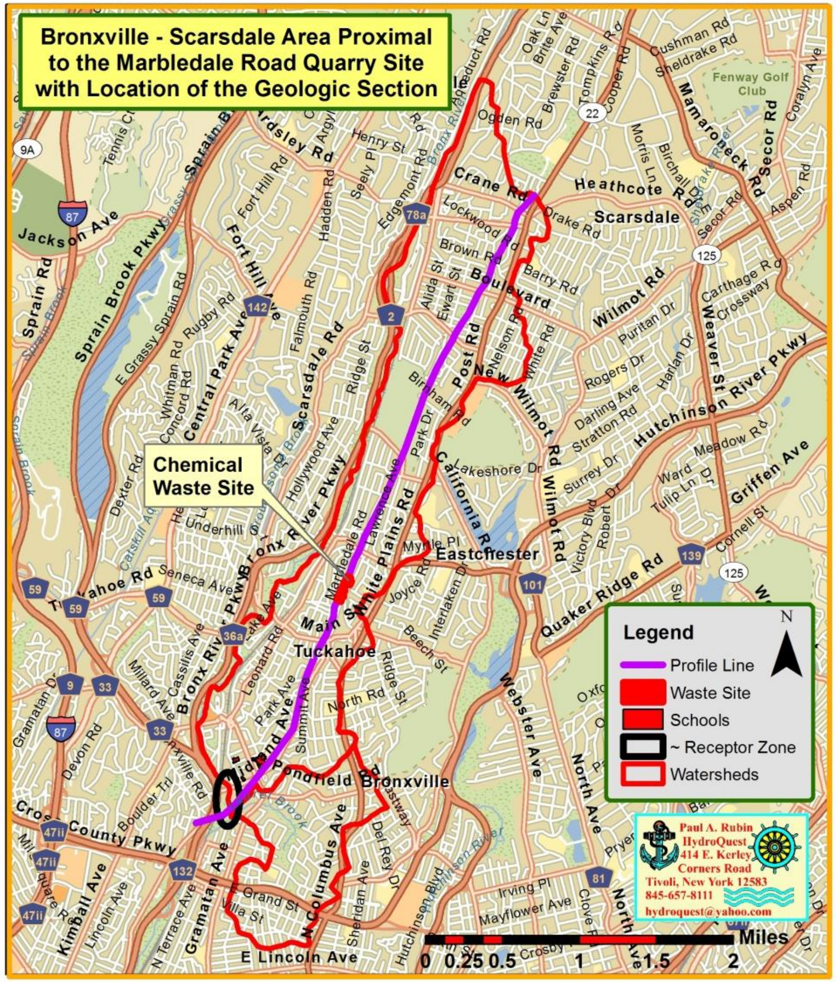
March 1, 2016


Former Marbledale Rd Quarry Area: Water-Filled Quarry Areas as Depicted on Multiple Years of Aerial Photography
1947: ~ 0.74 acres Not filled
1947: ~ 1.28 acres
1940: ~ 1.06 acres
C'
1947: Difficult to discern water-filled areas
1954 Quarry Pond: ~ 1.63 acres
C
1940: ~ 1.61 acres
Legend
N
~ Project Site
KI Martial Arts
1940 Photography
1947 Photography
1954 Photography
C-C' Section Line
0 0.025 0.05 0.1 0.15 0.2
Miles
2013 Imagery
HydroQuest Graphic


