VOLUME I

FINAL REPORT

PRELIMINARY ASSESSMENT

MAIN PLANT SITE

CIBA-GEIGY CORPORATION

GLENS FALLS, NEW YORK

SEPTEMBER 18, 1987

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VOLUME 1

Products manufactured on the site over the years include color pigments, aqueous dispersions and colored plastic concentrates used in the manufacture of paints, printing inks, plastics, fibers, and other items. The types of pigments produced include lead chromates (yellow and orange); chromium oxide (green); cadmium pigments (yellow, orange, and red); organic blues, yellows, and reds; and iron blues. Other materials used on the site include zinc and strontium chromates and various sulfate, acetate, and antimony compounds. The site was used for the extraction of bichromate from chromite ore. The ore itself was stockpiled on the eastern portion of the site, and the U.S. Army obtained permission to stockpile chromium ore in the eastern area of the site during the Korean War.

The Glens Falls Feeder Canal, which runs along the northern boundary of the site, was constructed from 1817 to 1825. Canal drawings dated July 1, 1912, show only one large building and several smaller structures on what now is the Ciba-Geigy plant site. The large building is labelled, "Wall Paper Mill" and is probably Ciba-Geigy Building No. 10. A small structure adjacent to the canal just west of Weir Brook is labelled "Lime Kiln". The drawings also show leaks in the Canal in the northwest area of the plant site and one leak in the vicinity of what is now Building 44. Leaks from the canal into Ciba-Geigy property have been a continuous condition over the years.

The Delaware and Hudson Railroad Corporation line was built in the late 1800's. Right-of-Way and Track maps, dated May 15, 1924, indicate that, at that time, Weir Brook passed under the railroad through an 8.5 ft. x 7.5 ft. stone arch culvert with 8 ft. x 10 ft. concrete extensions.

A total of nine old production wells were previously drilled on the site, beginning at least as early as about 1940. Five of these wells cannot now be located. After acquisition of the site by Ciba-Geigy Corporation in 1979, a

<u>TABLES</u>

FIGURES

EXECUTIVE SUMMARY

Ciba-Geigy Corporation has completed a preliminary assessment of its plant site at Glens Falls, New York. The work for the preliminary assessment included field surveys, an extensive program of 78 soil borings to determine surficial and underlying geologic and hydrogeologic conditions at the site, a similarly extensive program of sampling and analysis of ground water at the plant site through installation of 26 wells, and sampling and analysis of surface water in the Hudson River adjacent to the plant site. The work plan for the preliminary assessment was approved by the New York State Department of Environmental Conservation (NYSDEC).

The preliminary assessment identified no significant environmental or health impacts associated with the plant site. The major findings can be summarized as follows:

Geology

The field survey and soil borings confirmed the extent of three adjacent units used for the storage of waste near the west side of the site--the north waste pile, north lagoon, and south waste pile. The borings confirmed that these units are located virtually on bedrock. Ciba-Geigy has filed a closure plan under the Resource Conservation and Recovery Act for these units.

The field survey and soil borings located two areas on the plant site where fill material had been placed--an area south and west of Building 49 and an area around Building 56 and south of Building 45. The fill material consists largely of soil and ore tailings from the former practice of ore processing at the site. The field survey also located small amounts of chromium ore in the area of the east parking lot, where such ore was stockpiled in the 1950's.

As part of the field survey and soil boring program, the deposited materials observed were analyzed for metals content and for leaching potential in the Extraction Procedure (E.P.) toxicity test. Low concentrations of chromium, lead, barium, and cadmium--the metals potentially associated with the pigment manufacturing operations at the plant site--were observed as well as total cyanide. Only 15 of the 432 analyses exceed the E.P. toxicity values.

The deep borings indicate that the underlying bedrock consists primarily of limestones. The bedrock is not porous and therefore the only opportunity for ground water transmission between the shallow bedrock and deep bedrock would be through vertical fractures.

Hydrogeology

The soil monitoring and ground water monitoring program showed strong vertical gradients in the aquifers at the site. The data indicate that there is a partial aquiclude in the upper zone of the bedrock and that the shallow bedrock aquifer and deep bedrock aquifer are essentially separate systems. A study of carbonate equilibria suggests that the lack of vertical flow between the shallow bedrock and deep bedrock may result from the sealing of vertical fractures in the bedrock by calcite deposition. The ground water flow direction is from north to south under the plant site. The surficial aquifer appears to be discharging to the Hudson River. The ground water elevation data collected from cluster bedrock wells suggests that the deep bedrock aquifer and portions of the shallow bedrock aquifer may be flowing under the Hudson River.

Ground Water Analysis

The ground water monitoring data generally show low levels--frequently at or below the detection limits--of the constituents potentially associated with the prior and present manufacturing operations at the plant site. To the extent a trend could be observed, the ground water in the deep bedrock generally had lower levels of constituents than the surficial aquifer and the shallow bedrock aquifer. Historical data indicate that inorganic constituent levels have significantly decreased over the past seven years in the wells where such data have been collected. No correlation between inorganic constituents and fill areas was observed. Low levels of organic constituents were found in isolated areas.

The hydrogeologic data and the ground water analysis enabled a calculation to be made of the amounts of major constituents that potentially could be discharging to the Hudson River. The calculation demonstrated that any such amounts, including those discharged through permitted run-off outfalls, would be less than is permitted under SPDES permits currently held by Ciba-Geigy and would be undetectable in the river.

Surface Water Analysis

Surface water sampling and analysis upstream and downstream of the plant found no detectable impact on the Hudson River or Feeder Canal.

Areas for Future Study

Additional soil borings could be installed in the vicinity of Old Production Well No. 1 in an effort to locate a source of chromium. All old production wells should be located and grouted, if possible.

Possible Remedial Actions

A range of remedial actions has been prepared for further evaluation.

- No action. Petition NYSDEC to reassign its current wastewater pretreatment plant permit allocations to the tile pipes discharging to the east and west pumping stations and to the ground waters. Both the stations and the ground waters should be allowed to discharge to the River.

- If the source of chromium contamination in Old Production Well No. 1 cannot be located and remediated, consideration should be given to pumping of the well. The discharge should be to the Hudson River under a SPDES Permit.

- The entire site could be secured in such a way as to prevent access by the public.
- Portions of the site could be covered with a shallow (less than one foot) layer of soil, perhaps with chemical additives to further decrease ground water and/or contaminant migration; however, capping does not seem warranted.

SECTION I

INTRODUCTION

1.1 Purpose

The purpose of this Preliminary Site Assessment is to perform the work tasks that were defined in the Ciba-Geigy Main Plant Site Work Plan approved by New York State Department of Environmental Conservation (NYSDEC) on September 9, 1986. This work plan was developed as a part of a Compliance Agreement and Order between Ciba-Geigy Corporation and NYSDEC. The scope and background of the Preliminary Assessment are outlined in the following section.

1.2 Scope of Present Study

Ciba-Geigy Corporation acquired a pigment manufacturing facility in Glens Falls, New York, in September, 1979. On October 5, 1984, Ciba-Geigy submitted an application to the NYSDEC and USEPA for a RCRA Part B permit for two hazardous waste facilities: a pretreatment plant sludge storage lagoon and a drum storage area. The drum storage area currently has RCRA A interim status under permit No. NYD002069748. A draft permit, prepared in accordance with 6NYCRR Part 373, has been written for the drum storage area, and a final permit is expected soon. The sludge lagoon lost its interim status on November 7, 1985. On July 3, 1985, a meeting was held at the NYSDEC offices in Albany, New York, to discuss how the permit would be issued. In attendance were staff from Ciba-Geigy, NYSDEC, and Malcolm Pirnie, Inc., with USEPA staff members participating via a telephone link. The principal decisions reached at this meeting were as follows:

1. Ciba-Geigy Corporation would delete the sludge lagoon from its application for a RCRA Part B permit. The portions of the application dealing with the drum storage area would continue to be processed by the NYSDEC and the USEPA.

2. Ciba-Geigy would develop a work plan for assessing the extent and effects of potential ground water contamination, submit this plan to NYSDEC for review, and proceed with the work upon plan approval.

Malcolm Pirnie, Inc. was retained by Ciba-Geigy to implement the work plan. The Compliance Agreement and Order (Appendix I) were approved by Ciba-Geigy on December 12, 1986, and by NYSDEC on December 29, 1986. The work plan (Appendix II) was made part of the Order and was designed to address all known or suspected contamination problems resulting from past fill/waste disposal practices on the site.

The work involved in the preliminary site investigation involved eight tasks, as follows:

Task 1 - Existing Data Collection and Review

Task 2 - Background Field Surveys

Task 3 - Investigation of Extent of Hazardous Industrial Wastes

Task 4 - Supplemental Ground Water Investigations, including Additional Hydrogeologic Studies

Task 5 - Preparation of an Interim Report

Task 6 - Supplemental Surface Water Investigations

Task 7 - Evaluation of Environmental Impacts

Task 8 - Preparation of Preliminary Assessment Report.

A list of remedial action alternatives has also been developed as part of the preliminary assessment report.

Field work for the present study was begun on February 3, 1987, by Malcolm Pirnie, Inc., Dunn Geoscience, and Aquatec Inc. personnel, and was completed in August, 1987.

1.3 Site Location and Description

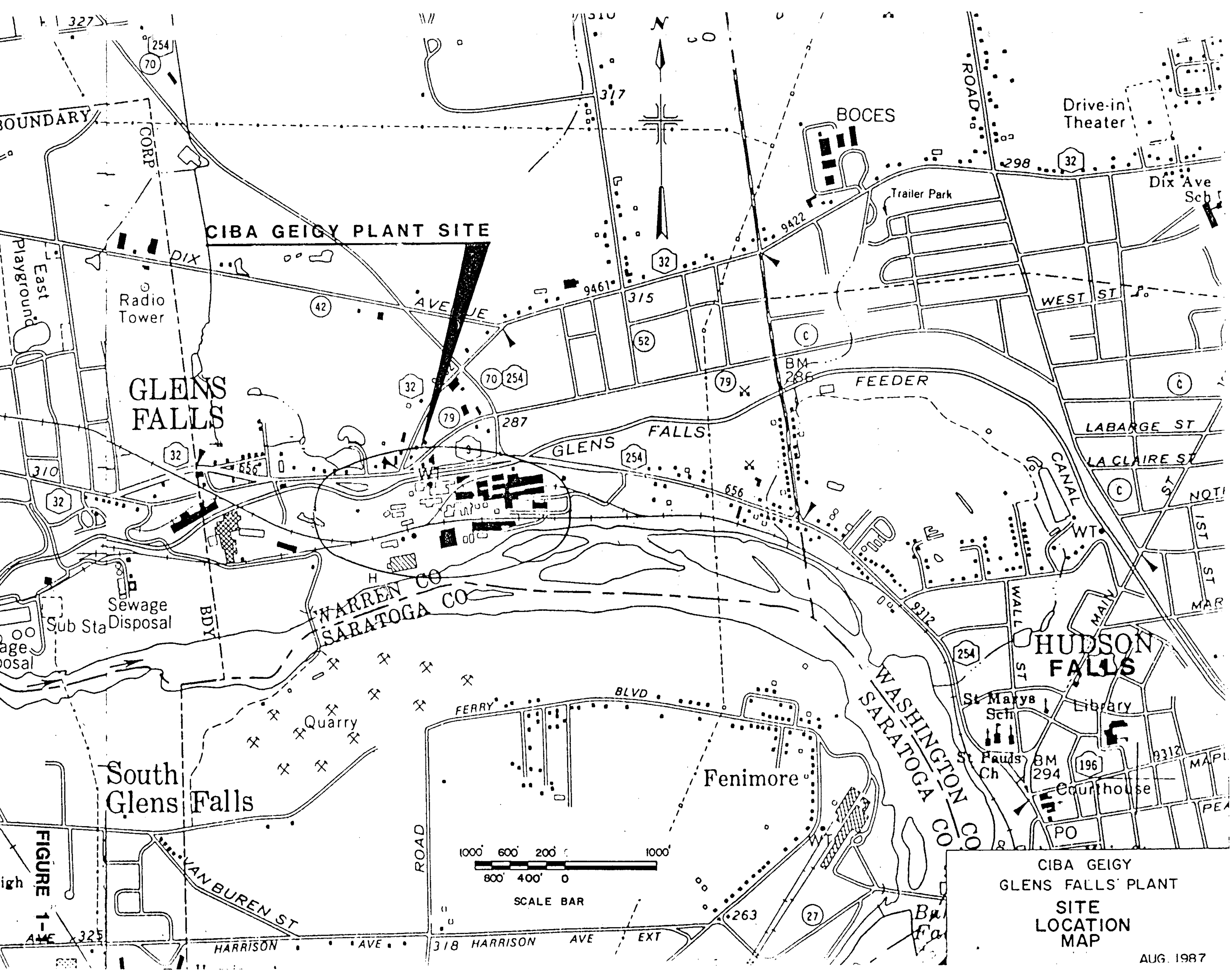
The Ciba-Geigy Corporation, Glens Falls plant, is located in the Town of Queensbury, between the City of Glens Falls and Village of Hudson Falls in

Warren County, New York. The total area of the plant property (hereafter referred to as the "site") is comprised of approximately 75 acres and 28 buildings. It is bounded on the north by the Glens Falls Feeder Canal and on the south by the Hudson River. The Glens Falls Portland Cement Company borders the western boundary. A private residence and cement plant borders the eastern boundary of the site. A map showing the location of the Ciba-Geigy Main Plant Site is presented on Figure 1-1, Site Location Map.

The site topography may be characterized as sloping from the Glens Falls Feeder Canal and Warren Street on the north to the Hudson River on the south. The ground drops steeply from an elevation of about 281 feet (USGS datum) along an abandoned towpath, on the south side of the Feeder Canal, to elevations of 265 to 270 at the top of the slope on the plant site proper, and then more gradually to elevations of from 235 to 240 feet on the top of the river bank. The river bank itself is quite steep and has been covered with stone rip-rap in some areas to protect it from erosion. Normal river elevations are in the 209 to 210 foot range.

A branch of the Delaware and Hudson Railroad passes through the site from east to west, and a number of sidings have been constructed to serve the plant. The railroad is on approximately the same grade as its surroundings in the easterly portion of the site, but is on fill above the surrounding ground level in the westerly section of the site.

The Glens Falls Feeder Canal is part of the New York State Barge Canal System. From May through December, this canal carries water from the Hudson River to the Champlain Canal, located northeast of the Village of Fort Edward. During this period, water levels in the canal generally range from three to four foot deep, and the water surface elevation is in the 277 to 278 foot range. The Feeder Canal water surface level is controlled by an overflow weir, located about 140 feet west of Building 47. The discharge over this weir formerly flowed to the Hudson River through a large gully known as Weir Brook, but, as manufacturing operations on the site expanded, the stream was diverted. It now flows through a 48-inch diameter drain pipe to the river



CIBA GEIGY
GLENS FALLS PLANT
SITE LOCATION MAP
AUG. 1987

FIGURE 1-

along a course which approximates the old stream channel in some reaches, but is as much as 50 feet away from the old channel in other areas.

A large portion of the site is either paved or occupied by buildings. As a result, most precipitation runs off rapidly and relatively little percolates into the ground. Uncontaminated storm water runoff is collected in a storm sewer system which extends over much of the site, while runoff from production areas which might be contaminated, such as diked enclosures around chemical tanks and dust collectors, is conveyed to the wastewater pretreatment plant via the industrial wastewater sewer system.

In 1983, Ciba-Geigy constructed a storm water retention basin in a portion of the parking lot on the east end of the site and eliminated a number of surface water discharges to the Hudson River and to the culverted Weir Brook. The basin receives drainage from the production area north of the Delaware and Hudson Railroad and east of Weir Brook, plus runoff from the area between Building 45 and the railroad tracks. After a storm event, the water in the basin is sampled and analyzed. Depending upon the results of these analyses, the water may be discharged to the River, or pumped to the pretreatment plant. However, the collected water has always been acceptable for discharge without pretreatment.

Surface water runoff from the areas west of Weir Brook and north of the railroad tracks enters Weir Brook, or the industrial sewer system in that area. Surface drainage from an old incineration area in the southwest corner of the site flows to the Hudson River, as does runoff from precipitation falling on the river bank or on the parking lot on the east end of the site. Runoff from roofs and paved areas surrounding production buildings between the river's edge and the railroad is collected by the industrial sewer system.

Sanitary sewage generated on the site is collected by a separate sanitary sewer system. This wastewater is pumped directly to the Glens Falls municipal sewage treatment plant.

Other wastewaters generated on the site include cooling water and backwash water from a process water filtration plant. A State Pollution Discharge Elimination System Permit (SPDES) has been issued to Ciba-Geigy Corporation for discharge to the Hudson River. These permitted discharge points are shown on the site plan on Plate 1 and are described in Table 5-3 in Section V of this report.

The wastewater pretreatment plant discharges to the Glens Falls Municipal Sewage Treatment Plant located on the Hudson River about 2000 feet west of the plant. The SPDES permit for the municipal plant includes allowances for wastes produced by Ciba-Geigy.

Potable water used on the Ciba-Geigy site is obtained from the Town of Queensbury municipal water supply system. Process water is obtained from the Hudson River and, for some processes which require colder water, from Old Production Well No. 7, located in the southeast corner of the parking lot at the east end of the plant site.

A system of bench marks has been established on the site. The locations of these vertical control points are shown on the site plan (Plate 1).

1.4 Site History

The origin of the Ciba-Geigy plant site dates back to January, 1901, when the American Wallpaper Company was incorporated for the purpose of manufacturing wallpaper. In July, 1915, Imperial Color Works, Inc. was formed in order to manufacture chemical pigment colors, and in July, 1916, Underwood Paper Mills, Inc. was formed for the manufacture of paper pulp. All three companies occupied portions of the present Ciba-Geigy plant site. In June, 1921, these three companies were consolidated into The Tait Paper and Color Industries, Inc. In March, 1929, the name of this consolidated company was changed to Imperial Paper and Color Corporation, and in January, 1959, the name was again changed to Imperial Color Chemical & Paper Corp. In 1960, the Imperial Color Chemical & Paper Corp. was purchased by Hercules, Inc., which sold the wallpaper division in 1962. In 1979, the Glens Falls site was acquired by Ciba-Geigy Corporation.

hydrogeologic survey was conducted by Dunn Geoscience Corporation. Twenty-one wells and fifteen subsurface borings were installed from 1980 to 1982. Two of the wells, Numbers 11 and 12, were subsequently destroyed during construction of a wastewater pumping station. The locations of all these wells, plus new wells drilled as part of this site assessment, are shown on the site plan (Plate 1).

1.5 Potential Sources of Contamination

Prior to preparation of the work plan for this assessment, a number of areas of material deposition had been identified on the Ciba-Geigy Main Plant Site; these included (1) the north waste pile, (2) south waste pile, (3) north lagoon, (4) the area south and west of Building 49, (5) a former incineration area in the southwestern corner of the site, (6) an area surrounding Buildings 48 and 56 and extending to a point on the easterly side of Weir Brook; (7) an area along the river bank south of Building 45; and (8) an area on either side of the railroad tracks, in what is now the parking lot in the eastern portion of the site. Subsurface borings installed during this assessment indicate that the area along the river bank from the incineration area on the west to the area south of Building 45 has been partially filled with tailings and related material. Thus, the three distinct areas (5 through 7 above) in that portion of the plant site identified in the work plan now appear to be a single area of deposition. Plate 2 presents a map of the site delineating the approximate extent of areas of deposition.

1.5.1 North Waste Pile, South Waste Pile and North Lagoon

The north waste pile, situated on soil and rock, covers approximately 49,200 ft^2 in area and extends from 20 to 30 feet above the original ground elevation. Located in the northwest corner of the plant site, it contains approximately 45,000 tons of materials which are predominantly tailings. It has not been used since June, 1978.

The south waste pile, approximately 45,600 ft^2 in size, was originally constructed in 1971 to 1972 as a waste water treatment plant sludge holding lagoon. The construction plans called for this lagoon to be lined with asphalt placed over a compacted, native subgrade. During construction of the lagoon, however, bedrock was encountered in the eastern two thirds of the excavation. A vertical rock ledge, apparently the edge of an abandoned limestone quarry, was found running in a north-south direction through the area. Ground water was encountered to the west of this ledge, and a series of 4-inch diameter perforated pipe underdrains were installed to dewater the excavation. Sand and gravel were compacted over the underdrains, and the lagoon was then sealed with asphalt. The drains under the asphalt lining have subsequently been cut and capped east of the south waste pile. This area was actively used for the storage of wastewater sludges from 1972 to 1976 and was then taken out of service and filled to about 25 feet above the surrounding ground elevation with general industrial wastes, filter cloths, laboratory samples, tank cleanings, plastics, discarded pigments, soil, broken concrete, and demolition debris until June 1978. The estimated quantity is 46,000 tons of solids.

The north lagoon, approximately 38,400 ft^2 in size, was also constructed in 1972. Because of the difficulties encountered in constructing the south lagoon (later the south waste pile), two 12-inch diameter, vitrified tile underdrains were installed above the bedrock along the northerly edge of the site to intercept ground water flowing southward from the Feeder Canal. These underdrains along the northerly edge of the north lagoon are connected to the plant's industrial sewer system, and the intercepted ground water is treated in the industrial wastewater pretreatment plant. The excavation was lined with a 30 mil chlorinated polyethylene (CPE) liner. The north lagoon contains an estimated 8,000 cubic yards of wastewater sludge.

This lagoon and the south waste pile were excavated in an area previously filled with tailings; the excavated tailings were deposited in the north waste pile.

A 24-inch reinforced concrete pipe culvert is located between the north lagoon and south waste pile. This pipe drains surface runoff from the adjacent cement company lands and, to a lesser extent, the north and south waste piles. This culvert leads to the Ciba-Geigy storm drainage system and discharges to the Hudson River via Weir Brook.

