core run resulted in no sample recovery. Video and geophysical logging tools subsequently lowered into the corehole were obstructed by a collapsed zone at a depth of 107 feet, and retrieved to the surface. The corehole was then enlarged with a five-inch diameter air hammer and deepened to 174 feet. The video and geophysical logging were repeated the next day, but the bottom seven feet of the hole had collapsed overnight. The collapse was in the Syracuse Formation, 15 feet below the base of the Camillus. The caliper log and the video camera revealed that the smooth-walled boring in the Syracuse led to a 2 1/2-foot-thick void. The pre-collapse thickness of the void is unknown.

5.0 HYDROGEOLOGIC CONDITIONS

5.1 HYDROLOGY

5.1.1 Surface Drainage

The Study Area is in the watershed of the Genesee River, which is located to the southeast of the Village of Caledonia and flows northward and enters Lake Ontario at the City of Rochester, New York. The surface of the Study Area is characterized by sinking streams, wide areas with virtually no overland flow, and voluminous springs along Spring Creek in the Village of Caledonia. Oatka Creek, which lies to the west and to the north of the Study Area, is the major drainage feature within the area. Spring Creek, a spring-fed tributary to Oatka Creek, is quite significant in terms of the local hydrogeology. The creek flows to the north along the eastern edge of the Study Area, and enters Oatka Creek in the Village of Mumford. Several intermittent (seasonal) streams also drain portions of the Study Area and its nearby surroundings. These streams are notable in that each sinks into the subsurface through cracks and fissures in the bedrock. The most important of the sinking streams is Mud Creek. When the water table is high, however, Mud Creek flows along its entire length, and discharges into Oatka Creek 5,000 feet northeast of the spill site. Refer to Plate 2 for the locations of the major drainage features within and bordering the Study Area.

These surface drainage features (sinking streams, limited runoff, voluminous springs) reflect the underdrained nature of the exposed bedrock surface. This underdrained condition further indicates that secondary porosity must be well developed in the shallow bedrock, thereby permitting rapid infiltration of precipitation and runoff, and access to significant subsurface groundwater migration pathways.

Oatka Creek

Oatka Creek flows north through the Town of LeRoy, over the Onondaga cuesta at Buttermilk Falls, and into an east-west oriented ice-marginal drainage channel to which it is confined until its confluence with the Genesee River. The confluence of the two streams is located near Scottsville, approximately 11 miles east-northeast of the spill site. It is possible that Oatka Creek loses water to the subsurface west of the Study Area, in the south to north stretch from the Village of LeRoy to Buttermilk Falls, where it flows across surface exposures of the Onondaga limestone.

Mud Creek

Mud Creek is the most significant of the sinking (or losing) streams within the Study Area. The creek rises on till-covered uplands in the Town of Pavilion in Genesee County and flows northward through the Town of LeRoy toward Oatka Creek. Surface water runoff is sufficiently high for a few weeks each year such that Mud Creek flows all the way to its confluence with Oatka Creek. The losing reach of Mud Creek north of the LeRoy Airport is either dry, or draining into the subsurface, primarily in one or two seasonally ponded areas. The upstream pond is located approximately 1,500 feet north of Route 5, on Dolomite Products Company property, at an approximate elevation of 770 feet. (The company dewaters their quarry into this pond during the spring months.) Small whirlpools have been observed in very shallow water at the edge of the creekbed near the pond. When the creek is flowing this far north, its discharge has been observed (not measured) to decrease with increasing distance north of this pond, providing additional evidence that the creek loses water through the improved bedrock channel. The downstream pond is located immediately to the southeast of the spill site, both north and south of the mainline railroad grade, at an approximate elevation of 735 feet. These surface water features are shown on Plate 1.

Mud Creek flows across the bedrock surface (or very thin overburden) to the southwest, south and immediately to the northeast of the Site. In most areas, the drainage channel is relatively narrow and well defined. The channel on Dolomite Products Company property has been relocated and deepened to move the surface water away from the quarry faces. Immediately to the southeast of the Site, however, the stream occupies a broader valley. This section of the Mud Creek valley may be influenced by disturbed bedrock features in the subsurface. As described previously, a closed depression ("swallet") exists in the Mud Creek valley just to the north of the arch culvert. Regardless of the stage of Mud Creek, ponded water is always present in this depression. The diameter of the pond is as little as a few tens of feet during the dry season. Measurements of the surface elevation of the pond at different times of the year suggest that it represents the local water table (Section 5.3.1).