Bronxville - Scarsdale Area Proximal
to the Marbledale Road Quarry Site
with Location of the Geologic Section
Chemical
Waste Site
Legend
Profile Line
Waste Site
Schools
~ Receptor Zone
Watersheds
N
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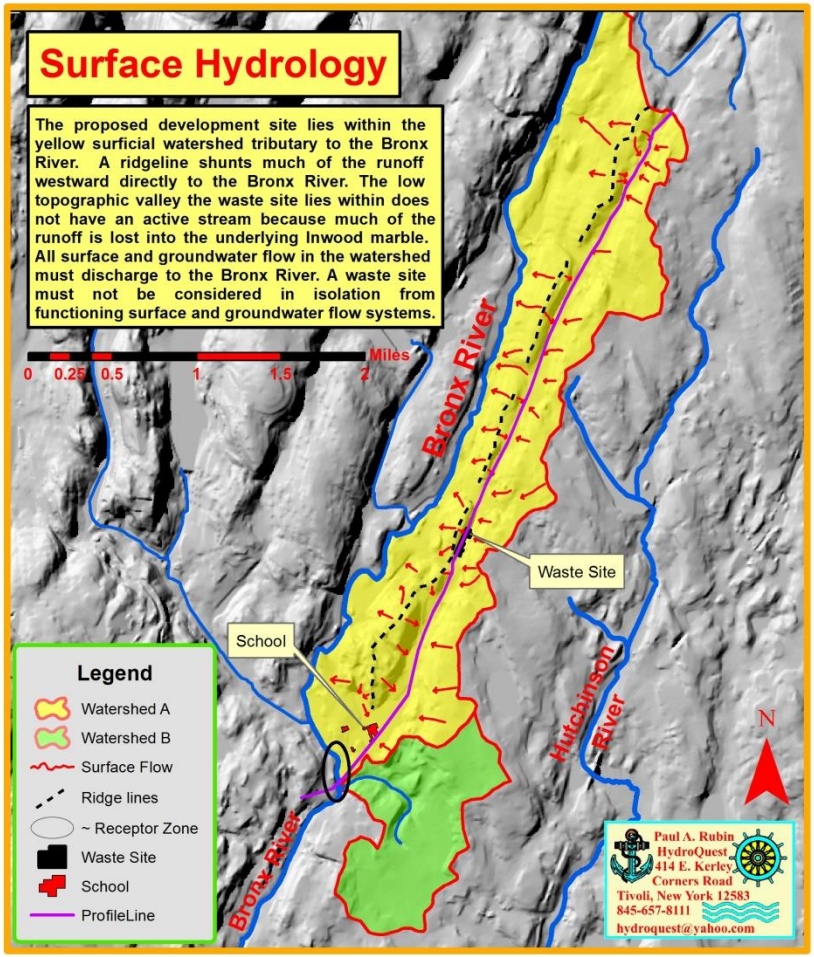
0 0.25 0.5 1 1.5 2 Miles
Scarsdale
Eastchester
Tuckahoe
Bronxville
Fenway Golf Club
Crane Rd
Heathcote Rd
Post Rd
Boulevard
White Plains Rd
Marbledale Rd
Main St
Pondfield Rd
Bronx River Pkwy
Sprain Brook Pkwy
Hutchinson River Pkwy
Cross County Pkwy
California Rd
Wilmot Rd
New Wilmot Rd
Scarsdale Rd
Central Park Ave
Fort Hill Ave
Tuckahoe Rd
Quaker Ridge Rd
Webster Ave
North Ave
Gramatan Ave
N Columbus Ave
E Lincoln Ave
Midland Ave
Jackson Ave
Mamaroneck Rd