Plant drawings for the north lagoon and north waste pile indicate that an old stone culvert existed under the easterly end of the north waste pile. Plant personnel had attempted to locate this culvert in 1984 to alleviate a problem with ground water flowing upward under Building 49, but were unable to find it. They did, however, locate a stone culvert about 80 feet east of the location as shown on the plant maps, and piped the flow from this culvert to the drains leading to Weir Brook. It is not known whether the culvert which they found is part of the one shown on the plant maps or a different drain altogether. Both the culvert found in 1984 and the earlier mapped location of an old stone culvert are shown on the site plan (Plate 1). These culverts are in the general locations of leaks from the Feeder Canal shown on the 1912 maps of the canal system.

1.5.2 Area South and West of Building 49

South and west of Building 49 is an area approximately 41,700 ft^2, with an estimated 16,000 tons of material. An industrial sewer and a storm drain pass through this area. The storm drain follows the general course of an old drainage ditch, which formerly carried runoff from the northwest corner of the site to Weir Brook.

1.5.3 Area from West Property Line to East of Building 45.

The incineration area is located south of the south waste pile and the Delaware and Hudson (D&H) Railroad. It contains some ash from the former practice of burning factory debris, as well as other materials deposited. There are no known sewers or underdrains in this area.

An area exists immediately east of the incineration area, which extends around Buildings 56 and 48 and east, past Building 8, to a point south of Building 45. Buildings 48 and 56 may be constructed on tailings and other deposited materials. The sewers and other utilities serving all these buildings pass through this area, as does the lower reach of Weir Brook.

A small pumping station near the outlet of the Weir Brook culvert (West Pumping Station) receives ground water from an underdrain installed in the old bed of Weir Brook, and discharges it to the industrial sewer. A second small pumping station located on the river bank southeast of Building 8 (East Pumping Station) collects ground water from a trench drain in this area and also discharges to the industrial sewer.

The incineration area, the area around Building 56, and the river bank south of Building 45 comprise a continuous area approximately 386,000 ft^2 in size and contain approximately 116,000 tons of material, predominantly ore tailings.

1.5.4 East End of Plant Site

At the east end of the plant site in the present parking lot is an area of approximately 46,500 ft^2 located on either side of the railroad tracks. The area formerly contained a stockpile of chrome ore. The amount of material present is estimated at 7,000 tons. The construction of a storm water impoundment basin required excavation in this area in 1983. Only small amounts of ore were discovered at that time.

SECTION II
SITE INVESTIGATION

2.1 Site Reconnaissance

As part of Task 2 in the approved work plan, on May 13, 1986, staff from Malcolm Pirnie, Inc. and Ciba-Geigy Corporation conducted a site reconnaissance. Subsurface samples were collected from the north and south waste piles using a three-inch bucket auger and a one-inch soil auger. Three samples were taken from the north waste pile, one from a depth of one foot and two from a depth of two feet. Three samples were also taken from the south waste pile at depths of one foot, two feet, and four feet. The samples were analyzed at Ciba-Geigy's laboratory for metals.

No evidence of dead or dying vegetation was noted along the riverbank. There is no vegetation in the main plant area, where the surface is either paved or covered with crushed stone.

2.2 Search for Old Production Wells

A number of attempts were made to locate Old Production Well Nos. 5, 6, 8, and 9 (as part of Task 2 in the approved work plan). This included several visual inspections for any evidence of their location, which yielded no information. Hence, on May 5, 1987, a metal detector was employed in the search for Old Production Wells 5, 8, and 9. The metal detector was not utilized in the search for Old Production Well No. 6 due to the large number of buried pipelines, metal tanks, and buildings in its presumed vicinity. The ground in the presumed vicinity of the wells was thoroughly surveyed with the detector. When a strong reading was recorded, the area was dug up in search of the wells. However, none of the production wells have been located to date.

2.3 Visual Inspection of Riverbank and Sampling of Seeps and Sediments

On May 6, 1987, a visual inspection of the riverbank adjacent to the plant site was conducted by Malcolm Pirnie personnel as part of Task 2 of the approved work plan. The inspection of the riverbank revealed three areas where small amounts of water were coming out of the bank and draining into the river. The largest had a discharge of less than 1 gpm, and was located approximately 25 feet north of Soil Boring #10. The water was clear, but the ground surrounding the seep was blue to dark blue in color. Two trickling seeps were observed below the western corner of Building 56, and below the water pumping station just west of Building 56, respectively. These seeps were located on the bank of the river which is covered with rip-rap. No other seeps or springs were observed. The location of these areas is shown on Plate 2.

The inspection also revealed the presence of what appeared to be plant materials on the riverbank and in the riverbed. Samples of the riverbed material were collected by Malcolm Pirnie personnel for visual inspection by Ciba-Geigy personnel.

In August 1987, Ciba-Geigy and NYSDEC personnel also made a visual inspection of the riverbank. During the inspection trip, the NYSDEC identified seeps and areas of the river bank and bed where water and sediment samples should be taken for laboratory analysis. The samples were subsequently obtained by Aquatec, Inc. personnel and are currently being analyzed in Aquatec's lab. When received, these data will be submitted under separate cover. Sample locations are identified on Plate 2.

2.4 Subsurface Boring and Sampling Program

On February 5, 1987, subsurface work began. Sampling was completed on April 3, 1987. The specific objectives of the installation of subsurface borings were to:

- Determine the dimensions and physical characteristics of the materials deposited on site;
- Obtain and analyze representative samples of the materials deposited on the site;
- Identify and analyze representative samples of the soils which underlie the site; and
- Locate the elevations of sand, clay, and bedrock on site.

Malcolm Pirnie and Dunn Geoscience Corporation personnel observed the installation of subsurface borings and monitoring wells. A total of 78 borings were drilled and sampled during this time. The subsurface boring logs, presented in Appendix III, indicate the sequence and depth of split spoon samples. The borings were installed at various locations around the site as shown in Plate 2. During the installation of the subsurface borings, many proposed locations were modified due to the occurrence of both above and below ground utilities.

Samples for laboratory analysis were collected, stored, and preserved in accordance with the approved work plan. These samples were shipped to the Aquatec, Inc. laboratory.

2.4.1 Subsurface Boring Techniques

The subsurface borings were completed using conventional hollow stem auger drilling and sampling techniques. The drill rigs used in this subsurface investigation were a CME-55 mounted on an all-terrain vehicle and a Mobile-61 truck-mounted rig. The all-terrain vehicle was utilized in locations inaccessible to the truck-mounted rig. All split spoons were washed in potable water provided by Ciba-Geigy, from the Town of Queensbury Water Supply, after each sample was taken.

The subsurface borings were drilled using 6 1/2 inch OD (outside diameter) hollow stem augers, and samples were obtained (as per D1586-84 ASTM standards) and recovered with a two-foot long split barrel sampler (split spoon). The split spoon was advanced beneath the bottom of the augers and driven into the subsurface with a 140 pound weight. The weight was permitted to free fall 30 inches, and blow counts were recorded for each six-inch interval. In addition to density measurements, blow counts can serve to identify strata boundaries.

A bentonite pellet seal at least one foot thick was placed on the bottom of all borings that were drilled to the top of rock. Five feet of bentonite-cement grout was placed above the bentonite seal and the borehole was then backfilled to the surface with clean sand. Borings sampled to the top of the clay unit were cement grouted and backfilled from the clay surface to the ground surface.

At the north and south waste piles, continuous split spoon samples were taken from each boring. The samples recovered were composited in four-foot sections and placed in sterilized sample jars for analysis by Aquatec, Inc. Borings at the waste piles were augered and sampled to refusal, which in most instances can be interpreted as the top of bedrock. Where refusal occurred well above the expected depth of bedrock (due, for example, to encountering impenetrable rubble or wood), the boring was moved approximately five feet away and reinstalled.

At areas other than the north and south waste piles, borings were generally terminated after penetrating a minimum depth of two feet into native soil. However, representative geographic distribution of borings were drilled to the top of rock to better determine bedrock elevations across the site. Split spoon samples were taken in these areas to identify the thickness and areal extent of the materials, and to locate the depth to the top of the clay unit. In most instances, this required continuous sampling. Subsurface samples from the split spoon were used to develop a geologic log during the drilling of each boring. Selected split spoon samples were retained for visual inspection. A summary of the depths at which clay or rock were encountered in the borings is shown in Table 3-1 in Section III of this report.

The drill rigs and tools were steam cleaned prior to mobilizing on the site, before going from one deposition area to another, and before demobilizing from the site. The wash water and steam condensate were discharged to the industrial sewer and treated in the wastewater pretreatment plant.

2.5 Monitoring Well Installations

Twenty-six monitoring wells were installed on the plant site in accordance with the approved work plan. Six of these wells were constructed in the unconsolidated deposits overlying bedrock; eleven were shallow bedrock wells constructed to monitor water quality in the zone between 5 and 15 feet below the top of the rock surface, and nine were deep rock wells which monitor the ground water in the zone from 25 to 35 feet below the rock surface. In addition, monitoring wells 17 and 20, installed under the direction of Dunn Geoscience in the 1980-81 period, were modified to monitor zones similar to the new wells. Three piezometers were also installed to obtain additional data on ground water levels. The locations of these wells and piezometers are shown on the site plan (Plate 1).

Surficial, shallow bedrock, and deep bedrock wells were installed in clusters about 10 feet apart at locations specified in the work plan for most wells. Figures 2-1, a-c show typical well construction details, while construction details for each of the individual wells are included in Appendix IV. Table 4-2 in Section IV of this report summarizes elevation and monitoring zone data for the various wells and piezometers.

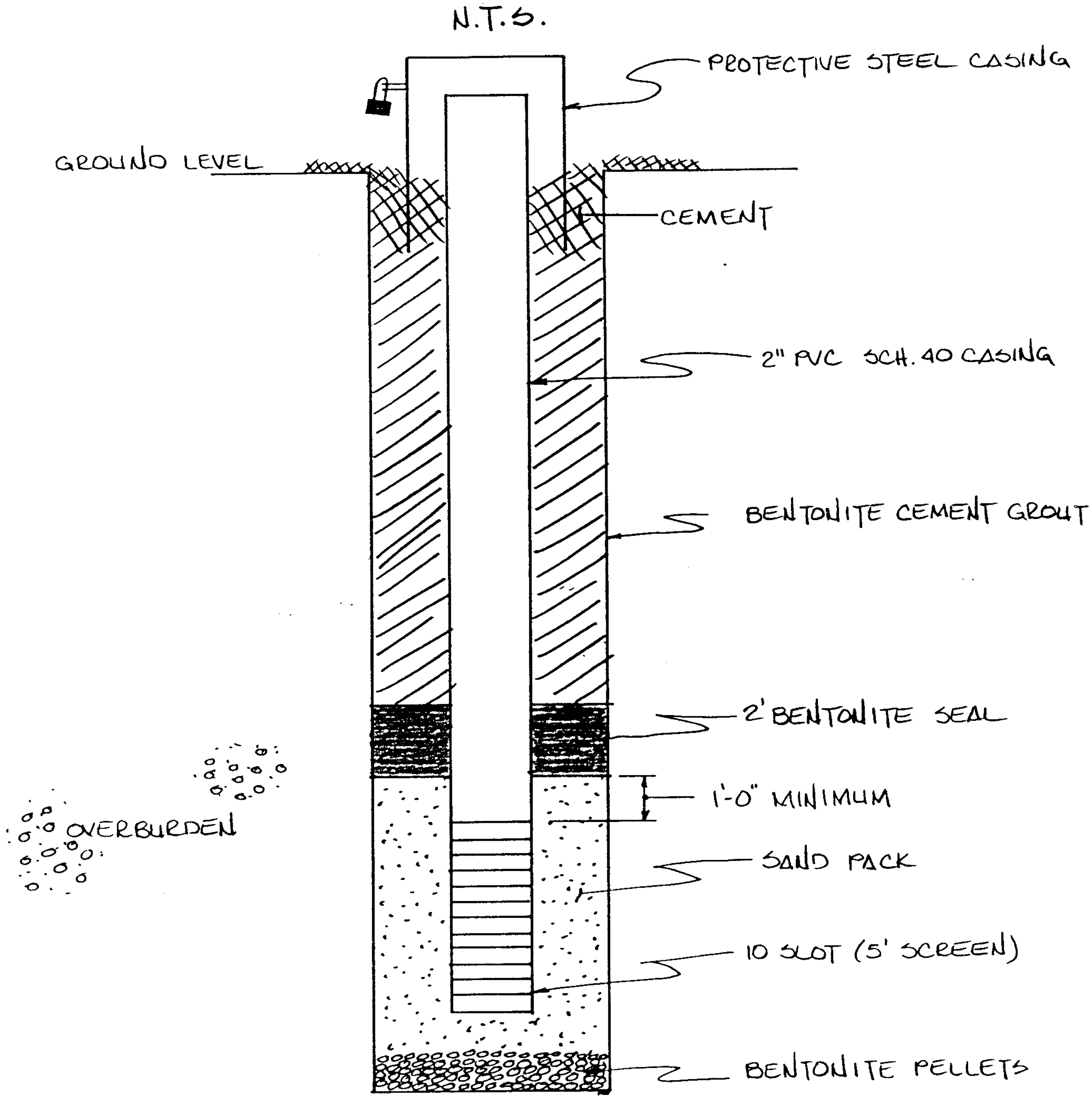
2.5.1 Surficial Well Installation

Two different drilling methods were used for construction of surficial wells. At those well sites where vertical permeability tests were to be conducted, a subsurface boring rig utilized four-inch flush joint steel casing to provide an undisturbed location for the permeability test. For the remaining surficial wells, a subsurface boring rig with hollow stem augers was utilized.

Continuous split spoon sampling was conducted in each surficial well bore hole. Upon completion of the subsurface sampling, the boring was backfilled with at least two feet of bentonite pellets and at least a half foot of filter sand. Two-inch PVC riser equipped with a five-foot length of 0.010 slot screen was placed on top of the sand. Additional sand was added to the annulus until the sandpack extended a minimum of one foot above the top of the screen. A two-foot thick bentonite pellet seal was then added above the sandpack, and the remainder of the boring was grouted with a cement-bentonite grout to the surface. A four-inch protective steel casing was placed over the two-inch PVC well riser to prevent unauthorized access and to provide protection for the PVC casing.

MALCOLM PIRNIE

TYPICAL SURFICIAL WELL CONSTRUCTION



MALCOLM PIRNIE

TYPICAL SHALLOW ROCK WELL CONSTRUCTION

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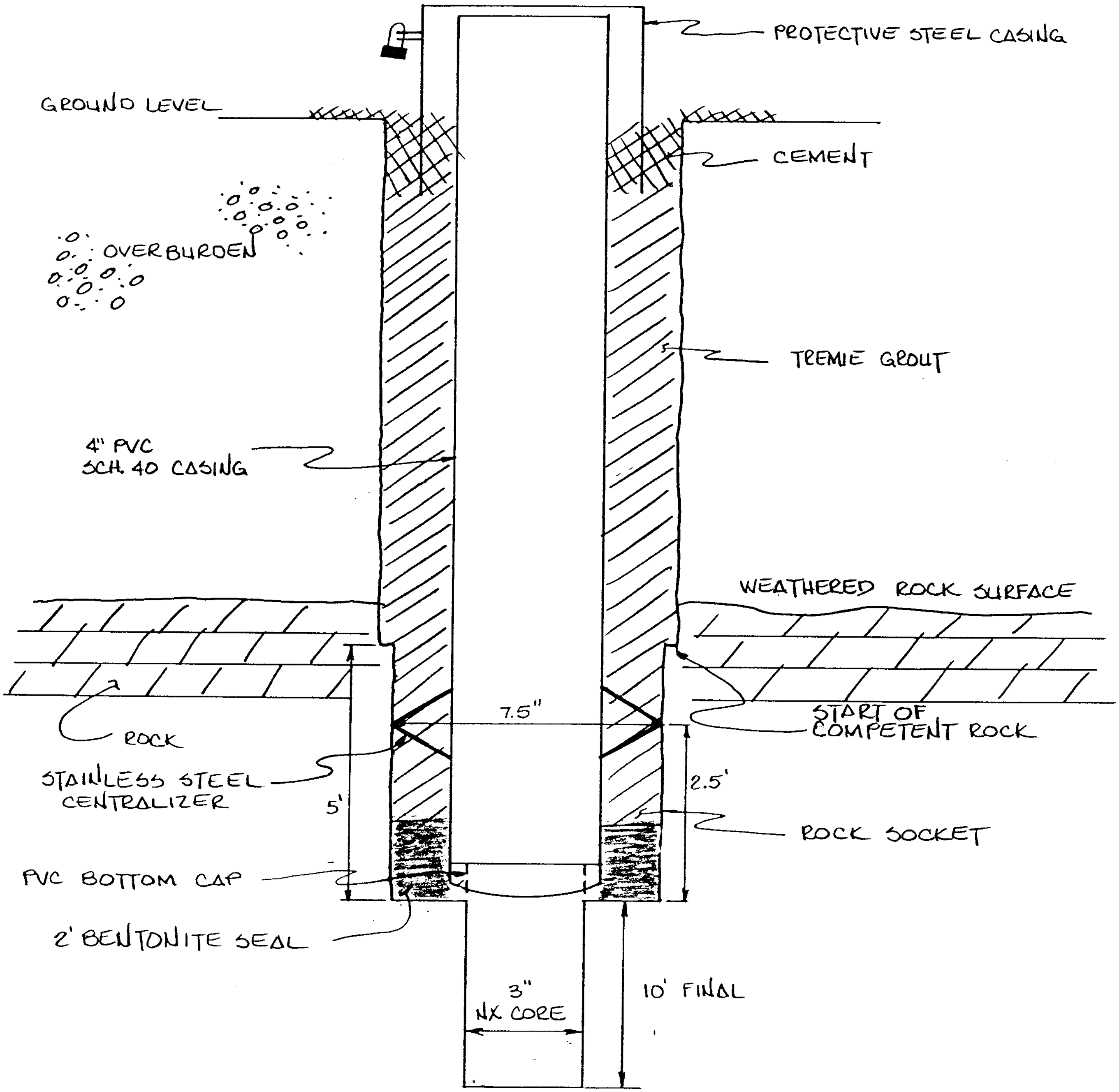
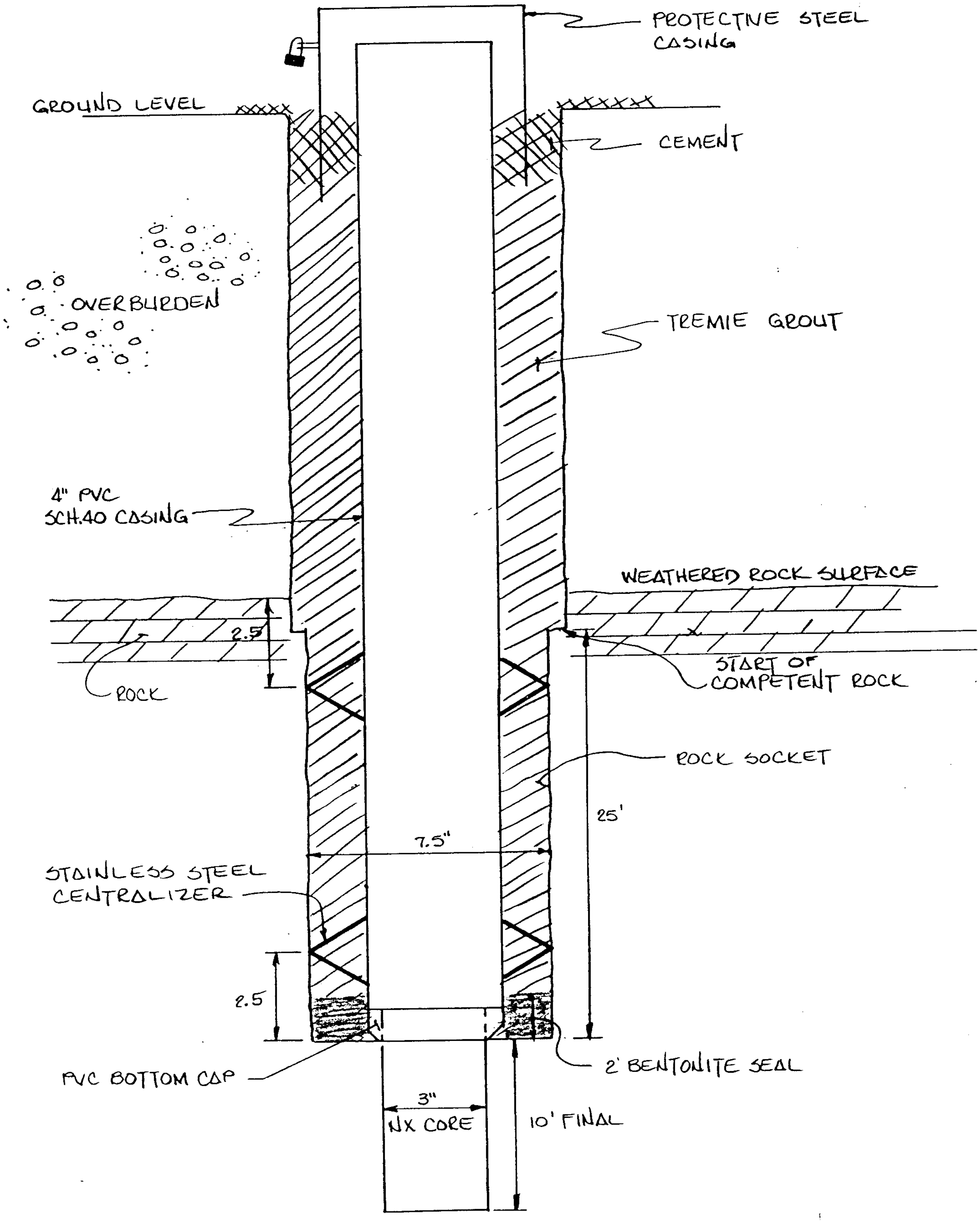


MALCOLM PIRNIE

TYPICAL DEEP ROCK WELL CONSTRUCTION

N.T.S.