Approximately 300 feet north of Gulf Road, Mud Creek has eroded a substantial gorge ("Mud Creek gorge") through approximately 70 feet of bedrock strata. This erosion must have occurred over the millennia before Mud Creek intersected the subsurface conduits to which it now discharges during most, if not all, of the year. Several seasonal springs discharge directly into the creekbed at various locations in the gorge. Approximately 2,100 feet north of Gulf Road, a large, possibly spring-fed, pond has formed in Mud Creek behind a man-made earthen dam. The pond (referred to hereafter as the "gorge pond") measures approximately 1,600 feet by 300 feet. The confluence of Mud Creek and Oatka Creek is located several hundred feet north of the dam.

Other Sinking Streams

Three additional streams sink beneath the surface at locations south and southwest of the Study Area. These streams sink after crossing from the till-covered uplands onto the fractured Onondaga limestone surface. The westernmost of these streams sinks in a closed depression at a golf course in LeRoy, at an elevation of approximately 805 feet. The golf course is located on the north side of Route 5, nearly two miles west-southwest of the spill site (see Plate 2).

Another stream forms a pond during periods of substantial surface water flow in the spring. This stream sinks below grade at an elevation of 740 feet as it flows onto the highly disrupted basin and ridge terrain along the south side of Route 5, two miles east-southeast (downgradient) of the spill site (location SW-22 on Plate 2). Just upstream of the pond, the stream cascades as a small waterfall over a 300-foot-long broken anticlinal ridge. Local strata are projected to consist of the Moorehouse member of the Onondaga Formation.

The least significant stream (in terms of probable discharge) sinks at a location 700 feet west of Callan Road and 2,500 feet south of Route 5, at an elevation of 765 feet (location SW-23 on Plate 2). This location is approximately two miles southeast (downgradient) of the spill site, and is projected to be at, or near, the top of the Onondaga Formation (possibly the Seneca member). This stream, which originates in a small wetland west of Skelly Road and is less than a mile long, begins to sink as it flows onto the exposed bedrock surface west of Callan Road.

Spring Creek

Spring Creek is sourced by multiple, large-volume springs at an approximate elevation of 655 feet above mean sea level in a residential neighborhood immediately west of downtown Caledonia. The creek flows north, and empties into Oatka Creek at a location 1.4 miles north of its headwaters, at an approximate elevation of 595 feet. The location and alignment of the creek suggest that the channel is structurally controlled. Most of the large springs known to be feeding Spring Creek are located near the town park and MacKay Park, between Route 36 and a point west of Spring Street. In fact, springs have been observed "boiling" out of several sections of the creek in MacKay Park. Some of these springs (boils) have a linear alignment suggesting that they originate along bedrock fractures in the creek bottom. The borehole video and caliper logging at well cluster DC-13 and DC-14 indicated that the bedrock strata projected to underlie Spring Creek opposite these clusters (Camillus and Bertie Formations, respectively - see Figure 4-2) are heavily fractured.

In addition to the springs, an extensive network of subsurface drainage pipes convey natural surface water and stormwater runoff to the headwaters of the creek, from multiple locations and directions along and south of Route 5. Additional springs are also likely to occur beneath and along the Spring Creek channel. Several of these [SPR-L23S (pipe) and SPR-12] were sampled frequently during the RI. Several additional springs (SPR-19, SPR-19A, SPR-21 and SPR-26) arise west of Spring Street, but eventually flow into Spring Creek. Spring Creek is considered to be hydrogeologically significant in that it serves as a discharge point for much of the groundwater flowing from west to east beneath the Study Area. Refer to Plate 2 for the locations of the spring sampling points.

5.1.2 Subsurface Drainage

Although little was initially known about the subsurface hydrologic regime, i.e., groundwater movement in the Study Area, the general rule-of-thumb is that the potentiometric surface or water table in an unconfined aquifer approximately mimics the surface topography. Since groundwater movement would be in a downgradient direction, i.e., from high head to low head, it would be assumed that the subsurface flow direction would be from the south to north throughout much of the Study area west of Flint Hill/Limerock Road (Livingston/Monroe County). East of this road, the surface topography slopes to the east and northeast toward Spring Creek and the Village of Mumford. As such, groundwater movement in this area would be expected to be toward the east and northeast. However, the subsurface flow pattern, as demonstrated by the contaminant plume, is in more of an easterly, and to some degree a southeasterly direction away from the spill site.