Surface Hydrology
The proposed development site lies within the yellow surficial watershed tributary to the Bronx River. A ridgeline shunts much of the runoff westward directly to the Bronx River. The low topographic valley the waste site lies within does not have an active stream because much of the runoff is lost into the underlying Inwood marble. All surface and groundwater flow in the watershed must discharge to the Bronx River. A waste site must not be considered in isolation from functioning surface and groundwater flow systems.
Miles
0 0.25 0.5 1 1.5 2
Bronx River
Waste Site
School
Hutchinson River
Bronx River
N
Legend
Watershed A
Watershed B
Surface Flow
Ridge lines
~ Receptor Zone
Waste Site
School
ProfileLine
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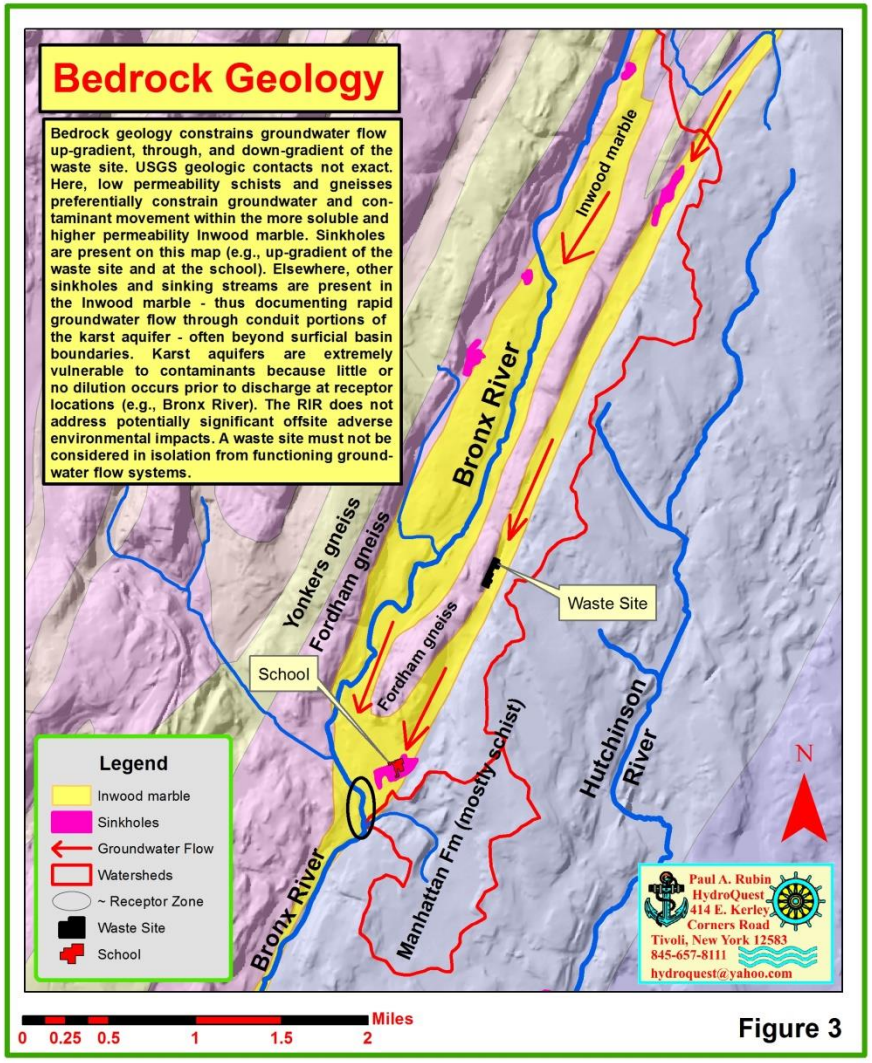
Bedrock Geology
Bedrock geology constrains groundwater flow up-gradient, through, and down-gradient of the waste site. USGS geologic contacts not exact. Here, low permeability schists and gneisses preferentially constrain groundwater and contaminant movement within the more soluble and higher permeability Inwood marble. Sinkholes are present on this map (e.g., up-gradient of the waste site and at the school). Elsewhere, other sinkholes and sinking streams are present in the Inwood marble - thus documenting rapid groundwater flow through conduit portions of the karst aquifer - often beyond surficial basin boundaries. Karst aquifers are extremely vulnerable to contaminants because little or no dilution occurs prior to discharge at receptor locations (e.g., Bronx River). The RIR does not address potentially significant offsite adverse environmental impacts. A waste site must not be considered in isolation from functioning groundwater flow systems.
Inwood marble
Bronx River
Yonkers gneiss
Fordham gneiss
Fordham gneiss
Waste Site
School
Hutchinson River
Manhattan Fm (mostly schist)
Bronx River
N
Legend
Inwood marble
Sinkholes
Groundwater Flow
Watersheds
~ Receptor Zone
Waste Site
School
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0 0.25 0.5 1 1.5 2
Miles