Compressed air was used to evacuate all water from the well after construction, and to flush any fine grained material from the screen. Development was discontinued when the well water ran clear.

2.5.2 Bedrock Well Installation

As noted above, bedrock cluster wells were designed to monitor two discrete zones in the rock aquifer. The final ten feet of each new rock well is a three-inch diameter (NX) core hole. This ten feet of open rock hole is the zone monitored at each well. The total depths of these wells vary across the site and are dependent on the depth to rock at each well location. Rock cores were collected from each bedrock well and examined by Dunn Geoscience personnel. The core logs are included in Appendix V. Also included in Appendix V are the core logs for borings installed during the 1980-1981 investigation.

The bedrock wells were drilled with an Ingersoll-Rand air rotary drill, except monitoring wells MW-30S and -30D, for which the all-terrain CME-55 was modified to drill with a 7 1/2 inch diameter air hammer. This modification was necessary due to the positions of MW-30S and -30D on the steep river bank. The rock coring was done primarily with the Mobile-61, although the CME-55 and an Acker skid rig were also used to core rock.

For each shallow rock well installed, eight-inch casing was advanced to the top of rock or about one foot into rock, using an 8-inch air driven rock hammer. Drilling mud was not used to keep the hole open, because the casing was advanced with a drilling hammer. When the 8-inch casing was set in unweathered, competent rock, as determined by the rate of penetration and nature of the cuttings, a 7 1/2 inch rock hammer was used to make a five-foot deep rock socket. Four-inch diameter flush joint schedule 40 PVC casing was installed from the bottom of the rock socket to approximately one and a half feet above ground level. One stainless steel centralizer was fastened to the four-inch schedule 40 PVC to keep it central in the rock socket. A two-foot thick minimum bentonite pellet seal was then placed in the annular space between the four-inch PVC and the 7 1/2 inch rock socket. A 30 to 1 cement:bentonite grout was tremie-pumped into the annulus above the bentonite seal, and the eight-inch casing was removed. Sufficient time, at least 24 hours, was allotted to allow the grout to set before the final ten feet of NX core was drilled. The time necessary had been previously determined by measuring the length of time it took such a cement:bentonite grout mixture to harden in a bucket. The final ten-foot core holes were then bailed and the recovery observed to determine whether sufficient water for sampling had been encountered; if not, the holes would have been drilled deeper until enough water was present. However, this never proved to be necessary as each well yielded sufficient water for sampling with only 10 feet of open core hole.

An exception to these methods occurred in the installation of monitoring well MW-17A. In this case, the eight-inch steel casing was left in place, because of potential ground instability, while performing air rotary drilling. At another location, MW-31 in the embankment area south of Building 45, a considerable amount of wood was encountered. It was therefore decided to drill the overburden with 8 1/2 inch augers for MW-30S and MW-30D which were located in the same area. These holes were augered to rock, a bentonite-based drilling mud was pumped into place, and the augers were removed. The eight-inch casing was then set on rock. At one other location, MW-33S, the annular space was tremie-grouted with cement:bentonite grout. The two-foot bentonite seal was inadvertently not emplaced. NYSDEC was informed of this and agreed that this would not affect the integrity of the well.

For each deep bedrock well, a discrete zone 25 to 35 feet below the top of rock was to be monitored. Using an eight-inch air driven hammer, eight-inch steel casing was advanced to the top of bedrock, or approximately one foot into bedrock, depending on how deep the rock was weathered. The bedrock was then cored (NX) to a depth of 25 feet below top of rock using a three-inch OD diamond core barrel. The rock core (2 1/8 inches in diameter) was examined and logged in the field. The core hole was flushed with potable water obtained from the Main Plant Site during coring, to remove cuttings and to lubricate the core barrel. After coring to the desired depth, a 7 1/2 inch diameter rock hammer was used to ream the 25-foot NX rock core, thus creating a rock socket. Upon completion of the 25-foot rock socket, a four-inch schedule 40 PVC riser pipe was installed from the bottom of the rock socket to approximately one and a half feet above ground level. The four-inch PVC risers were fitted with bottom caps, which were later removed by core drilling.

A two-foot minimum depth of bentonite seal was employed at the bottom of the rock socket in the annular space between the four-inch PVC and 7 1/2 inch rock socket. The remaining hole was grouted using a 30 to 1 mixture of cement:bentonite grout as the eight-inch steel casing was removed. Two stainless steel centralizers were installed on the four-inch PVC to ensure that it was centralized in the rock socket. After a sufficient time was allotted for the grout to set, the final ten feet of NX core was drilled. The final ten feet of core hole was bailed to ensure that a sufficient amount of water had been encountered. The only exception to this deep bedrock well installation procedure occurred at monitoring well MW-33D, where two feet of bentonite pellets and a bottom cap were inadvertently not emplaced. This allowed the grout mixture to enter the four-inch PVC casing. The grout was subsequently drilled from the four-inch casing; all other specifications for the well construction were consistent with the work plan. The NYSDEC was informed of this and agreed that this was an acceptable well construction.

2.5.3 Conversion of Existing Wells

Existing Dunn monitoring well number 17 (Appendix V) was converted to monitor between the top of rock and 35 feet below top of bedrock. This was accomplished by leaving the Dunn well riser pipe in place and by pouring bentonite pellets into the hole, thereby sealing it up to a depth of 35 feet below the top of the rock or 45 feet below ground surface. This conversion was done so that the well could monitor a more distinct zone, instead of the 70 feet of open rock, which it had been previously monitoring.

In addition to the above, existing monitoring well MW-20 was converted into MW-20D. Both the protective casing and the PVC well riser pipe were removed from the well. An 8-inch casing was driven to rock in the open hole. The existing 3-inch core hole in the rock was then drilled out to eight inches in diameter for the full depth of the old well, and a 4-inch PVC pipe was grouted into the resulting rock socket. A 10-foot, NX core hole was then drilled in the rock through the PVC riser pipe. The PVC well riser pipe was set at the bottom of the original well because it was doubted that the old, 3-inch core hole could be increased to eight inches in diameter while remaining centered over the 3-inch opening. Also, fill/waste was encountered in the lower several feet of the old NX hole, so it was decided to make a completely new, converted well out of the old, existing one. The subsequent construction followed procedures used in other rock wells, except that the rock socket extends 30 feet instead of the usual 25 feet and the well monitors the zone 30 to 40 feet below the top of rock instead of 25 to 35 feet.

2.6 Video Tape Investigations and Packer Testing

Under Task 4 of the approved work plan, water level measurements were taken in Old Production Well Nos. 1 and 2 while they were packed off at various depths. These wells were also sampled at the packer zones with a submersible pump and bailer in order to obtain bedrock aquifer samples from distinct levels (Table 5-3). Old Production Wells 1 and 2 and monitoring well MW-15, were also investigated with a small diameter video televiewer to determine the extent and distribution of fracturing. A single packer was installed in MW-15 to determine the distribution of vertical gradients. No ground water samples were obtained from MW-15.

2.6.1 Video Tape Procedure

On February 3, 1987, video taping of Old Production Well Nos. 1 and 2 and existing monitoring well MW-15 was initiated. The video taping served two purposes. First, the fractured zones in the bedrock were recorded, and second, the zones for packer testing were identified.

The video taping entailed the lowering of a small diameter camera down through the well borehole and observing the fractured zones in the formation on a monitoring screen. A video tape was recorded for future reference. As the camera was lowered down into the well, the depth of the zone being viewed was recorded. When a fracture or other feature of interest appeared on the screen, the camera was stopped and rotated around the borehole to observe the extent of the fracture along the borehole wall. An accurate determination of the size of the fracture could not be made due to the distortion and magnification of the video lens and viewing monitor. However, the depths to the various fractures observed are shown in Table 3-3 in Section III of this report.

2.6.2 Packer Testing

In order to distinguish significant fractures in terms of bedrock hydrogeology from the numerous fractures observed from the video televiewer, and to obtain vertical head distributions and water samples, a system of inflatable rubber packers mounted on a steel pipe was used to isolate and test discrete fracture zones in the well borehole. The zones which appeared to include a large amount of fracturing or the presence of a potentially large fracture, as seen with the video televiewer, were selected for packer testing. A more detailed description of the packer testing procedure is presented in a discussion of the results of the packer tests in Section 4.4.

2.7 Horizontal Permeability Tests

Horizontal permeability tests were performed on all newly installed surficial wells and piezometers on April 27 and 30, 1987. The permeability tests provide estimates of the hydraulic conductivity of the material immediately surrounding the well screen, and were performed as described below.

First, the small diameter bladder pumps used for sampling were removed from the wells and time was allowed for the water table to return to its static level. The static water level was then measured and recorded, and the water level drawn down by removing several bails of water from the well. The recovery of ground water was measured at predetermined, regular time intervals and the results were computer-plotted on semi-logarithmic graph paper using a time lag analysis (Appendix VII). A best fit line was then drawn through the data points.

Wells MW-24, MW-26, and piezometers P-46 and P-71 show two limbs in the graphical representation (see Appendix VII). The first, or steeper limb appears to represent water which was stored in the sand pack and moved quickly into the well after it was bailed, while the second, flatter limb represents the actual rate of flow of ground water from the surrounding material (e.g., waste, sand, or clay). The permeability results have therefore been gathered from the second limb. This phenomenon is most pronounced in wells with low permeability because of the contrast between the permeability of the sand pack and the surrounding material. Wells P-53, MW-28, MW-31, MW-34 and MW-45 show only one straight line, and permeabilities have been computed from this single limb. Table 4-5 in Section IV of this report presents the results of the in-situ permeability tests.

SECTION III
GEOLOGY

3.1 Surficial Geology - General

Overburden units in the general geographic area of the Ciba-Geigy site include sand and clay from Pleistocene Lake Albany, as well as minor till and Holocene alluvium (Connally, 1973). The lake sand is very fine to pebbly, well-sorted, and well-drained. Horizontally stratified sand usually reflects bottomset deltaic deposits from the Glens Falls Delta extending from the ancestral Hudson River, while cross-laminated sand represents beach or pebble-poor deltaic deposits.

The lake clay consists of varved clay and silt, contains some sand and occasional boulders, and is poorly drained. The clay was deposited in lakes which formed in front of the glacier and represents continuous deposition in glacial Lake Albany.

The till may have a sandy or silty clay to clay loam matrix and varied amounts of cobbles and boulders; both compact (basal) and more loose (ablation) facies can be found. The alluvium consists of silt, sand, and gravel deposited on the floodplains of the Hudson River.

3.2 Surficial Geology - Site Specific

Results from the subsurface borings (Appendix III) provided information for preparation of the geologic cross-sections in Plates 2, a-e. These cross-sections indicate that the Ciba-Geigy plant site is underlain at various locations by the following overburden materials: fill/waste and soil on the site frequently occur in alternating layers or mixed within any one layer.

As used here, the term "fill/waste" refers to material resulting from or used in manufacturing processes on the site. By far the largest portion of this material is spent ore or ore tailings, from the former manufacturing process of extracting bichromate from chromium ore. The levels of residual metal in the ore tailings are very low. The ore itself also exists on the site, predominantly in the parking lot of the east end of the plant, where it was stockpiled during the Korean War.

The term "clean fill" identifies material, which was not laid down by natural depositional forces such as water or wind. Such material may either be native sediments reworked in place, or clean materials from some other area on site or off site which have been artificially emplaced.

The term "soil" describes sediments, such as sand, silt, clay, or gravel, which are undisturbed and have been deposited naturally by water or wind.

Till (gravelly, silty sand containing cobbles and boulders) occurs rarely on the plant site and is never more than a few feet thick. A layer of lacustrine clay underlies large sections of the site. This clay is stiff and grey or brown-grey; silt varves are prevalent, sand layers less so. The clay or varved clay and silt layers are typical of Lake Albany clays found through the area. Extensive testing of the soil at numerous sites along the upper Hudson River show it to have a permeability of generally less than $1x10^{-6}$ cm/sec and sometimes as low as $1x10^{-8}$ cm/sec. Even where in-situ permeability tests have been conducted in boreholes which intercept sand lenses or turbidites within the clay, the permeability of the soil is generally $1x10^{-5}$ cm/sec or less. The clay also exhibits good cation exchange capacity.

In order to define the elevation of the clay layer under the site, Table 3-1 has been prepared. This table summarizes data on the depth to clay and the elevation of the top of the clay layer, where present. The table also shows the thickness of overburden materials (depth to rock) and the elevation of the top of the bedrock surface for those borings which were drilled to bedrock. Where dashes appear under the heading "depth to clay", no clay was encountered. In SB-11, SB-35, SB-37, and SB-86, the borings ended in either fill or sand, and do not end in rock. Plate 3 provides a visual presentation of the areas of the site in which the clay layer was not encountered.

Additional data on the surficial geology of the site have been gleaned from old drawings of the plant site provided by Ciba-Geigy. They show, for instance, that the embankment immediately south of Buildings 36 and 40 has been cut back to varying degrees over the years. That portion of the river bank just west of Building 56 and east of MW-28, 27S, and 27D was built out.

TABLE 3-1
SUBSURFACE BORING INFORMATION

NUMBER	GROUND ELEV	DEPTH TO CLAY	DEPTH TO ROCK	TOTAL DEPTH	CLAY ELEV	ROCK ELEV	BOTTOM ELEV	ENDS IN
S.B.1	239.0	8.0	-	10.0	231.0	-	229.0	CLAY
S.B.2	238.6	7.0	-	8.0	231.6	-	230.6	CLAY
S.B.3	240.6	6.4	-	8.0	234.2	-	232.6	CLAY
S.B.4	240.5	8.0	-	8.0	232.5	-	232.5	CLAY
S.B.5	246.4	13.0	-	14.0	233.4	-	232.4	CLAY
S.B.6	245.3	10.0	-	10.0	235.3	-	235.3	CLAY
S.B.7	247.2	12.5	-	14.0	234.7	-	233.2	CLAY
S.B.8	246.3	12.0	15.0	15.0	234.3	231.3	231.3	ROCK
S.B.9	237.3	14.7	-	16.0	222.6	-	221.3	CLAY
S.B.10	217.1	-	16.0	16.0	-	201.1	201.1	ROCK
S.B.11	215.5	-	-	15.5	-	-	200.0	FILL
S.B.12	237.0	25.6	-	28.0	211.4	-	209.0	CLAY
S.B.13A	238.0	23.0	-	28.0	215.0	-	210.0	CLAY
S.B.14	237.8	6.0	-	14.0	231.8	-	223.8	CLAY
S.B.15	235.7	6.0	-	8.0	229.7	-	227.7	CLAY
S.B.16	237.5	20.8	-	22.0	216.7	-	215.5	CLAY
S.B.17	238.4	-	19.2	19.2	-	219.2	219.2	ROCK
S.B.18	237.1	5.0	-	8.0	232.1	-	229.1	CLAY
S.B.19	231.3	20.0	-	20.0	211.3	-	211.3	CLAY
S.B.20	235.2	12.4	25.0	25.0	222.8	210.2	210.2	ROCK
S.B.21	235.9	8.0	-	11.0	227.9	-	224.9	CLAY
S.B.22	237.3	7.5	-	10.0	229.8	-	227.3	CLAY
S.B.23	233.8	16.0	-	17.0	217.8	-	216.8	CLAY
S.B.24	236.0	15.0	-	16.0	221.0	-	220.0	CLAY
S.B.25	237.6	-	23.8	23.8	-	213.8	213.8	ROCK
S.B.26				NO BORING				
S.B.27	237.5	28.0	-	30.0	209.5	-	207.5	CLAY
S.B.28	240.1	10.0	-	14.0	230.1	-	226.1	CLAY
S.B.29	239.2	10.0	11.0	11.0	229.2	228.2	228.2	ROCK
S.B.30	238.4	-	12.6	12.6	-	225.8	225.8	ROCK
S.B.31	240.9	8.0	10.7	10.7	232.9	230.2	230.2	ROCK
S.B.32				NO BORING				
S.B.33	245.3	6.0	14.8	14.8	239.3	230.5	230.5	ROCK
S.B.34				NO BORING				
S.B.35	256.6	-	-	12.0	-	-	244.6	SAND
S.B.36	257.9	14.0	14.8	14.8	243.9	243.1	243.1	ROCK
S.B.37	257.4	-	-	16.0	-	-	241.4	FILL
S.B.38	258.1	12.2	13.5	13.5	245.9	244.6	244.6	ROCK
S.B.39	258.1	-	14.8	14.8	-	243.3	243.3	ROCK
S.B.40	269.6	-	25.5	25.5	-	244.1	244.1	ASPHALT LINER
S.B.41	275.1	-	-	29.4	-	-	245.7	ASPHALT LINER
S.B.42	277.5	-	-	31.1	-	-	246.4	ASPHALT LINER
S.B.43	280.2	-	-	37.0	-	-	243.2	ASPHALT LINER
S.B.44	282.2	-	-	36.4	-	-	245.8	ASPHALT LINER
S.B.45	281.4	-	23.5	23.5	-	257.9	257.9	ROCK
S.B.46	276.8	-	21.4	21.4	-	255.4	255.4	ROCK
S.B.47	281.0	-	26.5	26.5	-	254.5	254.5	ROCK
S.B.48	280.5	20.0	21.5	21.5	260.5	259.0	259.0	ROCK

TABLE 3-1
SUBSURFACE BORING INFORMATION

NUMBER	GROUND ELEV	DEPTH TO CLAY	DEPTH TO ROCK	TOTAL DEPTH	CLAY ELEV	ROCK ELEV	BOTTOM ELEV	ENDS IN
S.B.49	240.0	-	14.5	14.5	-	225.5	225.5	ROCK
S.B.50	242.0	18.0	19.0	19.0	224.0	223.0	223.0	ROCK
S.B.51	242.6	10.0	-	11.0	232.6	-	231.6	CLAY
S.B.52	240.6	-	17.7	17.7	-	222.9	222.9	ROCK
S.B.53	240.2	13.0	-	14.0	227.2	-	226.2	CLAY
S.B.54	240.2	11.0	13.0	13.0	229.2	227.2	227.2	ROCK
S.B.55	239.6	11.0	-	12.0	228.6	-	227.6	CLAY
S.B.56	236.6	9.2	-	14.0	227.4	-	222.6	CLAY
S.B.57				NO BORING				
S.B.58	238.1	10.5	-	18.0	227.6	-	220.1	CLAY
S.B.59	236.6	8.0	24.0	24.0	228.6	212.6	212.6	ROCK
S.B.60	237.3	14.2	22.5	22.5	223.1	214.8	214.8	ROCK
S.B.61	240.2	11.0	-	12.0	229.2	-	228.2	CLAY
S.B.62	241.8	10.0	-	11.0	231.8	-	230.8	CLAY
S.B.63	240.7	10.0	-	11.0	230.7	-	229.7	CLAY
S.B.64	239.8	11.8	-	12.0	228.0	-	227.8	CLAY
S.B.65	240.0	9.2	-	12.0	230.8	-	228.0	CLAY
S.B.66	241.1	12.0	13.5	13.5	229.1	227.6	227.6	ROCK
S.B.67	242.0	11.5	-	12.0	230.5	-	230.0	CLAY
S.B.68	242.5	14.5	-	16.0	228.0	-	226.5	CLAY
S.B.69	244.0	12.5	-	14.0	231.5	244.0	230.0	CLAY
S.B.70				NO BORING				
S.B.71	242.3	10.0	-	10.5	232.3	-	231.8	CLAY
S.B.72	244.0	12.0	-	12.5	232.0	-	231.5	ROCK
S.B.73	244.7	10.5	-	12.0	234.2	-	232.7	CLAY
S.B.74				NO BORING				
S.B.75				NO BORING				
S.B.76	249.1	0.5	-	4.0	248.6	-	245.1	CLAY
S.B.77	257.4	4.0	-	6.0	253.4	-	251.4	CLAY
S.B.78	256.2	5.0	-	5.0	251.2	-	251.2	CLAY
S.B.79	257.9	10.0	-	11.0	247.9	-	246.9	CLAY
S.B.80				NO BORING				
S.B.81				NO BORING				
S.B.82				NO BORING				
S.B.83				NO BORING				
S.B.84				NO BORING				
S.B.85	244.3	10.0	-	12.0	234.3	-	232.3	CLAY
S.B.86	243.5	-	-	5.0	-	-	238.5	SAND
S.B.87	246.2	-	16.5	16.5	-	229.7	229.7	ROCK
S.B.88	254.0	10.0	-	10.0	244.0	-	244.0	CLAY
S.B.89	258.6	-	14.5	14.5	-	244.1	244.1	ROCK
S.B.90	258.2	11.0	13.0	13.0	247.2	245.2	245.2	ROCK

Weir Brook was straightened when culverted, and formerly discharged to the Hudson River at the location of a small pumping station approximately 80 feet east of its present discharge point. A small stream or ditch joined Weir Brook south of the railroad tracks, after flowing through two small ponds to the east of Building 48. A larger ditch once led from what is now the north lagoon/waste pile area, which at the time was swampy ground; this ditch continued eastward, south of Building 49, until it joined Weir Brook. Its channel was as low as elevation 242 feet. The bed of Weir Brook itself was as low as elevation 216 feet, and old maps indicate that it had eroded its channel down to bedrock.

Many drawings of building foundations show that footings have been constructed on bedrock and are surrounded by perforated pipe or tile drains. These drawings typically do not describe the types of soils excavated during construction, but only indicate that the footings were to be poured directly on the rock or on a layer of crushed stone or compacted sand and gravel placed over the rock.