This subsurface flow pattern may be the result of drainage patterns developed during the deglaciation of the Study Area. As previously discussed, catastrophic glacial meltwater drainage flowed eastward over much of the Study Area during the final episodes of deglaciation. While much of the drainage followed an overland route, eventually the flow was superimposed upon and found its way into the subsurface network of joints, bedding planes and other openings in the bedrock. Since the surface drainage was to the east, the subsurface flow was, most likely, influenced to follow this same direction of flow. The end result was a general west to east subsurface flow direction toward the present villages of Caledonia and Mumford, and possibly even as far to the southeast as the Genesee River Valley. Although there is some localized groundwater flow to the north, close to the Onondaga escarpment, this flow direction is secondary to the west to east groundwater flow direction demonstrated to exist within the Study Area. Further evidence of this is the relative lack of springs emanating from the northerly facing escarpment into the Oatka Creek valley between LeRoy and Mumford.

Refer to Figure 5-1 for details of pertinent hydrogeologic features and groundwater flow within the Study Area.

5.2 CONCEPTUAL HYDROGEOLOGIC SYSTEM

A conceptual model of the hydrogeologic system in the Study Area was developed based on information obtained during the course of the RI. The conceptual model consists of a single hydrogeologic unit comprised of sedimentary, bedded limestone and dolomite (carbonate) rock. The sequence of carbonate rocks comprising the hydrogeologic unit includes the lower members of the Onondaga Formation, the Bois Blanc, Akron, Bertie, and Camillus Formations, and the uppermost strata of the Syracuse Formation. The conceptual model does not include the typically thin and dry overburden materials.

The rock strata that comprise the hydrogeologic unit are intersected by both horizontal and vertical fractures (bedding planes and joints). For this reason, the hydrogeologic unit is heterogeneous and anisotropic; and the behavior of groundwater and contaminants within the hydrogeologic system will not be uniform or predictable. However, the fact that the derailment/spill occurred approximately 24 years ago, and that the TCE contamination in the groundwater has had that period of time to migrate and reach some degree of equilibrium, has produced a gross-scale indication of the behavior of groundwater/contaminant movement within the hydrogeologic system.

The concept of a system consisting of a single hydrogeologic unit may be overly simplified; however, the conceptual model was developed with the knowledge that departures from the model occur in some portions of the Study Area. For example, localized zones of perched water are present at monitoring well clusters DC-2, DC-4, and DC-8, and the Falkirk member of the Bertie Formation may be hydraulically isolated from the underlying rocks as well, at well clusters DC-2 and DC-4. Elsewhere, abundant water level data lead to the conclusion that the entire investigated thickness of bedrock (up to 200 feet) beneath the Study Area behaves, in general, as a single hydrogeologic unit. Water levels measured during the 10-month period from November 1993 to September 1994 exhibited only minor to moderate vertical hydraulic gradients at the 18 monitoring well cluster locations. Refer to Plate 2 for the locations of all monitoring well clusters. Refer to Appendix P-1 for a compilation of all water level readings taken during this period and to Appendix Q for graphic plots of the water levels at each well cluster.

The hydraulic conductivity (K) test results for various vertical intervals throughout the hydrogeologic unit are high, particularly for a bedrock system. The dipping fractures and solution-widened bedding planes noted in the core, and caliper and video logs, provide high permeability groundwater flowpaths within the unit. K values in the 10^{-2} to 10^{-4} cm/sec range are typical for tested strata in the Study Area. With the exception of the rubbleized rock of the lower Camillus, the groundwater storage capacity of the investigated strata is assumed to be quite low. Evidence of the low storativity is provided by the large seasonal range of groundwater levels, and by the rapid response of water levels to precipitation events.