Figure 3

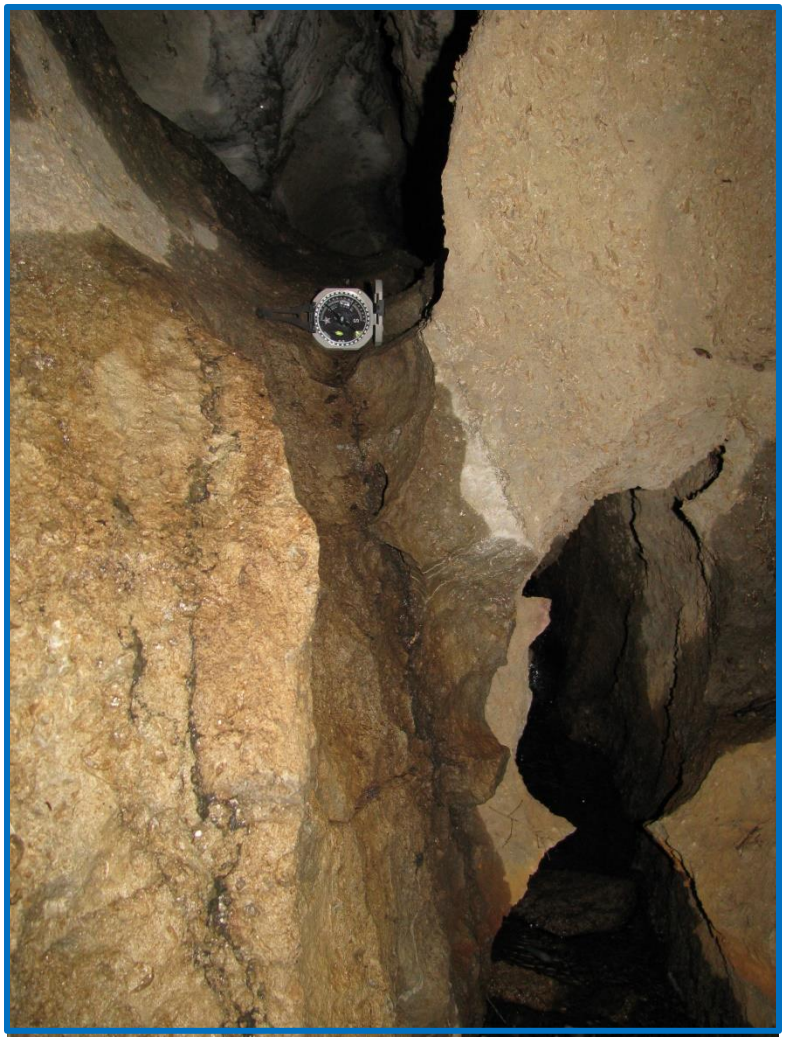
Groundwater flow occurs from north to south within soil and the underlying permeable Inwood Marble (aka Tuckahoe Marble) under a steep hydraulic gradient. Groundwater flow within the Inwood Marble is constrained by low permeability schist and gneiss bedrock situated directly east and west of the north to south trending marble. Groundwater and contaminants conducted within the marble must discharge into the Bronx River which represents the low regional base level. The lack of liners and leachate collection systems within the two huge quarries (each ~100 ft wide x 800 ft long x 85^{+} ft deep) of the Marbledale Quarry Landfill provide NO mechanism to contain the chemical contaminants present. Therefore, the probability of a release of the contaminants into the environment is 100 percent assured [375-2.7(a)(3)(xiii)].

Karst Hydrology

Groundwater flow within the Inwood Marble occurs within fractures and conduits. Terrains characterized by rapid groundwater flow through soluble bedrock, including marbles, are referred to as karst terrains. Often, but not always, karst terrains exhibit one or more of the following features – sinkholes, sinking streams, lack of surface streams, solution conduits, caves, and springs. Groundwater and contaminant migration in conduit portions of karst aquifers can be rapid, far more so than in fractured bedrock portions of karst aquifers. Because conduit portions of karst aquifers are open, little or no contaminant dilution occurs before groundwater discharges from springs often miles away from where surface water flows or infiltrates into the ground. Springs generally appear near some controlling feature such as an insoluble underlying bedrock contact or regional base level (e.g., river, ocean). Locally, the Bronx River forms the regional base level. Contaminants transported from the Marbledale Quarry Landfill almost certainly discharge in one or more springs close to or in the Bronx River, somewhere within the area encompassing the Inwood Marble. Proper waste site characterization requires determination of offsite locations of karst springs via the karst ASTM standard or updated equivalent.