3.2.1 Occurrence of Fill/Waste, Clean Fill and Soil

The geologic cross-sections presented on Plates 2, a-e (see Plate 2 for locations of sections) help depict the surficial geology of those areas of the site in which subsurface borings were made. Geologic cross-sections A-A' and B-B' indicate the following:

- Layers of silty clay and clay up to several feet underlie portions of the westerly end of the north waste pile, but were not encountered at subsurface boring 46 in the center of the pile. This pile contains a thickness of about 19 to 26 feet of predominantly ore tailings. Rock was encountered at depths between 21.4 and 26.5 feet below ground surface. The south (downgradient) end of the north waste pile is located directly on bedrock.

- The north lagoon is constructed on or very close to bedrock. Construction drawings call for a 12-inch minimum thickness of sand immediately under the chlorinated polyethylene (CPE) liner for this lagoon.

- The south waste pile is also constructed on or very close to the bedrock surface. Rock ledges encountered during the construction of the former south lagoon indicate that limestone might have been quarried in this area before it became part of the pigments manufacturing plant. The south waste pile consists of fill/waste (ranging from about 25 to 36 feet thick) above the asphalt liner and bedrock. Subsurface boring 43 in the western end of the pile recovered one foot of silt and clay soil just before refusal at 37 feet below the ground surface.

- The D&H Railroad appears to be constructed on an embankment placed over natural soil in this area. Although no borings were made immediately adjacent to the track bed, SB-77, 78 and 79 on a shelf of higher, wooded ground just south of the track found silty sand and sand as the uppermost soil strata.

- Fill/waste extends from the top of the river bank to near the base of a wooded slope south of the D&H Railroad. This material is predominantly ore tailings, and is in excess of 10 feet thick in places. It overlies clay or a thin layer of sand found above the clay in some areas.

Section C-C', a north-south section taken east of the north and south waste piles and along the westerly side of Building 56, shows that fill/waste was encountered north of the Feeder Canal in the soil surrounding MW-24. It is presumed that the quarry north of the canal and just west of MW-24 may have extended into this location in the past. Inasmuch as the Feeder Canal predates any known pigment manufacturing operations on the site, it is assumed to be constructed on natural soil.

South and west of Building 49, fill/waste material 1 to 14 feet thick was encountered. The greater thicknesses occur in the southern and western portions of the drilled area. Soil in the form of sand 0.8 to 2 feet thick underlies the fill/waste in SB-35 and 36, while silt and clay with small amounts of sand and gravel underlie the fill/waste in SB-90 to the west of

Building 49. Rock was encountered at depths of 13 to 14.8 feet below the ground surface in SB-36, 38, 39, 89, and 90; in the other borings, rock was not encountered.

South of the railroad, between Building 48 and the river bank, the borings also encountered a relatively thick layer of fill/waste again predominantly ore tailings, overlying silty sands and clay. Construction drawings for Building 56 show that the top of the river bank was formerly located about where the southerly wall of the building now stands, and it is believed that the area between the building and the top of the existing river bank consists entirely of clean fill or a mixture of clean fill and fill/waste.

Sections D-D' and E-E' are taken generally parallel to the river bank. Section D-D' extends from the westerly property line of the site to a point near the east end of Building 45, as shown on Plate 2, and shows fill/waste overlying natural soil throughout its length. Subsurface boring 60, on the west end of the site, shows only a few feet of fill/waste material at the ground surface while SB-12 at the east end of this section found about 20 feet of fill/waste on the river bank near the east end of Building 45. The section also indicates that the layer of clay over bedrock varies greatly in thickness and has an undulating surface.

On the embankment south of Building 45, 2 to 20 feet of fill/waste were encountered; this was sometimes mixed with clean fill, especially in the topographically lower borings, SB-10 and SB-11. Borings SB-9, 12, 13, and 14 were terminated in clay soil; SB-10 reached bedrock at 16 feet. SB-11 ends in a fill/waste-clean fill mixture.

Section E-E' shows that fill/waste extends from Boring 73, located about 150 feet from the west property line, to the west side of Building Number 8. The section also shows that the clay and silt and clay layers over bedrock are generally thin in this area and do not exist near boring 49.

Subsurface borings at the eastern end of the site in the parking lot area encountered fill/waste from chrome ore storage ranging in thickness from 0 to

12 feet. Soil in the form of sand occurred between 4 and 16 feet below ground surface, and clay soil was found as shallow as 6.4 feet. Subsurface borings SB-8 and SB-87 north of the railroad tracks reached bedrock at 15 and 16.5 feet, respectively. Subsurface borings SB-5 and SB-86 terminate in sand, and SB-1, 2, 3, 4, 6, 7, and 85 end in clay, while SB-88 (installed near MW-33S and 33D) terminates in silt and clay. Borings at the perimeter of the drilled area contain little to no fill/waste.

3.2.2 Calculation of Fill/Waste Volumes

As a result of the subsurface drilling investigation for the Ciba-Geigy Preliminary Site Assessment, five specific areas containing fill/waste were identified on the site: (1) the north waste pile, (2) the south waste pile, (3) the area south and west of building 49, (4) the area extending from the incineration area to the Hudson River bank south of building 45, and (5) the area in the parking lot on either side of the railroad tracks (see Plate 2). No drilling was conducted in the north lagoon, but this facility is known to contain about 8,000 yd^3 of wastewater plant sludge. In response to Task 8d of the approved work plan, calculations have been made of the quantities of fill/waste which have been deposited on the site. To make the calculation, the five areas were graphically divided into grids 50 feet x 50 feet in size, generally with a subsurface boring as the centroid of the grid. The thickness of fill/waste encountered in the specific boring (see Appendix III) was then assigned to the grid. Where the subsurface borings indicated a substantial thickness of clean fill, the volume of clean fill was not included in the calculation. Therefore, the calculations are for fill/waste only.

Where a 50-foot sequence grid did not contain a subsurface boring, the depth of fill/waste in the grid was estimated from adjacent borings. Thicknesses of fill/waste were calculated only to the edge of the areas where subsurface borings were installed. No extrapolation was made beyond the subsurface investigation limits.

Conversion from volumes in cubic feet to tons for the specific areas in question, except the parking lot, was accomplished by using a specific weight of 108 lbs/ft^3, the average value for natural fine to very fine grained soils

(Peck, Hanson & Thornburn, 1974). This was utilized since the predominant fill/waste type in these areas was reddish to reddish brown ore tailings, which was itself fine to very fine grained. For the parking lot, a specific weight of 121 lbs/ft^3 was used, which is the average value for natural medium to coarse grained soils, since the most common fill/waste here was chrome ore. These conversions were made to better compare volume estimates from the present study to previous estimates made by Ciba-Geigy. The results are summarized in Table 3-2:

Table 3-2
Estimated Tons of Fill/Waste Materials in Areas Investigated

	North Waste Pile	South Waste Pile	Building 49	Inc. Area-Building 56-Building 45	Parking Lot
Previous Ciba-Geigy Estimates (tons)	100,000	47,000	21,000	Unknown + 121,000 + 24,000	Unknown
Present Estimates (yd^3)	30,787	31,343	10,741	79,676	4,167
Present Estimates (tons)	45,000	46,000	16,000	116,000	7,000

3.3 Bedrock Geology - General

The city of Glens Falls and the Ciba Geigy Main Plant Site are situated near the confluence of several geologic provinces. To the north and west lie the Adirondack Mountains whose present petrologic character was formed during the Grenville Orogeny, a mountain-making episode dated at approximately 1.1 billion years ago. These Precambrian aged rocks are often referred to as "basement" rocks and underlie all of the younger sediments in New York State, outcropping only in the Adirondack Mountains and the greater New York City area. These rocks underlie the Ciba Geigy Main Plant Site at an approximate depth of 900 feet. They generally possess no effective porosity and only poor secondary fracture permeability with typical 6-inch homeowners' wells producing less than 5 gpm. Because of their considerable depth beneath the site, their poor permeability, and the hydrogeologic setting of the younger rocks above they are concluded to have no influence on the present study; they are mentioned here only to complete the record.

Immediately overlying the Precambrian basement rocks in the study area, and separated by a pronounced unconformity, are the upper Cambrian aged Potsdam Sandstone and Ticonderoga Formation. The lower Potsdam Sandstone represents a prograding beach from a shallow sea moving from southeast to northwest. Its mineralogy is typical of beach facies in that it is comprised chiefly of rounded quartz grains that have since been recemented by siliceous solutions to form an almost pure silicate rock. Because of the silicate cement the rock possesses almost no effective porosity like the basement rocks beneath, though it does possess some secondary fracture permeability. This rock type also has no effect on the present study because it underlies the site at a depth of approximately 700 feet.

The Potsdam grades transitionally upwards into the Ticonderoga Formation, an interbedded sequence of highly siliceous sands and variably sandy dolostones. These represent a shallow shelf sequence and are seen in equivalent units around the Adirondack periphery. Like the two preceding rock types, the Ticonderoga Formation is too deep underneath the Main Plant Site (700 feet) to affect the present study.

The paleoenvironment of a broad continental shelf persisted into Early Ordovician time (500 to 465 million years ago) with the deposition of the Beekmantown Group. This is a series of carbonates and minor sands that extend upwards in the stratigraphic column until they are truncated by the Knox Unconformity, which represents a period of uplift and erosion possibly associated with the very beginnings of closure of the Proto-Atlantic Ocean. The thick, Beekmantown carbonates represent a fairly continuous record of deposition interrupted by only a few minor disconformities.

The Beekmantown Group is comprised principally of dolostones which may be variably limey and sandy. Paleokarst fillings are quite common beneath the disconformities and the Knox Unconformity. Calcite, too, is relatively common as vug fillings and fracture fillings. Despite their carbonate makeup, the rocks of the Beekmantown Group are not known to be prone to solution cavities anywhere in their outcrop breadth around the Adirondack periphery. They also possess little if any primary porosity and instead transmit water by secondary fracture permeability as do the underlying rocks. In fracture or fault zones the amount of water transmission can occasionally be considerable (in excess of 100 gpm) though more normal yields are from 5 to 10 gpm.

The transgression of Late-Medial Ordovician (450-440 million years ago) seas over older eroded strata was extensive. The paleoenvironments ranged from supra-tidal to distal subtidal shelf to proximal slope. The Black River Group, consisting of limestones, was the first group of rocks to be deposited in these seas, and is represented in the study area by the Isle La Motte Limestone. An intermediate, earlier member, the Amsterdam Limestone is approximately 40 feet thick in the Saratoga Springs area but is absent under the Main Plant Site. The Isle La Motte is approximately 65 thick in the study area and outcrops on the western end of the Main Plant Site while the underlying Beekmantown dolostones outcrop on the eastern end juxtaposed by the Knox Unconformity.

The Isle La Motte is easily distinguished by its massive, fine-grained texture and dark grey color, consistently N3 to N4 as determined by a standard color chart. Despite its limey nature, the Isle La Motte does not exhibit any evidence of karsting in its outcrop area or in the drill core from this study. Instead, its permeability is secondary fracture permeability with water being transmitted along joints and bedding planes. Typical yields for a 6-inch well may average 5 to 10 gpm with higher values in faults and fracture zones.

This completes the statigraphic column as it relates to the study area with the Isle La Motte Limestone being the youngest or uppermost rock on the plant site. However, several other points of general interest to this study should be mentioned.

First, it is important to note that there are no significant shale units which might act as aquicludes within the stratigraphic column. It is also important to note that none of the above rocks possess effective primary porosity; all transmission of water is via secondary permeability along joints and bedding planes. Further, despite the fact that most of the immediately affected rocks are carbonates, there is no evidence that karsting is a factor to be considered with regard to water transmission or should even be suspected of being a factor. In fact, all available evidence is to the contrary.

The younger overlying rocks such as the Glens Falls Limestone of the Trenton Group and the Snake Hill Shale have not been discussed because they do not directly impinge upon the study area. Also not directly of interest are the rocks a few miles to the east of the Taconic Allochthon. Of possible interest, however, is their associated thrust faulting, and, in a larger sense, faulting around the Adirondack periphery.

Fisher (1984) identifies eight separate episodes of faulting present in the greater Glens Falls-Whitehall area. Several of these are low-angle thrusting episodes associated with the Taconic Orogeny. Most workers have identified the cessation of these events with the melange sequences to the east overriding the autochthonous shelf rocks. Recent work (Whitney and Davin, 1987) has identified possible thrusting in the basement rocks near Whitehall associated with the later Taconic event but nowhere at this writing have low angle thrust faults been identified within the autochthonous shelf rocks such as are found under the Main Plant Site.

Conceivably of more interest are the later episodes of block faulting associated with the doming of the Adirondacks. Young (in preparation, 1987) has proposed that Neogene aged block faulting associated with the Adirondack uplift is displayed in the carbonates surrounding the Adirondack periphery associated with pronounced undenuded topographic scarps. Nowhere under the Main Plant Site are topographic scarps evidenced or in the immediate vicinity investigated. In fact, as will be discussed under the site specific bedrock geology, all available evidence points toward the fact that while discernible block faults can be identified several miles distant, the Main Plant Site and immediate surroundings appear to rest within a large undisturbed block.

3.4 Bedrock Geology - Site Specific

As was mentioned in the general geology section, outcropping bedrock on the site is comprised of two varieties of carbonates separated by a pronounced unconformity--the Knox Unconformity. The older or lower rocks are dolostones of the Fort Ann Formation of the Beekmantown Group. They are various shades of grey from a dark (N3) grey to light (N5 to N6) greys, contain various calcite (rose and white) vug and fracture fillings, and extensive local primary slump features. Despite the "look alike" character of the dolostones of the Beekmantown Group the identity of this formation is made with relative surety because of the close agreement of the lithologic descriptions with published accounts and the drill core log of Old Production Well No. 2 on the Main Plant Site in Fisher (1984).

As can be seen on the geologic cross sections accompanying this report, the lower dolostones of the Fort Ann Formation outcrop only on the eastern half of the Main Plant Site because they are controlled by the irregular Knox Unconformity. The unconformity dips downward toward the western half of the site exposing the rocks above. These rocks can also be identified as units of the Isle La Motte Limestone, a consistent series of N3 to N4, massive and medium to thickly bedded limestones. The trough represented by these limestones thins to the north so that not far off the site to the north the Isle La Motte Limestone probably pinches out to be supplanted by the lower Fort Ann dolostones.

Although it is not recorded in the literature, it should be noted that a thin intermediate unit, the argillaceous Amsterdam Limestone, which is approximately 40 feet thick in the Saratoga Springs vicinity, is not encountered beneath the Isle La Motte Limestone. Instead, it is represented by an ill defined facies change of shaley limestone, one to two feet thick, in only some of the boreholes. In other boreholes the transition from limestone to the dolostones is abrupt without an argillaceous facies being present.

It should be noted that while the rocks above are described as being present at the Ciba-Geigy Main Plant Site, they do not actually outcrop but are buried beneath a thin veneer of glacial debris and manmade fill. In fact, for this reason there is very little natural outcropping in the vicinity. Consequently, the geologic map of the area produced by Fisher (1984) is somewhat in error with regard to the Main Plant Site and vicinity. The detection of the Knox Unconformity and the limestones above is a function of hard evidence of drill core, and should be considered much more definitive than the geologic map.

The rocks of the study area dip southeastward at a low dip angle of approximately 2.2 degrees, and their strike is approximately N70 E. These facts relate to the flow of ground water beneath the site, as is discussed in the section on hydrogeology.

The cement quarry across the Hudson River from the Ciba-Geigy plant was visited during mid July. Complete structural continuity with the rocks of the Ciba-Geigy Main Plant Site was observed. Accordingly, the Hudson River is not fault controlled in this portion of its course, and there are no faults on or adjacent to the site that would act as ground water conduits. Also noted was a two-inch artesian well in the bottom of the westernmost portion of the quarry at approximate elevation 111.5 feet. The eastern end of the quarry across from the Ciba-Geigy Main Plant Site is somewhat higher than in the western end of the quarry, the floor being excavated down to an approximate elevation of 158 feet.

With regard to structural geology, there is no evidence of faulting (normal, reverse, or thrust) on site nor immediately adjacent to the site. Instead, all available evidence points toward there being stratigraphic continuity across the Main Plant Site and in the vicinity.

As noted in Section 2.6, a video televiewer was used to identify the extent of fractures in the rock boreholes of Old Production Well Nos. 1 and 2 and MW-15. A number of fracture zones were identified during this work. In Old Production Well No. 1, sixteen discrete fractures were observed with the video camera. In MW-15, nine fractures were identified using the video camera. In Old Production Well No. 2, eleven fractures were identified, all of which were in the upper 120 feet of a total of 260 feet viewed. Table 3-3 shows the depth at which these fractures were identified. However, only a few of the fractures viewed in the three wells appeared to be water-bearing or fractures through which water exits the borehole. Therefore, only a few of the fractures may be significant in terms of the bedrock hydrogeologic regime.

Several of the fractures were rimmed by rounded concretions that could not be an artifact of the drilling process. The most probable interpretation is that they are calcium carbonate concretions derived from ground water with an excess of calcium. This interpretation is discussed more fully in the section on calcium carbonate equilibria, Section 4.3.

Two production wells on site are known to produce in excess of 100 gpm, indicating the possible presence of extensive fracture zones. Old Production Well No. 3 near the center of the site produced water in these quantities as does Old Production Well No. 7 located on the extreme eastern portion of the site adjacent to the Hudson River.

During the drilling of boreholes and from review of core logs for wells installed during this project some fracturing was noted. Specifically, wells 20S, 20D, 27D, 29S (bottom 3 feet), 30D, 35D, 36D, and 40D revealed zones of fragmented and fractured rock.

Table 3-3

VIDEO TAPE OBSERVATIONS OF FRACTURE ZONES
(feet below top of casing)

Zone #	Well No. 1	Zone #	Well No. 2	Zone #	MW - 15
1)	22.30	1)	10.5	1)	24.6
2)	28.86	2)	17.06	2)	25.26
3)	36.74	3)	19.35	3)	38.70
4)	54.45	4)	25.26	4)	39.03
5)	70.19	5)	35.42	5)	40.34
6)	72.82	6)	37.72	6)	42.31
7)	87.90	7)	45.26	7)	42.97
8)	101.68	8)	81.67	8)	43.62
9)	103.32	9)	83.97	9)	45.92
10)	104.30	10)	93.81		
11)	104.96	11)	102.01		
12)	107.58				
13)	120.38				
14)	120.70				
15)	121.36				
16)	126.61				

SECTION IV
HYDROGEOLOGY

4.1 General

Information gained from the 26 new wells and three piezometers installed during this study, the 21 wells installed in the early 1980's, and two old production wells which were investigated provides a significant amount of data on the hydrogeology of the plant site. In-situ permeability tests conducted in wells drilled in the overburden soils on the site provide the basis for an estimate of groundwater flow rates in the surficial aquifer, and the subsurface borings installed in the overburden have yielded information on the location of clay layers which act as aquicludes.

4.2 Ground Water Contour Maps

Two rounds of water level measurements were performed April 28 and May 29, 1987. The water surface elevations are shown in Table 4-1, because the wells had not been fully developed by early April.

Strong downward vertical gradients exist in the ground waters on the site. The water surface elevations in the surficial aquifer wells are generally higher than those recorded for the shallow bedrock wells. The shallow bedrock wells, in turn, showed higher potentiometric surfaces than adjacent, deeper bedrock wells.

Based on the historic data from the wells installed during the early 1980's, it was anticipated that the clay layer overlying bedrock in parts of the site acted as an aquiclude to separate the surficial and bedrock aquifers. However, it was not anticipated that downward vertical gradients existed in the bedrock ground waters themselves. The data on the paired, shallow and deep bedrock wells installed for this study indicate that the bedrock wells installed during 1980 and 1981, were of little use in determining the piezometric surface of the bedrock aquifer on the site. These older wells, exhibit a potentiometric surface which is a composite of the water pressures over as much as 70 feet of rock. These wells were not used in preparing bedrock ground water contour maps.

Table 4-1

Water Level Elevations* In Monitoring Wells

Well No.	Water Elevation April 28, 1987	Water Elevation May 29, 1987
MW-1	216.01	211.0
MW-2	230.91	236.49
MW-4	210.41	209.30
MW-5	213.43	DRY
MW-6	220.64	219.27
MW-7	DRY	DRY
MW-8	229.66	229.03
MW-9	237.45	236.08
MW-10	231.41	231.20
MW-13	207.64	206.78
MW-14	217.96	DRY
MW-15	233.70	233.50
MW-16	DRY	268.72
MW-17D	285.08	284.11
MW-17S	284.97	283.98
MW-18	282.53	282.38
MW-19	239.30	235.93
MW-20S	245.77	245.06
MW-20D	221.97	221.55
MW-21	213.62	213.30
MW-22	225.43	230.81
MW-23S	264.80	264.07
MW-23D	241.39	244.56
MW-24	275.03	275.17
MW-25S	219.64	219.59
MW-25D	194.37	195.91
MW-26	231.32	230.56
MW-27S	209.88	210.23
MW-27D	201.96	201.73
MW-28	231.15	229.00
MW-29S	199.02	201.00
MW-30S	203.24	202.24
MW-30D	203.28	202.24
MW-31	209.50	208.65
MW-33S	235.76	235.54
MW-33D	216.32	208.44
MW-34	221.21	219.83
MW-35S	209.42	208.91
MW-35D	202.88	202.08
MW-36S	234.29	233.81
MW-36D	218.19	217.29
MW-37S	258.73	257.73

*Water levels are given on USGS Datum.

Table 4-1 (cont.)