Precipitation across the Study Area results in relatively uniformly distributed (i.e., diffuse) vertical recharge to the bedrock system. In addition, it is postulated that there are at least two zones of potentially significant recharge to the groundwater system. One such zone is an east-west-oriented belt located at the southern limit of the exposed limestone bedrock. Runoff from the till-covered uplands south of Route 5 between LeRoy and Caledonia is the source of this recharge. The four streams previously discussed in Section 5.1.1 sink into the subsurface within this recharge belt, which is shown conceptually on Figure 5-1. The sinking streams are shown on Plate 2. The second source of potentially significant groundwater recharge may be Oatka Creek. If the underlying Onondaga Formation is jointed and fractured in the area between the Village of LeRoy reservoir and Buttermilk Falls, then the stretch of Oatka Creek between these points may also provide recharge to the bedrock hydrogeologic system. This influx of groundwater, if it occurs, most likely flows eastward into the Study Area.

Continuous water level monitoring was performed at several wells west of Church Road during a two-month period in the spring of 1994 (April 5th to June 8th). The results show that groundwater levels rose rapidly during spring precipitation events, probably in response to concentrated recharge from some of the sinking (i.e. losing) streams mentioned above. Additionally, seasonal changes in precipitation and surface water runoff caused large fluctuations (30-50 feet was typical) in groundwater levels during the 10-month monitoring period (November 1993 - September 1994). As indicated above, such pronounced water level responses at most locations in the Study Area suggest that both vertical and horizontal hydraulic conductivity is substantial, and that storativity is low in the thick bedrock section underlying the area. Figure 5-2 illustrates the striking similarity of water level trends in the middle-Camillus wells utilizing graphs of water levels in two wells (DC-4C and DC-12D) located 2 1/2 miles apart. Note that the horizontal axis on the figure is a linear time scale, as it is on all water level graphs in this report. All of the other mid-Camillus wells located between these two wells demonstrate a similar pattern (see graphs in Appendix Q). It should be noted that the graphs of the water levels in the Camillus wells at clusters DC-8 through DC-11, which are within this area, appear dissimilar to DC-4C and DC-12D between early March and early April, 1994.

This apparent dissimilarity is due to the fact that water levels were not measured at these locations on March 24, 1994.

Hydraulic or potentiometric heads ("heads") within many well clusters exhibit remarkable consistency, i.e. show very little variation with stratigraphic position for a given round of water level measurements. In many instances, the heads are much higher than the level of nearby streams. The existence of similar heads within the wells in many well clusters suggests that there is good vertical communication within the bedrock at these locations, and that groundwater flow is primarily horizontal in the vicinity of such well clusters. The head relationships with respect to nearby streams indicate that the streams normally function as discharge areas for the groundwater in the hydrogeologic system. Discharge occurs in the Mud Creek gorge, and in the area of Spring Creek in Caledonia via the Bertie and Camillus Formations, which are exposed or very near the ground surface in the two areas. The thick, extensive deltaic deposits located to the east and south of the Village of Caledonia may also receive substantial subsurface "discharge" from the bedrock hydrogeologic unit during certain times of the year.

5.3 HYDROGEOLOGIC SYSTEM BEHAVIOR

5.3.1 Seasonal Water Level Fluctuations

Groundwater levels were observed to fluctuate seasonally at all monitoring well cluster locations and at the "swallet" during the 10-month monitoring period. The minimum (i.e., lowest) water levels in most wells throughout the Study Area were observed in November 1993 or September 1994. The maximum water levels were recorded in March or April 1994. Groundwater levels in the northeast United States are usually highest in the early spring, before the growing season begins, and are lowest at the end of the growing season in September or October. Groundwater levels range over a 30-35 foot interval to the west of Mud Creek, and over a 40-58 foot interval between Mud Creek and well cluster DC-12. They rise and fall the least (10 feet) near Spring Creek. Table 5-1 shows the approximate water level range for the most reactive well(s) at each of the 18 well cluster locations. The geologic unit(s) monitored in each of the 55 monitoring wells installed at the 18 locations are listed in Table 5-2. The table in Appendix P-2 shows the elevations of the ponded water in the "swallet" in comparison to groundwater elevations in nearby monitoring wells DC-15A and DC-16. The data show that the water levels in the pond were consistently several feet above those in the wells. Although the seasonal range of water levels is less at the pond, the water levels move in tandem in the three areas, suggesting that the pond locally represents the water table.