Evidence for Rapid Groundwater Flow in Conduits within the Inwood Marble:

- **Sinking streams within the marble both in the area and within the same valley as the Marbledale Quarry Landfill;**
- **Lack of surface drainage along much of the valley containing the Marbledale Quarry Landfill;**
- **Reference to the karstic nature of the Inwood Marble by the US Geological Survey;**
- **The presence of a large and elongate sinkhole within the same valley as the Marbledale Quarry Landfill. If sediment within this sinkhole was not being actively sapped into the subsurface and being carried away by rapid groundwater flow, the sinkhole would not be present. Instead, its existence would have been masked by glacial till deposited by the most recent glacial advance. Thus, conduit portions of the karst aquifer are both present and functioning.**



Marbles and limestones are soluble types of bedrock. Groundwater flow occurs within fractures and conduits. Water and contaminant flow in conduits is far more rapid than that in fractures.

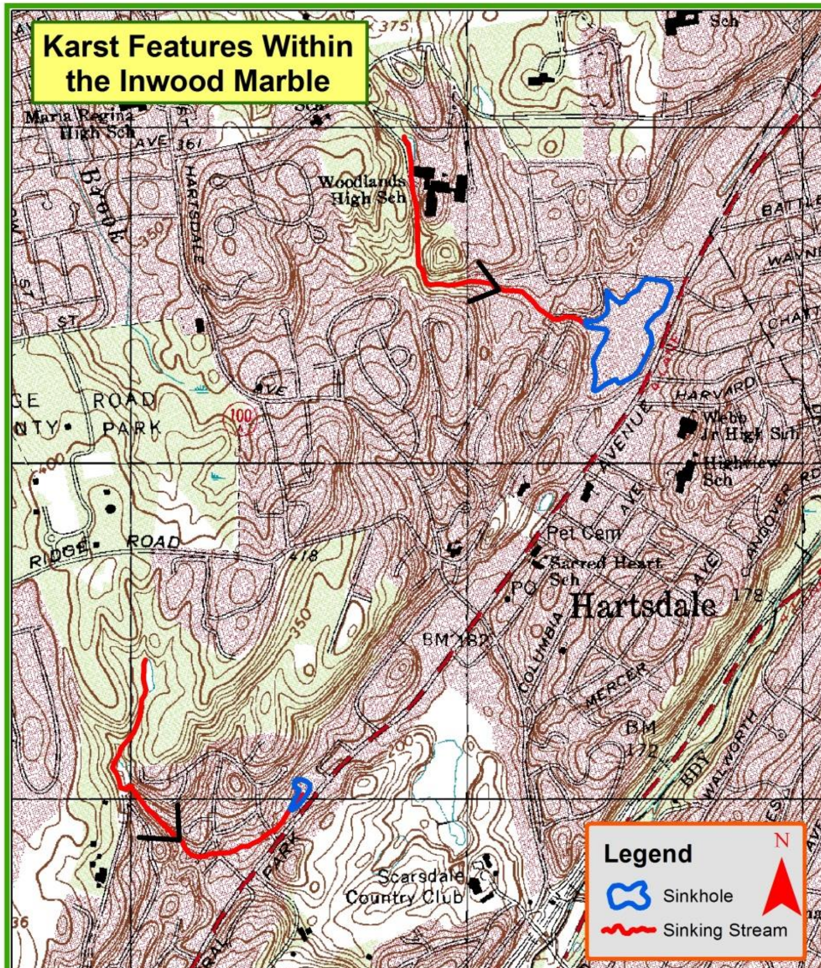


Figure 6

0 | 0.125 | 0.25 | 0.5 | 0.75 | 1 Miles

HydroQuest Graphic

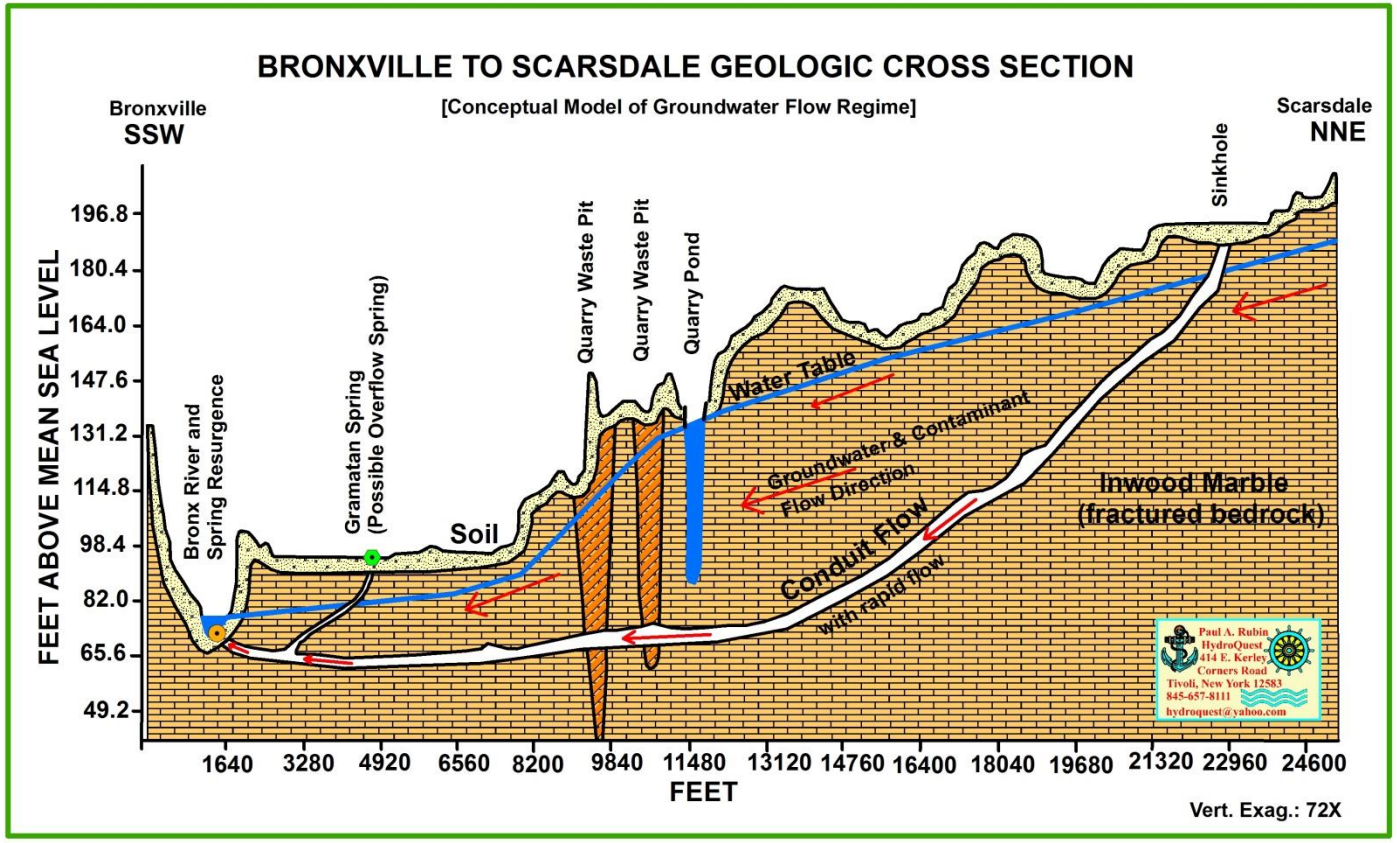

BRONXVILLE TO SCARSDALE GEOLOGIC CROSS SECTION
[Conceptual Model of Groundwater Flow Regime]
Bronxville
SSW
Scarsdale
NNE
FEET ABOVE MEAN SEA LEVEL
196.8
180.4
164.0
147.6
131.2
114.8
98.4
82.0
65.6
49.2
Bronx River and Spring Resurgence
Gramatan Spring (Possible Overflow Spring)
Quarry Waste Pit
Quarry Waste Pit
Quarry Pond
Sinkhole
Water Table
Groundwater & Contaminant Flow Direction
Soil