Well No.	Water Elevation April 28, 1987	Water Elevation May 29, 1987
MW-40S	264.25	265.53
MW-40D	232.94	232.92
MW-45	237.95	237.39
P-46	267.99	269.76
P-53	231.66	230.51
P-71	239.14	235.74
Hudson River	209.00±*	209.22

* Estimated water elevation based upon USGS gaging station data at Hadley and Fort Edward.

Table 4-2 provides data on the zones monitored by each of the wells on the site. Both shallow and deep bedrock wells monitored zones of about 10 feet.

In order to better illustrate the ground water regimes on the site, three sections were drawn approximately perpendicular to the river. The locations of these sections are shown on Plate 4, and the sections appear on Plates 7 to 9. The information plotted on these sections includes the bedrock profile, the profile of the surface of clay, where known to be present, major sewers crossing the sections, and the ground water elevations from the April 28 and May 29 measurements. Water tabble surfaces were then estimated for the surficial aquifer, the shallow bedrock aquifer (5 to 15 feet below top of rock) and the deep bedrock aquifer (25 to 35 feet below top of rock). These ground water profiles were then used in constructing the ground water contour maps for April 28, 1987, shown in Plates 4 to 6. Ground water contour maps for the May 29, 1987 measurements would show essentially the same flow patterns as those for April.

4.2.1 Potentiometric Surface in Surficial Aquifer

Referring to Plates 7 to 9 and to Table 4-1, it can be seen that the water table in the surficial aquifer is above the rock and generally above the clay layer which overlies rock in most portions of the site. In plotting the potentiometric surface of the surficial aquifer, it has been assumed that underdrains near the north lagoon and foundation drains around buildings depress the water table to some degree. Therefore, a straight line has not been drawn between the water surface elevations in adjacent wells. Rather, some interpretation has been made of the probable water table surface between wells based upon the presence of clay, drains, and other site specific features. This is particularly true for the northern portion of the plant site where little water surface elevation data are available for the surficial aquifer.

Three points should be noted with regard to the surficial aquifer.

- o The flow is from north to south toward the river and discharges to the river, except where it is intercepted by perforated drains and

TABLE 4-2
MONITORING WELL INFORMATION

WELL NO	MEASURING POINT ELEV	GROUND ELEV	DEPTH ROCK	ROCK ELEV	TOTAL DEPTH	ELEV MONITORED FROM	TO	ZONE MONITORED
17S	285.98	284.5	11.0	273.5	26.4	268.1 -	258.1	SHALLOW ROCK
20D	263.15	260.8	15.0	245.8	55.1	215.7 -	205.7	DEEP ROCK
20S	262.27	260.9	16.0	244.9	31.0	239.9 -	229.9	SHALLOW ROCK
23D	283.64	281.4	11.6	269.8	47.9	243.5 -	233.5	DEEP ROCK
23S	282.91	281.3	11.5	269.8	26.5	264.8 -	254.8	SHALLOW ROCK
24	283.33	281.5			11.6	274.9 -	269.9	SURFICIAL
25D	237.91	236.3	23.2	213.1	60.7	185.6 -	175.6	DEEP ROCK
25S	238.74	236.1	24.5	211.6	39.4	206.5 -	196.7	SHALLOW ROCK
26	238.57	236.7			8.0	233.6 -	228.7	SURFICIAL
27D	242.53	241.0	27.1	213.9	66.0	185.0 -	175.0	DEEP ROCK
27S	241.64	240.4	28.0	212.4	42.5	207.4 -	197.9	SHALLOW ROCK
28	241.00	240.2	27.3	212.9	27.3	217.9 -	212.9	SURFICIAL
29S	236.82	235.1	25.0	210.1	39.5	202.9 -	195.6	SHALLOW ROCK
30D	216.78	215.1	16.8	198.3	51.5	173.3 -	163.6	DEEP ROCK
30S	216.44	214.8	16.5	198.3	32.1	192.9 -	182.7	SHALLOW ROCK
31	217.44	215.0	16.0	199.0	16.0	204.0 -	199.0	SURFICIAL
32		N O T	I N S	T A L L	E D			
33D	254.34	252.2	16.0	236.2	52.4	209.4 -	199.8	DEEP ROCK
33S	254.11	251.9	16.0	235.9	31.9	229.6 -	220.0	SHALLOW ROCK
34	239.61	238.0	30.0	208.0	36.0	207.0 -	202.0	SURFICIAL
35D	239.93	238.7	34.5	204.2	67.1	181.7 -	171.7	DEEP ROCK
35S	240.32	238.5	32.5	206.0	48.6	199.3 -	189.9	SHALLOW ROCK
36S	261.96	260.7	18.1	242.6	33.0	237.1 -	227.7	SHALLOW ROCK
36D	262.94	260.9	18.6	242.3	57.2	213.7 -	203.7	DEEP ROCK
37S	266.08	263.8	6.0	257.8	20.1	252.5 -	243.7	SHALLOW ROCK
40S	281.50	279.6	18.0	261.6	33.5	256.1 -	246.1	SHALLOW ROCK
40D	281.39	279.6	18.0	261.6	52.9	236.6 -	226.7	DEEP ROCK
45	249.74	247.7			14.0	238.7 -	233.7	SURFICIAL
P-46	277.89	276.8	21.4	255.4	21.4	262.4 -	255.4	SURFICIAL
P-53	242.98	240.2			14.0	236.2 -	226.2	SURFICIAL
P-71	244.29	242.5			9.0	243.5 -	233.5	SURFICIAL
1	240.18	238.1	26.0	212.1	40.0	211.6 -	198.1	COMPOSITE ROCK
2	240.14	238.1	26.0	212.1	26.0	217.1 -	212.1	SURFICIAL
4	241.11	239.2	25.4	213.8	40.0	211.2 -	199.2	SHALLOW ROCK
5	241.03	239.0	15.0	213.6	28.0	216.0 -	211.0	SURF-ROCK COMPOSITE
6	236.99	235.1	15.0	220.1	40.0	214.6 -	195.1	COMPOSITE ROCK
7	236.66	235.2	18.5	220.2	10.5	229.7 -	224.7	SURFICIAL
8	242.66	241.6	18.5	223.1	45.0	220.6 -	196.6	COMPOSITE ROCK
9	242.35	240.4	12.1	221.9	10.5	235.4 -	230.4	SURFICIAL
10	257.41	256.1	12.1	244.0	53.0	240.1 -	203.1	COMPOSITE ROCK
11		W E L L	D	E S T	R O Y E	D		
12		W E L L	D	E S T	R O Y E	D		
13	234.32	233.0	36.3	196.7	42.0	198.5 -	196.0	SURF-ROCK COMPOSITE
14	234.32	232.7	36.3	196.4	17.0	220.7 -	215.7	SURFICIAL
15	282.60	280.5	24.0	256.9	60.0	254.4 -	220.9	COMPOSITE ROCK
16	283.12	281.2	24.0	257.2	13.0	273.2 -	268.2	SURFICIAL
17	286.18	284.6	10.0	274.6	45.7	273.1 -	204.6	COMPOSITE ROCK
18	286.73	284.8	10.0	274.8	10.8	279.0 -	274.0	SURFICIAL
19	245.58	243.3	10.5	232.8	41.5	231.8 -	201.8	COMPOSITE ROCK
20		C O N V	E R T	E D	T O	M. W.	2 0 D	
21	239.75	238.5	18.6	219.9	45.0	219.0 -	193.5	COMPOSITE ROCK
22	241.13	238.8	8.0	230.8	45.0	229.3 -	193.8	COMPOSITE ROCK

pumped to the industrial sewer. This the case near the outlet of Weir Brook and on the river bank south of Building 45.

- o The potentiometric surface in the surficial aquifer is generally higher than that in the shallow bedrock aquifer.

- o The surficial aquifer is recharged, in part, from the Feeder Canal. This is evidenced by the fact that after water was diverted into the canal early in May, when the barge canal system was placed in operation for the summer, the water level came up in piezometer P-46, while the water level fell in other surficial wells, in other areas of the site. Piezometer P-46 is located directly south of the Feeder Canal about 210 feet east of the western property boundary.

4.2.2 Potentiometric Surfaces in Bedrock Aquifers

The potentiometric surface of ground waters in the bedrock is dependent upon the location and depth at which the bedrock is monitored. When monitoring wells 17S and 17D, north of New York State Route 32, were measured in early April, 1987, both were flowing from the riser pipe onto the ground surface. These wells were artesian with respect to the surficial aquifer at that time, and remained so in late April and May, although the flow of water stopped. It can also be seen from Table 4-2 that there is a vertical gradient upward from the deep rock to the shallow rock at the location of these wells (17S and 17D) in the May 29 measurements.

As one moves south toward the river, a pronounced downward vertical gradient occurs between the shallow and deep bedrock wells (Table 4-2). At monitoring wells 25S and 25D in the southwest corner of the site, this vertical gradient was 24 feet in May and 25 feet in April. These wells are only about 10 feet apart, and MW-25D monitors the zone beginning only 10 feet below the bottom of MW-25S. Furthermore, the potentiometric surface in MW-25D is about 15 feet below the water surface in the adjacent Hudson River, while that of MW 25S is well above the river surface. The river varied from about elevation 209.0 to 210.0 on the dates on which measurements were made.

Table 4-3

Head Differentials in Bedrock Well Clusters

Well No.	Water Elevation May 29, 1987	Differential (Ft.)
17S	283.98	(0.13)
17D	284.11	
20S	245.06	23.51
20D	221.55	
23S	264.07	19.51
23D	244.56	
25S	219.59	23.68
25D	195.91	
27S	210.23	8.5
27D	201.73	
30S	202.24	0
30D	202.24	
33S	235.54	27.1
33D	208.44	
35S	208.91	6.83
35D	202.08	
36S	233.81	16.52
36D	217.29	
40S	265.53	32.61
40D	232.92	

Similarly, MW-27S and MW-27D, on the river bank a few hundred feet east of MW-25S and MW-25D, show a strong downward vertical gradient, although the water levels in MW-27S were about at the river level in late April and May. Moving further to the east, MW-29S exhibited a water level from 8 to 10 feet below the river level in late April and May. MW-30S and 30D initially showed a downward vertical gradient on April 6, with the water surface in MW-30S above the river level, but were at a common elevation below the river level on May 29.

The water level data described above imply that the bedrock monitoring wells are intercepting two discrete water bearing zones within the bedrock aquifer. Within the bedrock aquifer there are high and low zones of secondary permeability. The zones of higher secondary permeability appear to be separated by zones of lower secondary permeability. Certainly, the strong, downward vertical gradients show that there is little vertical movement between waters in different rock strata compared to the horizontal movement along bedding planes.

The data further indicate that the ground water in the deeper rock is not discharging to the Hudson River at the river's edge on the plant site. This was not anticipated when preparing the work plan for this study, because the Hudson River had long been believed to be the discharge point for ground waters in the region.

On June 30, 1987, a field visit was made to a limestone quarry operated by the Glens Falls Portland Cement Company on the south side of the Hudson River. This quarry is approximately 2500 feet long and 1000 feet wide and is within a few hundred feet of the river's edge. Its easterly end is located south of Ciba-Geigy Building 8 and its northern edge is only about 600 feet south of MW-25D. According to maps viewed at the Cement Company offices, the bottom of the quarry is at elevation 111.5 (USGS) at a sump in its west central area and elevation 158± at the quarry's easterly end.

The ground water contour maps based on the shallow and deeper bedrock wells, Plates 5 and 6, indicate that waters in the bedrock flow generally toward the south. The map for the bedrock wells which monitor the zone 25 to 35 feet below the top of rock (Plate 6) shows a component of flow toward the southwest on the extreme westerly portion of the site. This is in the general direction of the quarry. However, on the easterly portion of the site the available data indicate that the potentiometric surface slopes toward the southeast and not directly toward the quarry. Only one well, MW-33D near New York State Route 32 (River Street), monitors the 25 to 35 foot bedrock zone in this area. The water level in this well was at elevation 216.32 on April 28, 1987, but dropped to 208.44 on May 29. The May reading is below the water level in the Hudson River, which was at about elevation 209 on that date. This indicates that the water in this zone of the rock was not discharging to the river on that date.

4.3 Hydrogeochemical Relationship of On-Site Aquifers

A review of the historical ground water chemical data, obtained prior to the beginning of field work, indicated high pH's in many of the composite wells. This led to an early hypothesis that there could be the potential for calcium carbonate precipitation, if these elevated pH ground waters were saturated with respect to calcium. Additional data collected during this assessment suggested that a seal may exist in many well clusters as indicated by the vertical gradients. Accordingly, additional major element analyses, not required by the work plan, were undertaken to confirm the presence of this phenomena. The video tape of Old Production Wells No. 1 and 2, discussed in Section 2.6.1 above indicates the possible presence of a chemical precipitate in the water column. In addition, both wells have been partially filled in with the light colored material. It is possible that this material may be the same material settling through the water column. In addition, in Old Production Well No. 2 the rounded protuberances observed at a fracture (probably water bearing) could not be related to any drilling process which could have been used to install the well. Instead, they also suggest the presence of a chemical precipitate.

4.3.1 Carbonate Equilibria

To determine whether the groundwaters were satured with carbonates, calcium equilibria were calculated for all but two of the monitoring wells in the April and June samplings. These values are listed in the following table, with a sample calculation for the April sampling of MW-25D presented in Appendix VI. Of the 34 calculated values with this method, 22 are in agreement with the measured values (Table 4-4). In several instances where the calculated values are markedly different, the pH's are relatively low.

The values obtained in the above table indicate several significant patterns. The surficial and shallow wells tend to exhibit high pH values. These are unnatural values and probably result from the passage of water through highly alkaline materials. In this case, the alkaline material probably is cement dust from the plant immediately to the west of the Main Plant Site. Of the 34 calculated values using this method, 22 are in agreement with the measured values as shown on Table 4-4. In several instances where the calculated values are markedly different, the pH's are relatively low.

As Table 4-4 indicates, that when the low calculated values are similar to the low analytical results those ground waters with a higher pH are saturated with calcium. As the ground waters have migrated downward (in certain areas) from the surface they have encountered the natural limestone groundwater with higher ranges of dissolved calcium at a lower pH (ideally 8.3 at equilibrium). When the alkaline, saturated waters encounter the lower pH natural groundwaters, there is a consequent rise in pH coupled with a zone of oversaturation. The result is precipitation of calcium carbonate. This zone of oversaturation is generally present in a range of depths from the shallow to the deep wells and can be seen in many of the values in Table 4-4.

A zone of calcite deposition could seal any fractures in the bedrock and, in effect, create two separate aquifers. This is consistent within the observations of large vertical gradients in every well cluster (even the upgradient ones) with one exception addressed below. The data further indicate that the sealing and gradients indicate that the vertical fractures in the limestone are much smaller in width than the horizontal bedding plane fractures; otherwise there would be no remaining horizontal transmission of water in the zone of sealing.

Table 4-4
Calcium Equilibria

Sample	mg/l Calculated April	Calculated June	Analytical April	Analytical June	pH, Standard Units April	pH, Standard Units June
MW-34	23	217	17.1	14.8	10.3	9.9
MW-35S	24	264	34	47	9.1	8.0
MW-35D	6	63	43	104	9.8	8.3
MW-26	0.65	0.64	10	10.4	10.0	10.2
MW-25S	10	18	62	82	9.4	9.0
MW-25D	73	35	72	111	8.2	8.7
MW-27S	0.84	0.36	8.2	5	10.2	10.1
MW27D	430	583	240	290	7.2	7.1
MW-31	6.5×10^6	9.2×10^6	208	270	4.5	4.4
MW-30S	122	117	53	103	7.6	7.6
MW-30D	434	365	31	118	7.0	7.1
MW-33S	72	104	75	81	8.0	7.8
MW-33D	272	63	108	107	7.3	8.0
MW-24	82	86	63	83	8.0	7.8
MW-23S	218	225	174	198	7.3	7.3
MW-23D	6.6	NA*	14.6	NA	10.0	NA
MW-20S	46	95	173	177	7.8	7.5
MW-20D	15	ND*	13.1	NA*	8.7	NA

SU - Suspect Determination (Possible calcite precipitation during sampling)
* NA - Analysis Not Available
* ND - Not Determined

The only well group which does not clearly exhibit evidence of sealing is the MW-30 series, located in the south-central portion of the plant site. They exhibit marginally low pH's for limestone groundwater (7.0-7.6). MW-30S and MW-30D are the only two wells which do not exhibit a pronounced vertical gradient, but instead record the same water elevation. This indicates a joining of the wells by a vertically oriented fracture. The explanation for this phenomenon could be acidic surficial groundwater in the area that breached the calcite seal in this vicinity. MW-31, a surficial well near MW-30S and MW-30D was at pH 4.5 and 4.4 in April and June and the calculated saturation levels are high.

The seal appears to be 100 percent (or nearly so) emplaced in some of the well clusters and less so for other areas of the plant site. For instance, The MW-24, MW-23S, and MW-23D series displays a segregation of dissolved constituents between the shallow and deep wells, indicating a very effective seal in place.

4.3.2 Sodium Chloride

In support of the above, an analysis of major element chemistry was undertaken to better define the ground waters, particulary in the different bedrock zones monitored by the shallow and deep bedrock well clusters. This first considered the ground water quality of the upgradient wells.

While several upgradient wells were intended to be installed in this assessment, only wells MW-33S and MW-33D appear to have intersected what would constitute background ground water. Even these are slightly compromised, however, because there is a small, but distinct excess of Na and Cl in these wells which most probably is due to application of road salt. Also present is a slight excess of potassium, which is unusual for pristine groundwaters in limestone or dolomite. The total dissolved solids and specific conductance values in these two wells are relatively low, however, and along with MW-17D, MW-17S and MW-18, are probably the closest representatives to natural groundwaters on site.

The cluster of wells consisting of MW-24, MW-23S, and MW- 23D, north of the Feeder Canal and adjacent to NYS Route 32, display chemical pattern which provides further evidence of the carbonate sealing of fractures in the bedrock. Water level readings for these wells indicate the presence of strong vertical gradients in the ground water as shown below.

Well No.	Zone Monitored	Water Surface Elev. (USGS) April 28, 1987	Water Surface Elev. (USGS) May 29, 1987
24	Surficial Deposits	275.03	275.17
23S	5'-15' below top of rock	264.03	264.07
23D	25'-35' below top of rock	241.39	244.56

The analyses of sodium and chlorides in samples collected from these wells in April, 1987, show the following results.

Well No.	Concentration of Na^+ in ground	Cl^- water samples
24	61 mg/l	12.9 mg/l
23S	196 mg/l	380 mg/l
23D	75 mg/l	5.8 mg/l

The shallow bedrock well of the group contains sodium, and, in particular, chlorides. The molar Na/Cl ratios is well under 1. Therefore, the most likely source of the sodium and chlorides is road salt from nearby Route 32. It is believed that the salt is not present in as high levels in the surficial well, MW-24, because the "slug" of water containing the dissolved salt may have already passed through the overburden material into the shallow rock upgradient of MW24. Also, it is not present in as high levels in the deep well, MW-23D, of this group. As indicated in Table 4-4, The water from this latter well had a pH of 10.0 in the April sampling, and was supersaturated with respect to calcium by a factor of more than two at that time. This information tends to support the hypothesis that a carbonate seal has formed between the shallow and deep rock wells of this group.

4.3.3 Piper Plots

Piper plots are a longstanding method of categorizing groundwaters and determining whether or not one ground water mixes with another. Figure 4-1, a plot of the June sampling data for most of the wells, seems to demonstrate that two bedrock aquifers exist on the site in most areas.

FIGURE 4-1

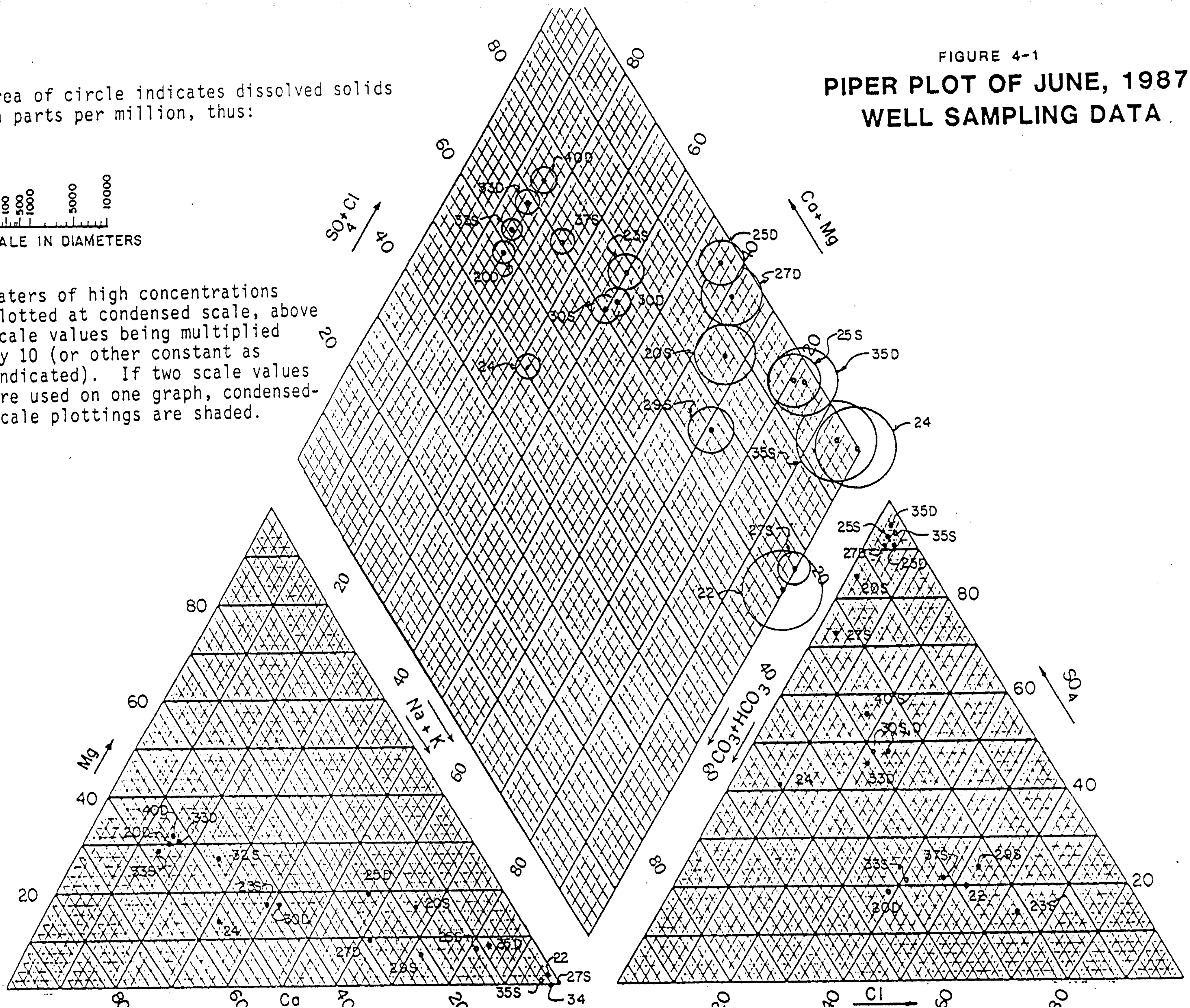
PIPER PLOT OF JUNE, 1987 WELL SAMPLING DATA

Area of circle indicates dissolved solids in parts per million, thus:

0 100 500 1000 5000 10000

SCALE IN DIAMETERS

Waters of high concentrations plotted at condensed scale, above scale values being multiplied by 10 (or other constant as indicated). If two scale values are used on one graph, condensed-scale plottings are shaded.