Figures 5-3 and 5-4 illustrate the measured water level elevations during the November 1993 to September 1994 period at well clusters DC-7R and DC-14, respectively. These two well cluster locations (3.1 miles apart) represent the known extremes of the water level range in the Study Area. For graphical emphasis, the 58-foot range of water levels at DC-7R and the six-foot range at DC-14 are both plotted against an 80-foot vertical axis.

On a given date, the water levels in the four wells at DC-7R fall within a narrow, two-foot range, despite the 190-foot thickness of monitored strata and the large seasonal range of water levels

(Figure 5-3). The near absence of vertical hydraulic gradients at this and many other well cluster locations suggests that bedrock with abundant high angle and horizontal fractures underlies major portions of the Study Area. These fractures act as conduits, and appear to allow relatively rapid"pressurization" of the hydrogeologic system at most monitored stratigraphic intervals throughout the Study Area. The vertical hydraulic gradients are commonly downward into the Falkirk from overlying strata, and upward into the Falkirk from underlying strata.

The nearly coincident water levels in the two wells at DC-14 on a given date, and the minimal seasonal range at this location, were as expected (Figure 5-4). Because Spring Creek has a relatively stable seasonal discharge, groundwater levels in nearby shallow wells exhibit low seasonal variance. During the 10-month monitoring period, potentiometric heads at DC-14 were 11 to 17 feet above the surface of Spring Creek, which is located approximately 650 feet to the east. The two wells at DC-14 are screened in the Falkirk member of the Bertie Formation (DC-14A) and the upper Camillus Formation (DC-14B), strata that are projected to directly underlie Spring Creek (see Figure 4-2). This relationship between groundwater levels and creek elevations, tabulated in Appendix P-3, suggests that groundwater in the monitored strata discharges to the creek.

5.3.2 Geographic and Stratigraphic Trends

5.3.2.1 West of Mud Creek

Twenty-three monitoring wells were installed at seven well cluster locations to the west and north of Mud Creek (DC-1, DC-2, DC-4, DC-5, DC-6, DC-15, and DC-16). These wells may be grouped on the basis of their locations with respect to the creek, and because the most reactive well(s) at each of these locations exhibit nearly identical seasonal water level ranges. Table 5-1 indicates the approximate water level range for the most reactive well(s) at each of the well cluster locations in the Study Area. The most reactive screened well at six of the well cluster locations west of Mud Creek showed a seasonal water level range of 31 to 34 feet. These wells are generally screened in the Camillus and Syracuse Formations (see Table 5-1). Vertical hydraulic gradients are generally larger in the well clusters located to the west of Mud Creek than in the two groups of wells located east of Mud Creek (as discussed in the following subsections). The spill site well cluster (DC-1) shows the lowest hydraulic gradients (and probably the highest vertical permeability) of any cluster west of Mud Creek. Regardless of the magnitude of vertical gradients within a cluster, wells completed in the Camillus Formation (generally two per cluster) exhibit the most similar water levels (refer to the water level graphs in Appendix Q).

The maximum water level elevations recorded in the wells west of Mud Creek were in the range of 735 to 740 feet above mean sea level (amsl). These water levels exceed, by a few feet, the approximate elevation of the Mud Creek channel (approximately 736 feet) near the spill site. A rise in groundwater levels toward this elevation is probably a good indicator of imminent flow in Mud Creek, which occurs for only brief periods of time during the spring of the year.

Perched water-bearing zones underlie cluster locations DC-2 and DC-4, but at different stratigraphic levels at each location (Figure 5-5). Water is perched in the upper Clarence at DC-2A, at a depth of approximately 18 feet, and near the base of the Clarence at DC-4A, at a depth of approximately 40 feet. Water levels in the perched zones were observed to fluctuate by five feet or less during the 10-month monitoring period. Although it is located only 200 feet south of DC-2, the perched water-bearing zone is not present at cluster DC-1. Another interesting difference between the two clusters is the absence of strong vertical hydraulic gradients at DC-1 (Figure 5-6), and their presence at DC-2 (Figure 5-7).