Conduit Flow with rapid flow
Inwood Marble (fractured bedrock)
1640
3280
4920
6560
8200
9840
11480
13120
14760
16400
18040
19680
21320
22960
24600
FEET
Vert. Exag.: 72X
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Figure. Hydrogeologically, it is not prudent to leave a huge chemical waste mass within an active groundwater flow system with no knowledge of where contaminants are going or who may be adversely impacted. The former marble quarry on Marbledale Road was filled with massive quantities of chemical wastes, inclusive of volatile and semi-volatile organics, metals, PCBs and more. Waste material is in direct contact with bedrock in an unlined setting with no chemical leachate collection or treatment. Groundwater flow is documented from north-northeast to south-southwest along the alignment of the soluble Inwood Marble. Developing and covering the waste material will not alter or stop down valley contaminant flow. Unfortunately and inappropriately, regulating agencies have not required characterization of off-site contaminant flow routes, presence, type, or concentration. More importantly, down-gradient receptors, inclusive of schools, have not been identified or investigated for potential adverse environmental and health impacts.

October 13, 2015

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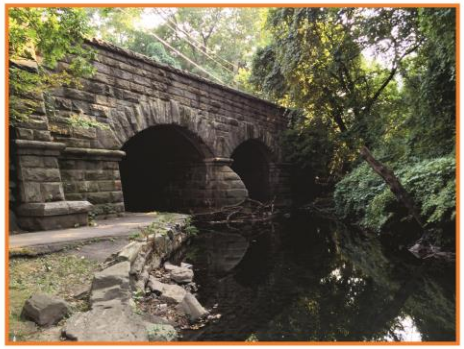
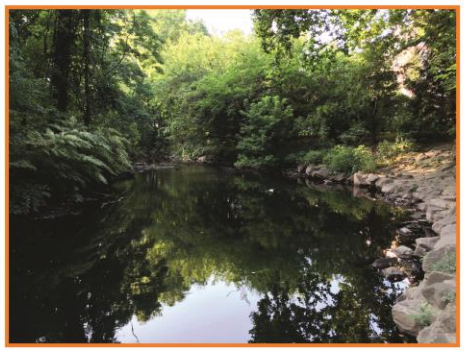
Potential Offsite Impacts Associated with Contaminant-Laden Groundwater Constitute a Significant Threat to Public Health or the Environment [375-2.7(a)(1)]