4.4 Packer Testing

As noted in Section II, packer tests were conducted in Old Production Well Nos. 1 and 2 and MW-15 to study discrete vertical head distribution in these wells. To investigate the 8-inch diameter production wells, pneumatic packers were utilized. To study a particular zone within the well, which had been previously identified from video televiewing, the packer assembly was lowered down the well until the upper and lower packers spanned the area of interest. The packers were then inflated to obtain a tight seal with the wall of the well and isolate the zone under study.

Water level measurements were taken in both the 4-inch diameter pipe to measure the head potential within the discrete fracture zone isolated by the packers and in the annular space between the 4-inch pipe and the 8-inch diameter production well.

The water levels obtained in the 4-inch diameter pipe in the various packer zones (vertical distribution of heads in the well) were compared to each other and to the pre-test static water levels in order to ascertain the presence of vertical flow components within the well borehole.

A submersible pump was lowered into the 4-inch pipe and used to pump water from the zone isolated by the packers. This was done not only to obtain representative ground water samples from the discrete zone, but to determine the presence of major water-bearing fractures. In certain zones the fractures were pumped dry almost immediately and did not recover enough to enable water sampling.

Four zones were identified for packer testing in Old Production Well No. 1, as indicated below:

Zone 1 - 144.2 - 131.7 feet below top of 8-inch casing [elev. 116.66 - 129.16]
Zone 2 - 127.6 - 115.1 feet below top of 8-inch casing [elev. 133.26 - 145.76]
Zone 3 - 110.0 - 97.5 feet below top of 8-inch casing [elev. 150.86 - 163.36]
Zone 4 - 81.1 - 68.6 feet below top of 8-inch casing [elev. 179.76 - 192.26]

A measuring point elevation of 260.86 feet was used for the top of the 8-inch casing based upon data received from Ciba-Geigy.

The sampling procedures that had been utilized for the packer tests indicated some minor problems occurred in that insufficient purging of the zone could not be accomplished. Therefore, additional sampling was undertaken by Aquatec, Inc.

Observations similar to those in Old Production Well No. 1 were made in Old Production Well No. 2. The major water-yielding fracture zone in Old Production Well No. 2 was at a depth of 102.7 - 90.2 feet at Zone 1. The vertical head distribution indicates upward flow from one zone to another zone. Monitoring well MW-15 was also packer tested. No anomalous fracturing, was observed with either the video televiewer or the packer.

Based on the problems associated with the sampling of Production Well No. 1, it was decided that an additional study would be conducted by Aquatec, Inc. The report on that sampling and analyses is included in Section 5.3.

4.5 Results of In-Situ Permeability Testing in Surficial Aquifer

As noted in Section II of this report, in-situ horizontal permeability tests were conducted in the wells and piezometers installed in the surficial aquifer. The results of these tests are presented in Table 4-5 and show that permeabilities range from a low of 3.7×10^{-5} cm/sec in fine, sandy fill at MW-26 to a high of 1.2×10^{-3} cm/sec in sand at piezometer P-53. Vertical permeabilities were also measured in the different soils and fill/wastes encountered on the site. The permeabilities are reasonable for the materials encountered. The results of these tests were considered when evaluating containment transport from the site to the Hudson River.

TABLE 4-5

IN-SITU PERMEABILITY TEST RESULTS

Location	Horizontal Permeability	Material Surrounding Well Screen
MW-24	6.0×10^{-5} cm/sec	Fill
MW-26	3.7×10^{-5} cm/sec	Sandy Fill
MW-28	4.6×10^{-5} cm/sec	Fill
MW-31	1.7×10^{-3} cm/sec	Fill and Sand
MW-34	4.6×10^{-5} cm/sec	Fine Sand and Silt
MW-45	1.5×10^{-3} cm/sec	Sand
P-46	1.0×10^{-4} cm/sec	Fill
P-53	1.2×10^{-3} cm/sec	Sand
P-71	1.8×10^{-4} cm/sec	Fill

Kv/Kh AND Kv PERMEABILITIES

Boring	Type of Test and Permeability Result	Depth	Material
MW-26	Kv/Kh 5.7×10^{-6} cm/sec	9 ft.	Clay
MW-26	Kv 1.8×10^{-3} cm/sec	8 ft.	Sand
MW-28	Kv/Kh 6.0×10^{-4} cm/sec	6 ft.	Fill
MW-28	Kv 2.0×10^{-3} cm/sec	6 ft.	Fill
MW-28	Kv/Kh 6.0×10^{-5} cm/sec	13 ft.	Sand and Fill
MW-28	Kv/Kh 7.3×10^{-5} cm/sec	16 ft.	Clay
MW-45	Kv/Kh 1.8×10^{-5} cm/sec	10 ft.	Sand
MW-45	Kv/Kh 8.73×10^{-6} cm/sec	14 ft.	Clay
SB-64	Kv/Kh 1.5×10^{-6} cm/sec	5 ft.	Fill
SB-64	Kv/Kh 2.3×10^{-5} cm/sec	9 ft.	Sand

Kv/Kh - Average Vertical & Horizontal Permeability
Kv - Vertical Permeability only

SECTION V
ANALYTICAL DATA

5.0 General

This section will discuss the analytical data obtained as part of this study from various media: soil, surface waters, and groundwater. Historical data collected on stormwater discharges also will be presented. The samples from the various media were collected in the locations as described in the previous sections.

5.1 Subsurface Materials

Subsurface samples were collected during the subsurface boring program and submitted to Aquatec, Inc. laboratory for analysis for a range of organic and inorganic parameters as stipulated in the approved work plan. In addition, in a meeting held on March 18, 1987, at the CIBA-GEIGY Main Plant Site with N.Y.S. DEC and Malcolm Pirnie representatives, N.Y.S DEC requested that EP Toxicity analyses for metals also be conducted. Information collected during this assessment has been summarized relative to each of the five fill/waste areas at the plant site, where appropriate, and by strata. The analytical protocol, chain-of-custody protocol and sampling procedures employed are as defined in the work plan (Appendix II). The detection limits and precision of the analytical procedures are included in Appendix VIII.

5.1.1 Analytical Results in Fill/Waste, Clean Fill and Soil

Both organic and inorganic parameters were analyzed for in the various kinds of fill/waste materials present on site. A total of 130 fill/waste (fill/waste and clean fill) samples were taken and analyzed from the north waste pile, south waste pile, area south and west of Building 49, area stretching from the incineration area around Building 56 to the embankment south of Building 45, and the area in the parking lot straddling the railroad tracks. A total of 53 samples were collected in sand, 7 in silt, 34 in clay, and 3 in topsoil from the riverbank south of Building 45. The complete results are included in Appendix IX.

5.1.1 Analytical Results in Fill/Waste, Clean Fill and Soil (Cont'd.)

In general, organic parameters are not prevalent in fill/waste deposits on the CIBA-GEIGY site. However, metals are present.

Isopleth fence diagrams have been constructed for the parameters of barium, chromium and lead on site as shown on Plates 11 through 13. These diagrams demonstrate that there is no pattern in terms of depth (or presumed age of fill/waste) or areal extent, in concentrations of any of these three parameters. Concentrations vary irregularly throughout the five investigated fill/waste areas on the site. In addition, no correlation is evident between high concentrations of metals in the fill/waste and samples which showed elevated EP Toxicity results.

Inspection of the data from the analyses of soil, clay and silt reveals that concentrations of the various parameters decrease vertically from fill/waste to sand, and from sand to clay.

5.1.2 EP Toxicity Results

A total of 54 samples were analyzed for EP Toxicity metals from the five identified fill/waste areas on site. From the resulting 432 analyses conducted, only 15 yielded results above detection limits: One for barium, six for cadmium, four for total chromium, and four for lead. All are from fill/waste or clean fill, with the exception of one sample each from SB-36-8 in sand and SB-38-7 in clay. Plate 10 shows those borings where EP Toxicity tests were performed. The complete sampling results are included in Appendix IX along with all other subsurface sample analytical results.

5.2 Analytical Results of Surface Water Sampling Program

Surface water samples from ten sampling stations in the vicinity of the CIBA-GEIGY Main Plant Site were taken in April and June of 1987. The quarry north of the site, the Glens Falls Feeder Canal, and the Hudson River (both upstream and downstream from the CIBA-GEIGY site) were all sampled. Sampling point locations are given in Figure 5-1 and are described in Appendix X. Results from these samplings are presented in Appendix X.

These data indicate no measurable influence of the site on any of these surface water bodies. Upstream and downstream sample results are comparable, and all samples show results on the order of background levels, as represented by the field blanks.

5.3 Analytical Results of Groundwater Sampling Program

Two rounds of groundwater samples were collected for analyses of metals and other selected parameters from all monitoring wells on CIBA-GEIGY's plant site by Aquatec, Inc. The first round was collected in the second half of April, while the second round was collected in early June, 1987. Generally, two well volumes of water were removed from each well before sampling. However, this resulted in pumping the well dry in some instances and, in those cases, only one volume was removed. All monitoring wells were equipped with dedicated, PVC bladder pumps to avoid the possibility of contamination from bailers. The analytical results of this sampling program are shown in Appendix XI. A comparison of upgradient and downgradient concentrations for hexavalent chromium and CN^- (total) are shown on Tables 5-1 and 5-2, respectively. These tables show that for these compounds, which appear to be most prevalent, the range of concentrations in specific areas of the plant site are small, and the concentrations are relatively low.

Table 5-1

Ground Water CR^{+6} Concentrations
Upgradient and Downgradient By
Zone Monitored By Areas

CR^{+6} Concentrations, mg/l

Position of Ground Water Monitoring Well	Upgradient			Downgradient		
Location	Surficial	Shallow Bedrock	Deep Bedrock	Surficial	Shallow Bedrock	Deep Bedrock
North of D&H Railroad Tracks West Side of Site	<.05	<.05	<0.05	None	<.05	<.05
South of D&H Railroad Tracks West Side of Site	None	None	None	7.0-21.0	<.05-0.87	<.05
East Side of Plant Site	<.05	<.05	<.05	<.05*	<.05	None

None - No ground water monitoring well in this position for this location.

* Composite well used (MW-2)

All ground water samples analyzed as unfiltered samples.

Table 5-2
Ground Water CN^- (Total) Concentrations
Upgradient and Downgradient

CN^- (Total) Concentrations, mg/l

Position of Ground Water Monitoring Well	Upgradient			Downgradient		
Location	Surficial	Shallow Bedrock	Deep Bedrock	Surficial	Shallow Bedrock	Deep Bedrock
North of D&H Railroad Tracks West Side of Site	<.02	<.02	<0.02	None	.040-1.67	<.02-0.31
South of D&H Railroad Tracks West Side of Site	None	None	None	0.20-5.6	0.156-0.27	0.06-0.27
East Side of Plant Site	0.26-.055	<.02	<.02	.023-.033*	<.02	None

None - No ground water monitoring well in this position for this location.

* Composite well used (MW-2)

All ground water samples analyzed as unfiltered samples.

TABLE 5-3

SURFICIAL AQUIFER WATER QUALITY AS DETERMINED FROM EAST AND WEST PUMPING STATIONS

Lab ID	Sample	Date	Cl mg./L.	CN mg./L.	F mg./L.	NO_3/NO_2 as N mg./L.	Cr+6 mg./L.	Sb mg./L.	As mg./L.	Ba mg./L.	Cd mg./L.	Cu mg./L.	Pb mg./L.	Fe mg./L.	Mg mg./L.	Mn mg./L.	Mo mg./L.	Hg mg./L.	Se mg./L.	Ag mg./L.	Na mg./L.	Zn mg./L.	Cr(tot) mg./L.	SO4 mg./L.	Ca mg./L.	K mg./L.
71772	W PUMP STA.	18-Jun-87	660	3.6	< .1	8.5	5.4																	400		
71773	W PUMP STA. fil.	18-Jun-87						< .3	< .01	< .2	< .005	< .025	< .005	1.23	15.8	< .015	0.19	< .0002	< .005	< .01	1030	< .02	15.2		21	< 5
71774	E PUMP STA.	18-Jun-87	540	1.14	0.19	2.2	13.6																	580		
71775	E PUMP STA. fil.	18-Jun-87						< .06	< .01	< .2	0.013	0.029	< .005	0.46	32	1.01	<-.1	< .0002	<.005	< .01	430	0.05	5.8		250	5.9

Lab ID	Sample	Date	Coliform Tot. Col. per 100 ml.	pH	Turbity (NTU)	Specific Cond. umhos/cm.	Phenols mg./L.	TOC mg./L.	TOX mg./L.	Pesticides - ug./L.: Endrin ug./L.	Lindane ug./L.	MethoxyClor ug./L.	Toxaphene ug./L.	Herbicides: 2,4-D ug./L.	2,4,5-TP ug./L.	Diss. Oxygen mg./L.	TDS mg./L.	Alk. as HCO3- mg./L.
71772	W PUMP STA.	18-Jun-87	< 2	10.1	3.6	3800	< .005	8.8	0.152	< .10	< .05	< .50	< 1.0	< 10	< 1		2190	120
71773	W PUMP STA. fil.	18-Jun-87																
71774	E PUMP STA.	18-Jun-87	2300	7.0	1.7	2700	< .005	5	0.20	< .10	< .05	< .50	< 1.0	< 10	< 1		1940	88
71775	E PUMP STA. fil.	18-Jun-87																

NOTE : Samples for these parameters were not filtered.

5.3 Analytical Results of Groundwater Sampling Program (Cont'd.)

In order to characterize the groundwater in the surficial aquifer at points along the river east of the Wier Brook discharge and south of Building 40, samples were collected from perforated pipe drains leading to two small pumping stations. One of these, the West Pumpting Station, is located between Building 56 and Building 8, while the East Pumping Station is situated between Building 8 and Building 40. One round of samples was collected from these pumping stations in June, 1987. The results are shown in Table 5-3.

During the period June 29 through July, 1987, eight monitoring wells were sampled for Appendix IX parameters as follows: MW-23S, MW-25S, MW27D, MW28, MW-29S, MW-31 and MW-34 and MW-36S. The analytical results indicate that most Appendix IX parameters are not detected in the wells or, if detected, were below practical quantitation limits. The analytical results are shown in Appendix XII.

Samples were collected for analyses of the water quality at different depths in Old Production Wells 1 and 2 during packer testing of these wells. The results of these analyses are shown in Table 5-4.

In Old Production Well 1, detectable levels of Cr+6 were found throughout the water column. In order to check the validity of these results, additional testing was performd by Aqautec, Inc. The results, which are included in the following pages, indicate that the Cr+6 contamination source is at or above the top of the water column.

5.3.1 Inorganic Constituents

A comparison of analytical data for monitoring wells 1 through 22 for the 1980-1983 period with the data collected in this study shows a general decline in contaminant levels from the first sampling in April of 1980 to the present. The data available can only encompass a few of the older composite wells but these are sufficient to discern the pattern of decline. Well MW-6, for instance, averaged approximately 8 mg/l total chromium from 1980 to 1983, while its present level is slightly under 3 mg/l. Well MW-10 averaged approximately 0.30 mg/l from 1980 to 1983 while its present level is at the limit of detection (0.05 mg/l). Well MV-13 exhibited a marked decline from July 1980 at 560 mg/l to July 1983 at 58 mg/l. Since then it has declined even further to its present level of 9.2 mg/l. Well MW-19 has remained about the same. Well MW-14 did not have enough water to sample

PRODUCTION WELL NO. 1

HEXAVALENT CHROMIUM
PROFILE STUDY

Prepared For:

Ciba-Geigy Corporation
Lower Warren Street
Glens Falls, New York 02801

Prepared By:

Aquatec, Inc.
75 Green Mountain Drive
South Burlington, Vermont 05403

2 September 1987

1. Introduction

On 11 August 1987, a meeting was held at Ciba-Geigy Corporation in Glens Falls, New York to discuss the source of hexavalent chromium found in Production Well No. 1. In attendance were Mrs. LaVerne Fagel and Ms. Allyson Boulerice of Ciba-Geigy, Mr. John Mulligan and Mr. James Young of Malcolm Pirnie, Inc., and Mr. John Diego and Mr. Neal Van Wyck of Aquatec, Inc. Initial samples collected by Malcolm Pirnie from production well No. 1 during a packer test were reported to have higher concentrations of hexavalent chromium at the lower zone than the middle and upper zones. Subsequent analysis of samples collected by Aquatec on 7 August 1987 (Aquatec ETR #11194) showed higher concentrations of hexavalent chromium in the stagnant water, but lower concentrations after pumping the well. Based on the conflicting data, Aquatec proposed to perform an in-depth study to determine the source of hexavalent chromium in production well No. 1. This study plan was developed by Mr. John R. Diego and Mr. Roger C. Binkerd, engineers at Aquatec.

2. Methods

Discrete water samples were collected from production well No. 1 on 24 August 1987 with a 750 ml stainless steel and Teflon syringe sampler at five-foot intervals below the water table. The samples were analyzed for hexavalent chromium concentration.

Following the first set of syringe sampling, the well was pumped with a submersible centrifugal pump to remove the stagnant water. The pump was progressively lowered down through the water column at five-foot increments at selected time intervals. The water was pumped at approximately ten gallons per minute to the Ciba-Geigy wastewater treatment plant.

Immediately after pumping, a second set of syringe samples was collected to establish background conditions throughout the water column after removing stagnant water and prior to monitoring changes in hexavalent chromium concentrations.

The monitoring for changes in hexavalent chromium versus time was done by sampling from bladder pumps installed in the well at three elevations, 70, 100, and 130 feet, below the top of the casing. Samples were initially collected at one-, three- and then four-hour intervals. The volume of stagnant water remaining in the bladder pumps and discharge lines was calculated and two volumes were purged and discarded prior to collecting each subsequent sample.

Samples were collected from the bladder pumps until the concentrations started approaching the previous background concentrations. After the final bladder pump samples were collected, the pumps were removed and a third set of syringe samples was collected to show the hexavalent chromium concentration throughout the entire water column.

3. Results

Syringe samples collected on 24 August 1987 prior to pumping show a decreasing trend in hexavalent chromium concentration down to a depth of 130 feet (Table 1). This trend is a reflection of the pumping that took place the previous week. The maximum depth the well was pumped the previous week was approximately 120 feet below the top of the casing. The apparent zone influence of the pumping that took place at 120 feet was not significant enough to purge the water column below the 120-foot level.

Following the syringe sampling on 24 August 1987, the well was pumped for a total uninterrupted pumping time of five and one-half hours. The total volume of water pumped from the well was 3,300 gallons. The visual yellow color of the water at different levels during pumping was consistent with the results of the syringe samples collected prior to pumping.

The results of the second set of syringe samples collected immediately after pumping on 8/25/87 shown in Table 1 indicate a significant decrease in hexavalent chromium concentrations due to pumping.

The hexavalent chromium monitoring via the three bladder pumps started at 0200 hours on 25 August 1987 following the second set of syringe samples and ran until 1200 hours on 28 August 1987. Results are tabulated on Tables 2, 3, and 4 for depths of 70, 100, and 130 feet from the top of the casing, respectively. These data are also plotted versus time on Figure 1. The results show a steady increase in hexavalent chromium at the 70-foot level. The 100-foot level shows a slight increase in hexavalent chromium concentration over time, and the 130-foot level appears to remain relatively constant throughout the study.

4. Conclusion

Based on the data presented in this report, the hexavalent chromium in production well No. 1 appears to be entering the well at or above the static water level. Over time, the hexavalent chromium concentration in the well may become more homogeneous in the water column.

Table 5-4
Cr+6 Concentration in
Old Production Well No. 1

aquatec
ENVIRONMENTAL SERVICES
75 Green Mountain Drive, So. Burlington, VT 05403
TEL. 802/658-1074

ANALYTICAL REPORT

Ciba-Geigy Corporation

Date: 8/13/87
Project No: 86124
ETR No: 11194
Sample(s) Received On: 8/7/87
Page 1 of 1

Standard analyses were performed in accordance with Methods for Analysis of Water and Wastes, EPA-600/4/79-020, Test Methods for Evaluating Solid Waste, SW-846, or Standard Methods for the Examination of Water and Wastewater. All results are in mg/l unless otherwise noted.