Well clusters DC-2 (Figure 5-7), DC-4 (Figure 5-8), and DC-6 (Figure 5-9) encountered strong vertical hydraulic gradients directed into the Falkirk member from both above and below. The presence of such gradients suggests that the unit may be hydraulically isolated from both the overlying and underlying rocks at DC-2 and DC-4. As will be discussed in Section 5.3.3, the Falkirk does not appear to be hydraulically isolated from the overlying rocks at DC-6. The head in the Falkirk at DC-2B was measured to be up to 12 feet less than the head in the underlying Camillus Formation (DC-2C and DC-2D), and up to 40 feet less than in the overlying perched zone (DC-2A). The same low head characterizes the Falkirk at DC-4B to the west (Figure 5-8), and DC-6B to the east (Figure 5-9), with some notable differences. During two periods of high water levels (March and April, 1994), the normally low head in the Falkirk at DC-6B rose sharply (Figure 5-9) to within a few feet of the seasonally elevated heads in underlying and overlying rocks. This phenomenon was not noted at DC-2 (Figure 5-7) or DC-4 (Figure 5-8), where the heads in the Falkirk rose by much smaller amounts. The upward gradients directed into the Falkirk, therefore, increased with the seasonally higher water levels at DC-2 and DC-4, and decreased at DC-6. The shallower strata, i.e., the Falkirk and above, at DC-2 and DC-4, therefore, seem to be relatively unaffected by an interpreted seasonal influx of groundwater beneath the Mud Creek channel during the spring months. Well cluster DC-6, which is located much closer to the channel than are DC-2 or DC-4, is more likely to be impacted by rising water levels (or water pressure) beneath the channel. On the other hand, the deeper strata, i.e., Camillus and below, at all three locations (i.e., DC-2, DC-4, and DC-6) appear to be well connected to the water-bearing strata beneath the channel. A sequence of three figures illustrates this hydraulic connection. Figure 5-5 shows water levels in the "A" series of open hole wells in the five, four-well clusters west of Mud Creek. All of these wells are completed in the Onondaga Formation, except DC-1A, which is somewhat deeper. The slight rise in water levels in the perched zones at DC-2A and DC-4A contrasts sharply with the substantial water level response at the other three "A" wells in March and April. Figure 5-10 shows comparable data for the "B" series of wells in the same clusters. All five of these wells are screened mostly or entirely in the Falkirk. Once again, the water level responses at DC-2B and DC-4B are subdued when compared to the responses in the other three wells in this group. Figure 5-11, however, shows that all five Camillus wells responded in similar fashion during high water levels.

Hydraulic gradients at well cluster DC-5 were directed downward during all but the highest water levels (Figure 5-12). During lower water levels, the head in the shallow (A) well was about five feet higher than the head in the deep (D) well. Measured heads were highest in the Onondaga Formation, a few feet less in the underlying Bertie Formation, and a few feet lower still in the Camillus Formation. Regardless of the water level, the heads in the two Camillus wells (DC-5C and DC-5D) were nearly identical. When water levels were at their highest, total head differences were reduced to approximately one foot. The highest head shifted from the A well to the B well during the week of April 11th. This gradient reduction and reversal indicates that downward leakage of groundwater is not the primary recharge mechanism for deeper strata at well cluster DC-5.

5.3.2.2 East of Mud Creek

This group of 28 wells, which extends from well cluster DC-3 near Mud Creek to well cluster DC-12 located 2.3 miles southeast of the spill site, showed a much larger annual range of water levels than the wells on the west side of the creek. The most reactive well at each of the nine well clusters east of Mud Creek showed a seasonal water level range of 40 to 58 feet. Except for a few locations, vertical hydraulic gradients were essentially non-existent in this group of wells. The exceptions were at well clusters DC-3 and DC-17, located between Mud Creek and Church Road, and at well cluster DC-12, located along Route 5, 2.3 miles southeast of the spill site.

Maximum water levels in all four wells at well cluster DC-3 approached the elevation of Mud Creek, similar to the observation made at other wells located within a few hundred feet of the creek (Figure 5-13). On March 24, 1994, the water level in the shallow open-hole well (DC-3A) was at the ground surface (elevation 736 ± feet amsl), while water levels in the screened wells (DC-3B, DC-3C, and DC-3D) had risen to within seven feet of the ground surface. The high water level in DC-3A on March 24 is consistent with the observation that Mud Creek was flowing vigorously on that date.