- Vapor release into buildings located between the quarry waste site and Bronx River (~1.4 miles) via bedrock fractures and permeable soils (e.g., schools, businesses, homes);
- Areal spreading of groundwater contaminants via irrigation from wells;
- Areal spreading of waste site contaminants via irrigation from the Bronx River after groundwater discharges into the Bronx River;
- Degradation of Bronx River water quality;
- Degradation of Bronx River aquatic life and ecosystems (i.e., due to exposure to contaminants);
- Bioaccumulation of waste site contaminants in Bronx River fauna and sediments; and
- Dermal contact with contaminated Bronx River water and sediments by recreational users.

Groundwater flow occurs from north to south, from up-gradient of the Marbledale Quarry waste site, through the site, and down-gradient of the site. As long as a contaminant source remains in place, contaminants will migrate off-site. Covering the site with Brownfield buildings and a parking lot will do nothing to stop off-site migration of contaminants. In fact, premature development would preclude contaminant source removal - an important remedial option. Contaminant transport is occurring to the Bronx River. Off-site contaminant receptors must be located and monitored. Gramatan Spring may be one of these receptors.

The Marbledale Quarry Landfill poses a significant threat to public health or the environment and is causing, or presents an imminent danger of causing, either irreversible or irreparable damage to the environment. [3.75-2.7(b)(3)(i)(b)]





Photos of the down-gradient contaminant receptor area in the Bronx River