Paramcter	73440	73441	73442	73443	73444			
Hexavalent Chromium	42	42	41	<0.05	0.38			

Lab No.	Sample Description
73440.	Well water sample labeled PW1 Zone 1 collected 8/7/87 at 1315 hours.
73441.	Well water sample labeled PW1 Zone 2 collected 8/7/87 at 1312 hours.
73442.	Well water sample labeled PW1 Zone 3 collected 8/7/87 at 1307 hours.
73443.	Well water sample labeled PW1 120' collected 8/7/87 at 1450 hours.
73444.	Well water sample labeled PW1-composite collected 8/7/87 at 1445 hours.

Submitted By: John R. Dege Aquatec Inc.

TABLE 5-5

OLD PRODUCTION WELL #1

Syringe Samples Collected at 5-Foot Intervals

Depth of Sample From Top of Casing (ft.)	Hexavalent Chromium (mg/L)		
	Prior to Pumping (8/24/87)	Immediately After Pumping (8/25/87)	Following Bladder Pump Sampling (8/28/87)
65	60.0	-	54.9
70	57.0	12.0	52.0
75	51.0	7.8	42.9
80	42.0	7.1	35.4
85	39.0	5.1	27.5
90	33.0	4.1	23.0
95	32.0	4.0	16.2
100	21.0	6.0	11.1
105	32.0	5.7	6.2
110	12.0	5.2	4.5
115	8.4	4.9	3.3
120	5.2	4.6	1.0
125	6.3	5.0	1.8
130	61.0	2.2	1.8
135	78.0	3.8	2.5
140	100	5.0	3.8
145	18.0	3.2	4.5
150	76.0	3.1	2.1

TABLE 5-6

OLD PRODUCTION WELL #1

Samples Collected at 70 Feet

Date	Sample ID	Time	Cr^6 (mg/L)
8/25	PW-1.20	0200	12.0
8/25	PW-1.37	0340	16.0
8/25	PW-1.40	0500	16.0
8/25	PW-1.43	0600	19.0
8/25	PW-1.46	0700	18.0
8/25	PW-1.49	0800	19.0
8/25	PW-1.52	0900	20.0
8/25	PW-1.55	1000	19.0
8/25	PW-1.58	1100	19.0
8/25	PW-1.61	1200	20.0
8/25	PW-1.64	1300	21.9
8/25	PW-1.67	1400	22.3
8/25	PW-1.70	1500	23.4
8/25	PW-1.73	1800	25.8
8/25	PW-1.76	2100	26.7
8/25	PW-1.79	2400	28.4
8/26	PW-1.82	0400	29.2
8/26	PW-1.85	0800	29.7
8/26	PW-1.88	1230	32.4
8/26	PW-1.91	1600	33.8
8/26	PW-1.94	2000	35.4
8/26	PW-1.97	2400	36.4
8/27	PW-1.100	0400	37.9
8/27	PW-1.103	0800	40.1
8/27	PW-1.106	1200	41.8
8/27	PW-1.109	1600	41.2
8/27	PW-1.112	2000	42.3
8/27	PW-1.115	2400	42.9
8/28	PW-1.118	0400	42.9
8/28	PW-1.121	0800	43.5
8/28	PW-1.124	1200	49.2

TABLE 5-7

OLD PRODUCTION WELL #1

Samples Collected at 100 Feet

Date	Sample ID	Time	Cr^6 (mg/L)
8/25	PW-1.26	0200	6.0
8/25	PW-1.38	0340	4.6
8/25	PW-1.41	0500	4.2
8/25	PW-1.44	0600	3.7
8/25	PW-1.47	0700	3.1
8/25	PW-1.50	0800	3.1
8/25	PW-1.53	0900	2.9
8/25	PW-1.56	1000	3.2
8/25	PW-1.59	1100	3.2
8/25	PW-1.62	1200	3.1
8/25	PW-1.65	1300	3.2
8/25	PW-1.68	1400	3.2
8/25	PW-1.71	1500	3.3
8/25	PW-1.74	1800	3.8
8/25	PW-1.77	2100	4.4
8/25	PW-1.80	2400	4.5
8/26	PW-1.83	0400	4.6
8/26	PW-1.86	0800	5.1
8/26	PW-1.89	1230	6.1
8/26	PW-1.92	1600	5.7
8/26	PW-1.95	2000	6.7
8/26	PW-1.98	2400	6.9
8/27	PW-1.101	0400	7.2
8/27	PW-1.104	0800	8.4
8/27	PW-1.107	1200	7.3
8/27	PW-1.110	1600	8.0
8/27	PW-1.113	2000	7.8
8/27	PW-1.116	2400	8.7
8/28	PW-1.119	0400	9.2
8/28	PW-1.122	0800	9.4
8/28	PW-1.125	1200	9.0

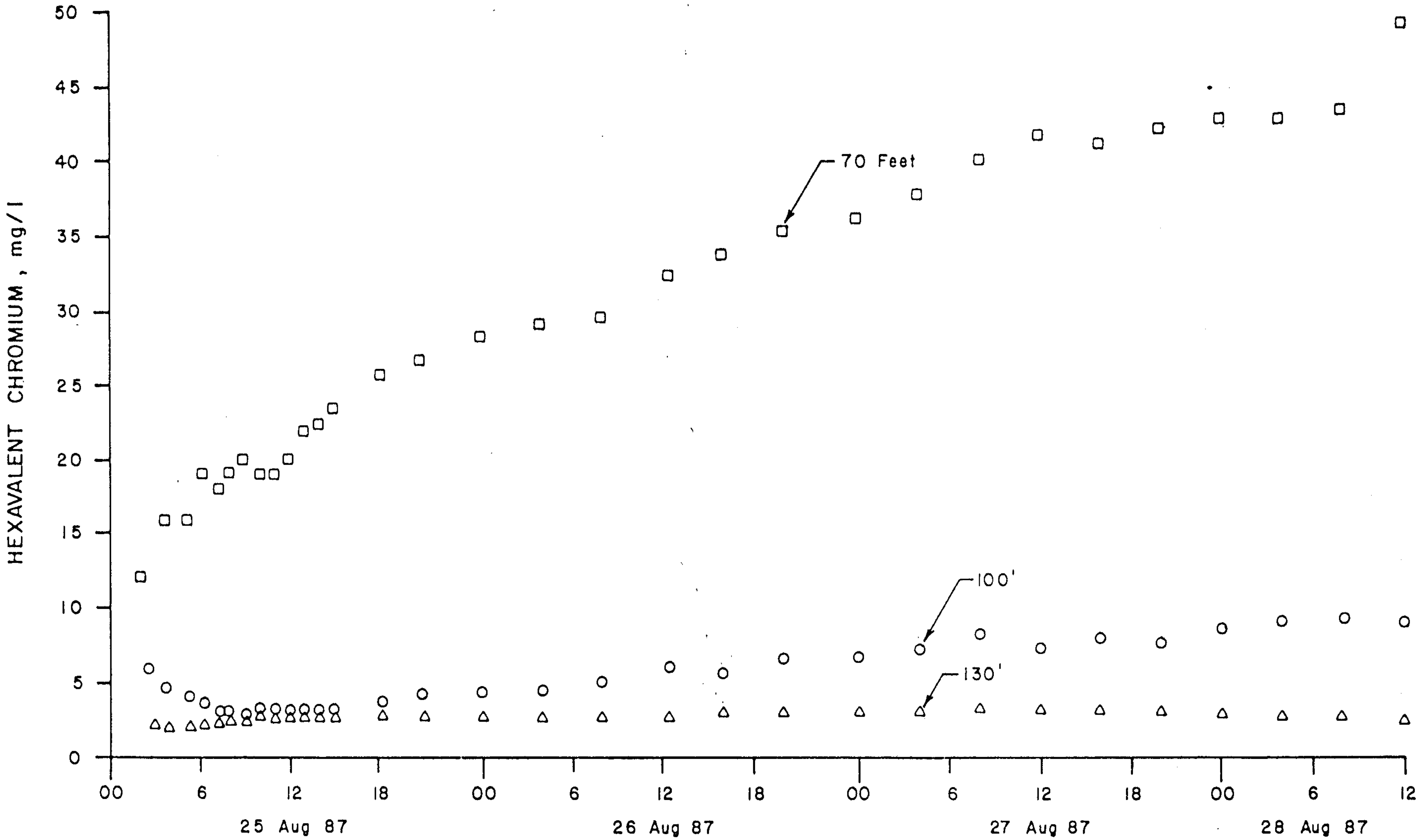
TABLE 5-8

OLD PRODUCTION WELL #1

Samples Collected at 130 Feet

Date	Sample ID	Time	Cr^6 (mg/L)
8/25	PW-1.32	0300	2.2
8/25	PW-1.39	0345	2.1
8/25	PW-1.42	0500	2.2
8/25	PW-1.45	0600	2.3
8/25	PW-1.48	0700	2.4
8/25	PW-1.51	0800	2.5
8/25	PW-1.54	0901	2.6
8/25	PW-1.57	1000	2.7
8/25	PW-1.60	1100	2.7
8/25	PW-1.63	1200	2.7
8/25	PW-1.66	1300	2.8
8/25	PW-1.69	1400	2.8
8/25	PW-1.72	1500	2.8
8/25	PW-1.75	1800	2.7
8/25	PW-1.78	2100	2.8
8/25	PW-1.81	2400	2.8
8/26	PW-1.84	0400	2.7
8/26	PW-1.87	0800	2.8
8/26	PW-1.90	1230	2.9
8/26	PW-1.93	1600	3.0
8/26	PW-1.96	2000	3.1
8/26	PW-1.99	2400	3.2
8/27	PW-1.102	0400	3.2
8/27	PW-1.105	0800	3.3
8/27	PW-1.108	1200	3.2
8/27	PW-1.111	1600	3.2
8/27	PW-1.114	2000	3.1
8/27	PW-1.117	2400	3.0
8/28	PW-1.120	0400	2.9
8/28	PW-1.123	0800	2.9
8/28	PW-1.126	1200	2.7

Figure 5-2



HEXAVALENT CHROMIUM CONCENTRATION versus TIME

CIBA - GEIGY PRODUCTION WELL No. 1

in this study, but from 1980 to 1983 it showed a decline from 290 mg/l to 110 mg/l. Well 21 exhibited a slight decline from an average of about 65 mg/l from 1980 to 1983 to its present level of 55 mg/l. Finally, Well MV-22 has shown a large decline from 150 mg/l in April of 1982 to it present average of two samplings of approximately 10.5 mg/l. All of these data are available for inspection in the Work Plan.

5.3.2 Organic Constituents in Ground Water

Ground water samples were collected during the April and June sampling rounds and were analyzed for pesticides and herbicides, phenols, TOC and TOX shown in Appendix XI.

In April and June four pesticides and, two herbicides were analyzed for. While three of the April samples contained reportable quantities of one or both herbicides, none of the five samples repeated these findings.

The TOC concentrations ranged from a low value of 5.0 mg/l to a high value of 77 mg/l, and total halogenated organics (TOX) values ranged from 0.020 to 20 mg/l.

After the first round of ground water samples results were reviewed, ground water monitoring wells were selected for APpendix IX parameters. Task 8 in approved work plan required the selection of "water samples including a limited scan for Appendix 23 of 6NYCRR Part 371, constituents (40 CFR Part 261), Appendix 8 modified and, when Appendix 8 parameters are called for, the 25 superfund pollutants will be run; and an identification of maximum concentrations for each constituent identified" (sic, Malcolm Pirnie, August 1986). The Appendix VIII parameter list which is found in 40 CFR 261, is a list of 375 hazardous waste constituents which is a composite of several other lists compiled under the Clean Water Act and chemicals identified by the U.S. Department of Transportation and several federal agencies. A revision was proposed by EPA (July 25, 1986) to reduce the number of parameters analyzed to 240 compounds. This final rule was published in 52 FR 25946 on July 9, 1987 and becomes effective on January 9, 1988. The rule eliminated from the list chemicals that were not normally found in ground waters and added 30 compounds to the list. Therefore, in order to be current, it was decided to conduct an Appendix IX analyses on selected ground water wells which would be "generally downgradient wells which show anomalous concentrations of parameters associated with plant processes" (Malcolm Pirnie, August 1986). The wells selected were MW-235 (upgradient) and MW-25S, MW-27D, MW-28, MW-29S, MW-31, MW-34, and MW-36S. The samples from these wells were taken from June 29 to July 1, 1987.

Of note is the presence of chlorobenzene. This organic compound can be correlated with the TOX analyses completed on the two ground water sampling rounds. For example, the highest concentration of TOX was from MW-36S (20 mg/l) and the Appendix IX concentration of clorobenzene was 2.8 mg/l. Additionally, the TOX concentration in MW-27D was 3.4 mg/l with an Appendix IX concentration of chlorobenzene at 3.6 mg/l. Other organizes were detected, but generally at low levels.

5.4 Analytical Results on Plant Discharges to River

The NYSDEC has issued a State Pollution Discharge Elimination System (SPDES) permit for the plant site for the eight discharges listed in Table 5-g. The locations of all these discharges are shown on Plate 1.

The stormwater runoff from the portion of the site north of the D & H Railroad and east of the Weir Brook culvert plus an area near Building 45 discharges to the storm water impoundment Basin in the parking lot on the east end of the site. It is analyzed prior to discharge. Since it has always been below the SPDES permit levels, it has been discharged directly to the river through an outfall sewer constructed in 1983.

Typical storm water quality data, are shown in Table 5-7. SPDES permit monitoring report data for discharges 101 and 108 are shown in Table 5-8.

Table 5-9

SPDES PERMIT ISSUED TO CIBA-GEIGY CORPORATION

Discharge No.	Description
002	Emergency overflow pipe from sanitary sewage pumping station. This pipe was removed and the overflow point plugged with concrete in 1983.
004	Process water filtration plant backwash water discharge.
007	Cooling water discharge from building 56.
008	Backwash from process water pumping station screens.
009	Formerly Wastewater Pretreatment Plant discharge. Now storm drainage from storm water impounding basin.
101	Storm water run-off from parking lot on east end of plant site.
102, 103, 104 & 105	Formerly four separate storm water discharge points; now combined into one discharge point, D.P. 102, west of the stormwater impounding basin. Used to discharge storm water from impoundment to Hudson River plus serves as discharge point for small areas of plant storm sewer system.
108	A ground water discharge to the River south of Building 45.

Table 5-10
Water Quality Data For Storm Water Runoff

Parameter	Units	SPDES Limit	April '86	May '86	June '86
Ph	S.U.	6.0-9.0	7.1	7.4	7.2
Cyanide (Total)	mg/l	0.8	0.017	<0.01	<0.01
Cadmium (Total)	mg/l	0.2	0.05	0.044	0.063
Chromium (Total)	mg/l	1.0	0.39	0.27	0.16
Copper (Total)	mg/l	0.8	0.036	0.070	<0.01
Iron (Total)	mg/l	4.0	0.24	0.23	0.35
Lead (Total)	mg/l	0.4	0.29	0.15	0.10
Aluminum (Total)	mg/l	4.0	<0.20	0.40	0.10
Methylane Chloride	mg/l	0.5	<0.005	<0.005	<0.005
Fluoride	mg/l	-	0.5	0.5	0.05
Total Filterable Residue	mg/l	500	310	495	220

Table 5-11

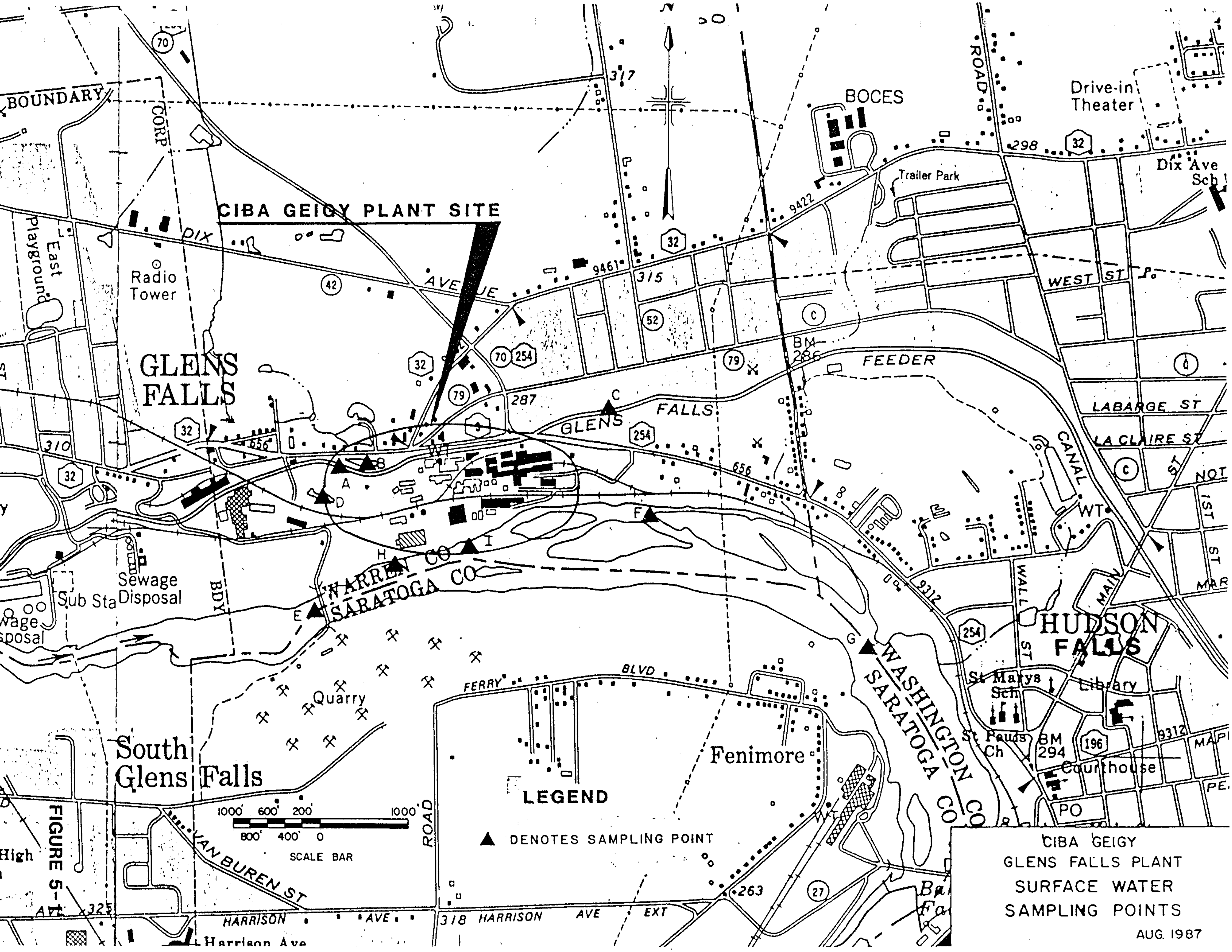
SAMPLING RESULTS
CIBA-GEIGY SPDES DISCHARGES 101 and 108

(All Results in mg/l)

Month	Outfall 101				
	Cd	Cr^{tot}	CN	Pb	Flow, GPD
Jan	-	-	-	-	0
Feb	-	-	-	-	0
Mar	-	0.04	-	0.14	180
Apr	-	<0.05	-	<0.14	1,900
May	-	<0.05	-	<0.10	N/A*
June	-	<0.05	-	<0.10	4,500
July	-	<0.05	-	<0.10	2,880
Average		<0.05		<0.10	2,365 gpd
SPDES Permit Limits	0.2	1.0	0.8	0.4	

*"Not analyzed"

Month	Outfall 108				
	Cd	Cr^{tot}	Cn	Pb	Flow, GPD
Jan	-	-	-	-	0
Feb	<0.02	<0.05	0.09	<0.10	144
Mar	<0.03	<0.03	0.10	<0.10	100
Apr	<0.02	<0.025	0.04	<0.10	5,760
May	<0.02	<0.05	0.08	0.14	2,160
June	<0.02	<0.05	0.11	<0.10	720
July	<0.02	<0.05	0.12	<0.10	1,440
Average	<0.02	<0.05	0.09	<0.10	1,940 gpd
SPDES Permit Limits	0.2	1.0	0.8	0.4	



CIBA GEIGY
GLENS FALLS PLANT
SURFACE WATER
SAMPLING POINTS
AUG. 1987

FIGURE 5-1

SECTION VI

ENVIRONMENTAL AND HEALTH IMPACTS

6.0 General

In this section, constituents of concern are identified, the amounts and pathways of constituent migration are discussed, potential receptors are identified, and environmental and health impacts are evaluated.

6.1 Constituents Evaluated

In order to develop a meaningful evaluation, surrogate constituents were used to limit the amount of data reviewed. Five inorganic constituents constitute the bulk of the parameters found in the materials deposited on the Ciba-Geigy plant site. These constituents were: chromium, total cyanide, barium, cadmium and lead. While both total chromium and hexavalent chromium were tested extensively, only hexavalent chromium was included in this evaluation. As shown in Table 6-1, the frequency of detection of the hexavalent chromium and total cyanide was the greatest. For the other inorganic constituents the detection, particularly in filtered samples, was low. Further, when detected, the value was low. This implies that the mobility and availability of cadmium, barium and lead to the environment, particuarly via ground water transport is low. Accordingly, for the purposes of this report no further consideration was given to these three metals.

While phenols were detected at low levels and chlorobenzene and other organics were also detected, albeit at isolated locations, it is believed that hexavalent chromium and total cyanide are the most useful constituents to evaluate further.

6.2 Contaminant Migration Pathways

6.2.1 Air Transport

Air transport is not considered to have an impact upon public health or the environment and, therefore, was not included in the approved work plan.