The most reactive wells at well cluster DC-3 (DC-3B and DC-3C) showed seasonal water level ranges of 47 feet (Figure 5-13). When water levels were below approximately 730 feet amsl at DC-3B, which they commonly were, the head in the A well was several feet to 17 feet above the head in the B well. This may be indicative of poor hydraulic communication between the strata screened in each of the wells. When water levels were above the 730-foot level, however, the hydraulic gradient between the A and B wells was drastically reduced, and was actually reversed on April 14, 1994. On that date, the head in the B (Falkirk) well was nearly two feet above the head in the A well.

Because the Falkirk/upper Camillus at well cluster DC-3 appears to be hydraulically isolated from both overlying and underlying strata, the decrease and reversal of hydraulic gradient may indicate that the isolated strata are pressurized (sourced) independently of the shallower strata. Except for the hydraulic gradient reversal, the water level graph for well cluster DC-6 (Figure 5-9) is quite similar to the graph for DC-3 (Figure 5-13). Regardless of water levels, heads in the Falkirk member and in the upper Camillus Formation (B and C wells) were generally the most similar, about one to two feet apart, at well cluster DC-3. This similarity indicates that good hydraulic communication exists between the strata screened in the B and C wells.

The most dynamic groundwater levels noted in the Study Area were recorded at well cluster DC-7R, located 3,100 feet southeast of the spill site and just west of Church Road (Figure 5-3). Routine measurements detected a 58-foot range of water levels during the 10-month monitoring period. However, the water levels in the four wells in this well cluster varied by little more than one foot for a given set of measurements. This uniformity demonstrates the existence of very low vertical gradients, at least at the time the measurements were made. Some interesting head reversals were noted at well cluster DC-7R whenever water levels exceeded 697 feet amsl. (This elevation corresponds to a point in the Clarence member, approximately ten feet above the top of the Edgecliff.) During the nine measurement rounds when water levels were below 697 feet, the Falkirk member (DC-7RB) had the lowest head, and the (deeper) Syracuse well (DC-7RD) had the highest head. During the seven measurement rounds when water levels were above 697 feet, the lowest head was usually in the "shallow" open-hole well (DC-7RA), and the highest head was in either the middle Camillus (DC-7RC) or the Syracuse (DC-7RD) well. Thus, the hydraulic gradient, although small, was generally upward during high water levels.

The dynamic system behavior and low hydraulic gradients observed in well cluster DC-7R suggest that the strata are highly transmissive of groundwater in both vertical and horizontal directions. The existence of upward gradients during high water levels is particularly significant, and suggests that the primary mechanism of system recharge is not infiltrating precipitation. Rather, the entire investigated thickness of the hydrogeologic unit at this location appears to be well-connected to a zone of concentrated recharge from some unidentified surface and/or subsurface location(s). Recharge directly affecting well cluster DC-7R may occur beneath either, or both, of the ponds that form along Mud Creek during periods of high water levels. Refer to Section 5.1.1 for a discussion of local drainage features, including the Mud Creek ponds.

Except for a zone of perched groundwater at DC-8A, the water level graphs for well clusters DC-8, DC-9, DC-10, and DC-11 are remarkably similar. The water level graphs for well clusters DC-8 (Figure 5-14) and DC-10 (Figure 5-15) are representative of this group of wells. The most reactive wells at each of the four well clusters showed water level ranges of 44 to 47 feet during the 10-month monitoring period. For a given set of measurements, water level elevations showed little variation within and between the four well clusters. Such low vertical and horizontal hydraulic gradients are consistent with high vertical and horizontal hydraulic conductivities in the central part of the Study Area.

Although occurring deeper in the stratigraphic section at well cluster DC-8 (Williamsville member of the Bertie Formation), the perched water-bearing zone (Figure 5-14) behaved similar to the perched zones at well clusters DC-2 (Figure 5-7) and DC-4 (Figure 5-8). Water levels in DC-8A varied by only about three feet during the monitoring period. A nearly 55-foot head difference was observed between the perched and underlying zones at DC-8 during low-water conditions in November 1993. The perched zone was still present when the deeper Falkirk well (DC-8B) was dry in November 1993, January 1994, and July through September 1994.