Table 6-1
Frequency of Detection in Ground Water

Inorganic	Number of Analyses* Total	Filtered	Frequency of Detection Total	Filtered
Cr^{+6}	62	0	22	N/A
Total Cn	62	N/A	50	N/A
Ba	53	31	3	1
Cd	53	31	2	2
Pb	53	31	8	1

*Not including QA samples.
N/A - Not Applicable

6.2.2 Ground Water Transport

As has been discussed in Section IV of this report, surficial ground water flowing through the Ciba-Geigy plant site generally discharges to the Hudson River. The Glens Falls Feeder Canal, located upgradient of the Ciba-Geigy main plant site, recharges, in part the surficial aquifer and portions of the shallow bedrock aquifer on the site. Ground water from the plant site does not discharge into the Feeder Canal. It cannot be definitively ascertained from this study if the quarry located north of the main plant site is recharging the surficial aquifer or the bedrock aquifers beneath the site.

Waters in the deep bedrock aquifer and, to some extent, the shallow bedrock aquifer exhibit piezometric surfaces, which indicate that they have the potential to flow under the Hudson River.

As discussed in Section V, the water quality of the Hudson River is unaffected as it passes the Ciba Geigy site. To confirm that finding, constituent loadings from the site have been estimated.

The discharge of constituents to the river through the ground water is dependent upon the rate of ground water discharged from the site and its degree of contamination. The ground water discharge rate can be estimated from knowledge of the hydraulic conductivity of the soil and fill/waste, the hydraulic gradient of the ground water table, and the cross-sectional area through which the ground water passes. The hydraulic conductivity of the soils and fill/waste have been determined by in-situ permeability data described in Section IV of this report, while the hydraulic gradients have been determined from sections showing the surface of the water table in the surficial aquifer.

In order to estimate the cross-sectional area through which the ground water discharges to the River, a section has been taken along the river bank as shown on Plate 14. This section shows the bedrock profile, the lacustrine clay layer immediately above the bedrock, where clay is present, and the ground water levels in the wells along the section line for two dates: April 28, 1987 and May 29, 1987. The section also shows the locations of the old stream bed of Weir Brook, the current Weir Brook culvert and the tile pipes and stone bed which carries ground water to the east and west pumping stations.

Table 6-2 presents an estimate of the ground water discharge to the Hudson River for April 28, 1987. The May 29, 1987 ground water elevations were lower than in April, and a flow estimate for this date would be lower as well. The cross-sectional area shown in Table 6-2 has been estimated from the section shown on Plate 14. The discharge areas for the waste and fill above the clay, the clay, and the shallow bedrock zone have been estimated separately. No estimate of discharge area is included for the deep bedrock zones or for the shallow bedrock east of the Weir Brook culvert because the ground waters in those zones do not exhibit sufficient potentiometric head to indicate discharge in the River in these areas. Also calculation of discharge cannot be performed in bedrock readily. It should be noted that the calculation for that flow in the shallow bedrock believed to be discharging to the river is based upon an average permeability as stipulated in the literature (Freeze and Cherry) and was included in Table 6-2 only for comparison purposes.

TABLE 6-2

ESTIMATED GROUND WATER DISCHARGE
FROM PLANT SITE WEST OF BUILDING 51
(April 1987 Ground Water Levels)

AREA DESIGNATION	X-Sect. Area (S.F.)	K Ft/day	I Ft/Ft	Q CF/day	Q lb/day
Discharge From Fill and Soil Above Clay					
MW-26	960	4.25	0.028	114.24	7128
MW-28	930	0.113	0.043	4.52	282
MW-34	3700	0.130	0.061	29.3	1831
West Pump Sta.	(discharges approximately 2000 CF/day to Industrial Sewer)				
MW-14	680	4.82	0.050	163.8	10226
East Pump Sta.	(discharges approximately 2000 CF/day to Industrial Sewer)				
MW-31	300	4.81	0.050	72.15	4502
Discharge from Clay					
MW-26	3100	0.016	0.028	1.39	87
MW-28	3360	0.21	0.043	30.3	1893
MW-34	1500	0.082	0.061	7.5	469
Weir Brook	1460	0.082	0.050	6.0	374
MW-14	3840	0.082	0.050	15.7	980
East P.S.	4730	0.082	0.050	19.4	1210
MS-31	3070	0.082	0.050	12.6	786
Discharge from Shallow Rock					
MS-25S	3770	0.028	0.09	9.5	593
MW-6 *	3180	0.028	0.10	8.9	555

* Area taken from MW-35S to a point about 65 feet west of Soil Boring 19 and from Elev. 204.5 to top of rock.

The permeabilities (K values) shown in Table 6-2 was taken from the in-situ horizontal permeability test data shown in Table 4-5 in Section IV, except for the permeability in the area associated with MW-26. For this location, a higher K value was used to reflect the presence of the sand layer below the fill/waste.

The hydraulic gradient, I, shown in the table was estimated from the profiles of the ground water table, shown in the section on Plates 7, 8 and 9, where these profiles cross the discharge section.

The discharge rate, Q, is in cubic feet per day, and in the Table has been calculated as the product of the permeability, K; the hydraulic gradient, I; and the cross-sectional area through which the discharge occurs. The discharge rate is also given in pounds per day in the Table. Given the low flow rates and the relative locations of the waste areas, it was not considered practical to calculate losses for individual waste areas.

The ground water discharge data shown in Table 6-2 have been combined with the analytical data from the April sampling of the wells along the River to prepare estimates of the discharge of selected inorganic contaminants as shown in Tables 6-3 and 6-4. In Table 6-3, the estimated amounts of hexavalent chromium discharged to the river are presented. These metals were below the detection level for the shallow and deep downgradient wells and they do not typically move through clay. Therefore, the estimates based on losses to the River are based on the flow rates through the fill/waste above the clay layer.

The estimated losses of total cyanide to the River, as shown in Table 6-4, include losses through the fill/waste, the clay and the shallow bedrock on the west end of the site. Because cyanide is not removed by the cation exchange capacity of the clay, this parameter is found in the shallow bedrock and, presumably in the ground water discharged through the clay.

As shown on Tables 6-3 and 6-4, the estimated amounts of hexavalent chromium and total cyanide discharged to the river are very low. Hexavalent

TABLE 6-3

ESTIMATED DISCHARGE OF CHROMIUM
TO HUDSON RIVER FROM GROUNDWATER
ON PLANT SITE WEST OF BUILDING 51*
(April 1987 Sampling Round Data)

DISCHARGE AREA	Pounds per Day Cr^{+6}
MW-26	0.149
MW-28	2.5×10^{-4}
MW-34	0.013
Weir Brook	Ground water discharge to Pump Station and to Sewer
MW-14	0.139
East Pump Sta.*	Ground waters discharge to Pump Station and to Sewer
MW-31	<0.00022
MW-25S	5×10^{-4}
MW-6	5×10^{-4}
TOTALS	<0.302

* The calculated discharge and metals loading is from the fill and soils above the clay layer in this area. Metals discharged from the ground waters in the clay are assumed to be negligible due to the cation exchange capacity of the clay.

TABLE 6-4

ESTIMATED DISCHARGE OF CYANIDE
TO HUDSON RIVER FROM GROUNDWATER
ON PLANT SITE WEST OF BUILDING 51
(April 1987 Sampling Results Except as Noted)

AREA DESIGNATION	CN in Ground Water (ppm)	Discharge From Soil & Above Clay (lb/day)	Discharge From Clay (lb/day)	Discharge From Rock (lb/day)	Total Discharge (lb/day)
MW-26	3.8	0.027	0.00033	-	0.02733
MW-28	0.73	0.0002	0.0014	-	0.0016
MW-34	0.24	0.00044	0.00011	-	0.00055
West Pump Sta.	3.6*	-	0.0013	-	0.0013
MW-14	1.14*	0.012	0.0011	-	0.0131
East Pump Sta.	1.14*	-	0.0014	-	0.0014
MW-31	<0.02	<0.00009	<0.000016	-	<0.000106
Shallow Bedrock around MW-6	0.35	-	-	0.00019	0.00019
MW-25S (Shallow Bedrock)	0.156	-	-	0.000092	0.000092
TOTAL		<0.03973	<0.005656	0.000282	0.045668

Hydraulic data obtained from Weir Brook area calculations.
* CN concentration taken from June Sampling; no data available for April.
\+ CN concentration taken from East Pump Station data; no data available for MW-14.

chromium discharges are estimated at less than 0.302 pounds per day, while the total cyanide release is estimated at 0.045 pounds per day. The minimum average seven consecutive day river flow with a recurrence in level of 10 years is 1,660 cfs. At this flow, extremely low levels of these constituents in the river would result.

6.2.3 Transport via Storm Water Runoff

All storm water runoff from the plant site discharges to the Hudson River or is pumped to the wastewater pretreatment plant. Pretreated wastewaters are discharged to the Glens Falls wastewater treatment plant for further processing and are then discharged to the River.

Water quality data for runoff from the most heavily developed portion of the plant site, as measured in samples taken from the storm water impounding area after a storm event, have been presented in Table 5.3, above. The storm water impounding basin receives the runoff from approximately 8 acres of the site which were characterized as most likely to produce contaminated runoff in a special study of the plant storm water system prepared by the Aware Corporation in 1981. The entire plant site south of the Feeder Canal and west of the fence separating the parking lot on the east end of the site from the site proper encompasses about 54 acres. Most of the plant site is much less likely to produce contaminated runoff than in the area tributary to the impounding basin. Therefore, a highly conservative estimate of the discharge of contaminants to the River can be made by applying the water quality data for the impounding basin to an estimate of total daily runoff.

The average annual rainfall measured at the Warren County Airport is 35.3 inches per year or 0.097 inches per day. If it is assumed that 15% of the total precipitation runs off from waste areas on the 54-acre site, the average annual runoff will be 6,919,500 cubic feet per year or about 19,000 cubic feet per day. Based upon the water quality data for April 1986, from Table 5-3 and a discharge rate of 19,000 cubic feet per day, the following losses of contaminants to the River results:

Total Cyanide	0.020 lb/day
Chromium (Total)	0.462 lb/day

As is noted above, the estimate is very conservative. The actual quantities of these contaminants is probably less than 50% of the amounts shown.

6.2.4 Contaminant Losses Through Erosion

The losses of contaminants to the Hudson River through erosion are, in part, included in the estimates for losses through storm water runoff. However, the storm water runoff figures do not take into account some of the waste and fill along the river bank during high flow periods. The river bank is covered by dumped stone rip rap from the west end of Building 56 to the east end of Building 45 and, thus, erosion in the area is minimal. Soil samples collected at the river's edge and in its bed adjacent to the shore line have been sent to the laboratory, but no analytical data are yet available. When these data become available, an estimate of erosion losses will be made.

6.2.5 Migration of Contaminant Through Excavation and Removal

The removal of excavated materials from the Ciba-Geigy plant site has been strictly controlled for many years. EP Toxicity tests are typically conducted on any excavated material or rubble from demolition work prior to permitting it to be removed from the area. When the results of these tests have indicated that the material might be hazardous, it has been shipped to an approved, hazardous waste landfill for disposal. Therefore, the migration of contaminants via excavation and removal is not considered a pathway of concern.

6.4 Potential Receptors

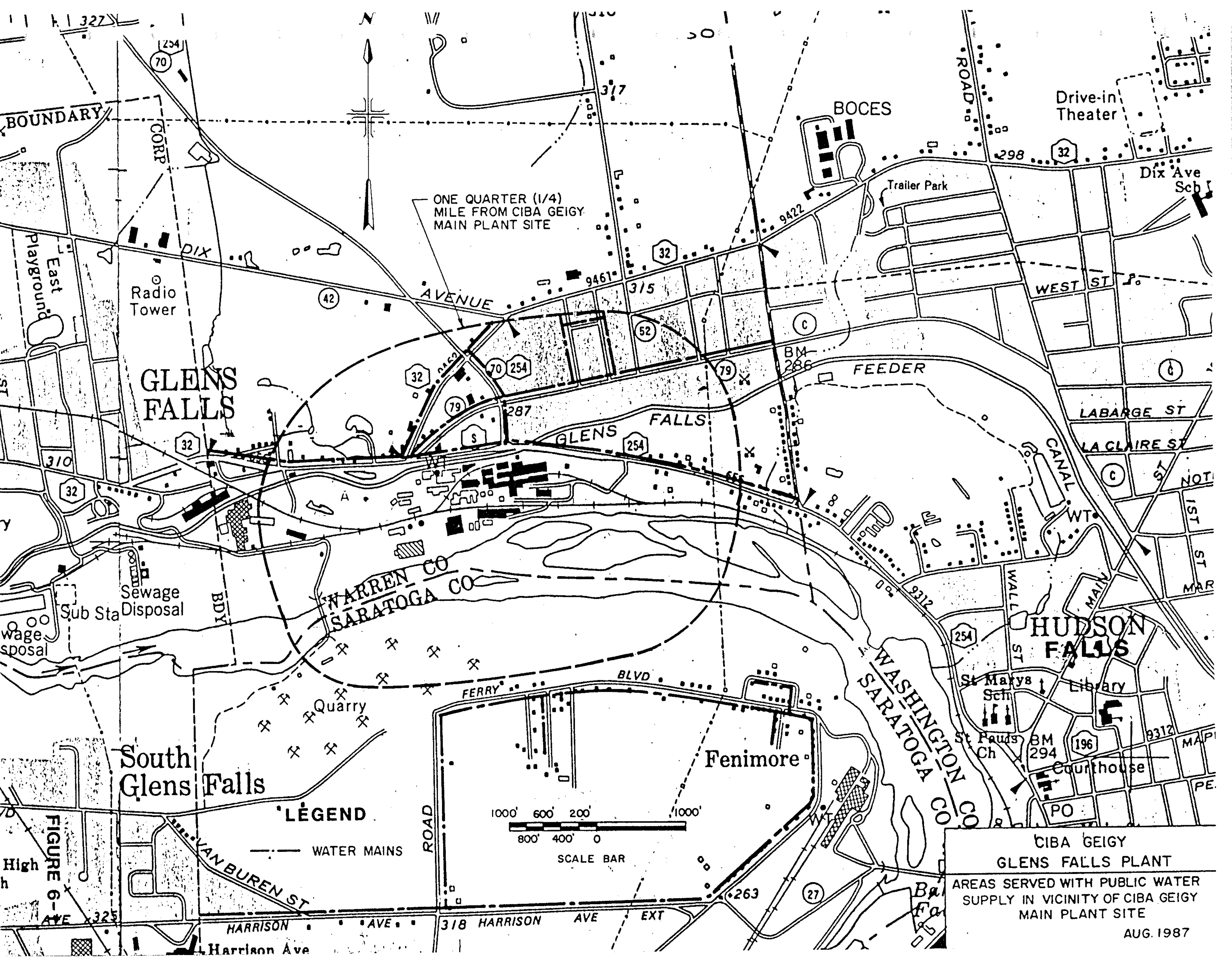
As noted above, the pathways of contaminant migration which might be of concern at the Ciba-Geigy plant site are ground water and stormwater discharges. All of the stormwater and certain ground waters is believed to discharge to the Hudson River. The ground waters in the deeper bedrock aquifer are believed to have the potential to flow under the River. Therefore, the potential receptor areas outside the plant boundaries are those related to the Hudson River and south of the River.

The Hudson River is classified as Class D from 1/4 mile north of Glens Falls to the Bakers Falls near Hudson Falls Village. As defined in Title 6

NYCRR Part 700, Class D waters are suitable for fishing only. The water quality is not considered suitable for primary and secondary contact recreation, and the Finch Pruyn Dam, upstream and the Bakers Falls Dam, downstream severely limit its use for boating. The water will not support fish propagation because of the dams and other physical constraints. The Hudson River between Fort Edward and Hadley contains small pockets of wetlands. Limited sensitive habitat information is available for the Hudson River upstream of Fort Edward. Consequently, sensitive habitats cannot be documented here. There is no significant recreational fishery between Glens Falls and the Troy Dam. Juvenile fish can still be found in the area, but there is a distinct absence of the mature segment of the fish population (MPI, 1984).

The Ciba-Geigy plant site is located at approximate Mile Point 199 on the River. The closest downstream municipal/institutional water supply intake is located at the Village of Waterford Water Treatment Plant at Mile Point 158. Periodic sampling of the water supply intake has not detected any problems related to materials known to be present on the Ciba-Geigy site.

As a portion of Task 1 of the approved Work Plan, an inventory was made of the homes and buildings within one-quarter mile of the plant site to determine whether they are supplied by public water or depend upon individual potable water supply wells (see map, Figure 6-1). The City of Glens Falls supplies water for buildings in the western portion of the quarter-mile area. In Warren County, the Queensbury water system, constructed in 1971, provides water for the area north and east of the Ciba-Geigy plant site. A review of the tax maps and the Queensbury Water District billing records indicate that approximately 13% of the land owners within the one-quarter mile limit north and east of the site do not appear on the Town of Queensbury billing list. This could mean that the property does not require water, or that the land owner has an individual water supply well on the property. Inasmuch as this area is not downgradient, with respect to the site's ground water flow, there should be little concern whether these people are using groundwater or the public water supply.



CIBA GEIGY
GLENS FALLS PLANT

AREAS SERVED WITH PUBLIC WATER SUPPLY IN VICINITY OF CIBA GEIGY MAIN PLANT SITE

AUG. 1987

FIGURE 6-

South of the Hudson River in the Town of Moreau, Saratoga County, there are very few homes or businesses within the quarter-mile radius of the Ciba-Geigy plant boundary. Water is supplied to this area from the Town of Moreau District No. 1 Water System as indicated on Figure 6-1. The Moreau system was put into service in 1954 and obtains its water from wells located west of the Village of South Glens Falls. Therefore, it is believed that no one is using groundwater for potable purposes in this area. The quarry on the south side of the Hudson River is also a potential receptor.

6.4 Mechanisms for Contact with Contamination

One of the potential mechanisms for contact with constituents of concern is by direct contact. The Ciba-Geigy main plant site has a chain link fence on the west, north and east sides of the plant site. The south side of the plant is bounded by the steep banks of the Hudson River, which are partially riprapped. The plant currently has a 24-hour guard service, seven days a week to preclude any unauthorized entry into the site. The D & H Railroad, which runs through the plant site, has limited fencing on the north and south boundaries and could allow unauthorized access to the plant site by people walking the track route. On the westerly boundary of the site is Glens Falls Portland Cement Corporation, which also has a perimeter fence and security guard. It is highly unlikely that people would enter the plant site because of the security available.

6.5 Environmental and Health Impacts

In regard to direct contact, the most concentrated wastes known to exist on the site are those within the south waste pile. This waste pile, together with the north waste pile and north lagoon, is totally enclosed by a chain link fence and the gate is kept locked. This area will be closed with an extensive cap, thereby eliminating the potential of exposure. In general plant site security systems preclude potential receptors from coming in contact with fill/wastes.

Environmental and health impacts associated with discharges into the Hudson River water are judged to be negligible. The minimum average seven consecutive day flow with a recurrence in level of 10 years (MA7CD/10) for the reach of the River adjacent to the Ciba-Geigy plant site is 1,660 cubic feet per second (cfs). The dilution afforded by the River, even at the MA7CD/10 flow rate, is so great that the minimal amounts of contaminants entering from the plant site cannot be measured in the stream. Furthermore, inasmuch as Ciba-Geigy is in the process of closing the Glens Falls plant and demolishing all the plant buildings, the discharge of wastes, whether through point source discharge points in accordance with SPDES permits or through the ground water, is declining rapidly.

SECTION VII

Preliminary Assessment

7.1 General

The tasks described in the approved work plan for the Preliminary Assessment of the Main Plant Site have been essentially completed. However, further study may be needed in specific areas. Recommendations for this additional work and for possible remedial actions are given in this section.

7.2 Recommendations for Additional Studies

The source of chrome contamination in Old Production Well should be identified, possibly through soil borings. In addition, soil borings may be needed further define the extent of material deposition in the western and of the old incineration area and in the parking lot.

Further efforts may be warranted to find all old production wells on site. This may be done by further research into plant records or, if necessary, by excavation. Once found, these wells and all composite rock monitoring wells should be filled with grout to prevent contaminant migration between aquifers.

The north waste pile, south waste pile and the lagoon should be closed in accordance with the closure plan which has been submitted to NYS DEC and US EPA.

7.3 Possible Remedial Actions

Any remedial actions which might be evaluated at this site should be considered in light of the following:

- Minor amounts of contaminants are migrating from the site to the Hudson River via surface water runoff and ground water discharges. The amounts of contaminants discharged, including those discharged through permitted outfall sewers, are for less than is permitted under SPDES permits currently held by Ciba-Geigy.

- No significant environmental or health impacts have been identified which are attributable to past or present practices on the site.

- Monitoring of ground water quality along the river bank should continue into the future to document the reduction in contamination of the ground water over time.

- The waste pile/lagoon area will be closed by capping.

The types of remedial actions could reasonably include the following:

1. No action. Petition NYSDEC to reassign its current wastewater pre-treatment plant permit allocations to the tile pipes discharging to the east and west pumping stations and to the ground waters. Both the stations and the ground waters should be allowed to discharge to the River.

2. If the source of chromium contamination in Old Production Well No. 1 cannot be located and remediated, consideration should be given to pumping of the well. The discharge should be to the Hudson River under a SPDES permit.

3. The organic contamination in MW-27D could be pumped and disposed at the municipal treatment plant.

4. The acid contamination and minor benzene contamination in MW-31 could be pumped and disposed at the municipal treatment plant.

5. Sewers could be sealed so as to minimize ground water migration.

6. Portions of the site could be covered with a shallow (less than one foot) layer of soil. Chemical additives such as cement dust, lime, and gypsum could further decrease ground water and/or contaminant migration.

7. Further capping beyond the waste pile/lagoon does not seem warranted.

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