Well cluster DC-12 was the only well cluster in which the hydraulic gradients were consistently directed downward throughout the 10-month monitoring period. Water level differences in the well cluster DC-12 wells increased somewhat with increasing water levels (Figure 5-16). Measured heads were highest in the Onondaga and Bois Blanc Formations (DC-12A), five to ten feet less in the underlying Bertie and upper Camillus Formations (DC-12B and DC-12C), and five to ten feet lower still in the middle portion of the Camillus Formation (DC-12D). Regardless of the water level, heads in the Bertie and upper Camillus wells (DC-12B and DC-12C) were nearly identical throughout the monitoring period.

5.3.2.3 Spring Creek Area

Two well-pairs (DC-13 and DC-14) comprise this group of wells. These wells exhibited the lowest seasonal range of water levels in the Study Area (less than 10 feet), with the exception of the wells that monitor perched water-bearing zones. Because Spring Creek has a fairly constant seasonal discharge, groundwater levels in these nearby shallow wells were expected to exhibit less variability than at all of the other monitoring wells, with the exception noted above.

During the monitoring period, water levels at well cluster DC-13, located approximately 1,000 feet west of Spring Creek, were seven to 17 feet above the surface of the creek (approximate elevation 629 feet amsl). The hydraulic gradient at this well cluster was directed downward during all measurements, with the exception of the September 1994 measurement (see Figure 5-17). The magnitude of the gradient at DC-13 was observed to rise with increasing water levels. Head differences of one to five feet were noted for a given pair of measurements during the monitoring period.

Water levels at DC-14 were 11 to 17 feet above the surface of Spring Creek (approximate elevation 636 feet amsl), located approximately 650 feet to the east. At DC-14, the vertical hydraulic gradient between the two wells was barely detectable (Figure 5-4).

The four wells at DC-13 and DC-14 are screened in the Bertie and Camillus Formations, strata that are projected to directly underlie Spring Creek. The relationships between the groundwater elevations at the well pairs and the surface water elevations of the creek suggest that groundwater in these formations discharges to the creek throughout the year.

5.3.3 Response to Individual Precipitation Events

<u>**General**</u>

Continuous-reading groundwater-level sensors and recording devices were installed and operated in 17 monitoring wells located to the west of Church Road during the spring months (April to June) of 1994. (These wells are referred to as the "monitored wells" throughout the rest of this subsection.) These recording devices were programmed to record water level elevations at 15 minute intervals in all monitored wells. Mr. Alan Mack of the NYSDEC State Fish Hatchery in Caledonia maintained a daily record of precipitation at the hatchery, which is located approximately 3.7 miles east of the Site. This record is contained in Appendix O.

There were eight significant precipitation events during the continuous water level monitoring period, which extended from April 5 through June 8, 1994. The events ranged from the melting of a seven-inch snowfall on April 7, to a 1.35-inch rainfall on April 13. Although 17 wells were monitored during various portions of the monitoring period, only seven wells were monitored during all eight precipitation events. The following events produced a water level response at all monitored wells: the April 7 melt (seven wells), the April 13 rainfall (13 wells), the May 7 and 8 (0.6") rainfall (all 17 wells), and the May 17 (0.25") rainfall (10 wells). Interestingly, the April 25 (0.6") rainfall produced no response at any of the 11 monitored wells. Only three of 13 monitored wells responded to the May 1 (0.45") rainfall. The half-inch (0.5") of rain that fell on May 15 produced a response at only five of 10 wells. Finally, only two wells out of 10 responded to the half-inch (0.5") rainfall on May 31.

Several curious water level changes occurred in the monitored wells during the spring monitoring period. All of the changes were apparently unrelated to precipitation events. On April 23, water levels in DC-6A and DC-6B rose by approximately one foot and three feet, respectively, for no apparent reason. On May 25, water level increases were recorded in the following wells: DC-5A and DC-5B (approximately 1 1/2 feet; see Figure 5-18), DC-6A and DC-6B (approximately six inches at DC-6A, less at DC-6B; see Figure 5-19), and DC-17B (approximately six inches; see Figure 5-20). Although these were not large increases, water levels were otherwise in a declining trend at these and all other monitored locations on May 25. Water levels fell sharply, by as much as two feet, at the following wells on May 6: DC-1A, DC-1B, DC-1C, and DC-1D (Figure 5-21), DC-5A and DC-5B (Figure 5-18), DC-6A and DC-6B (Figure 5-19), DC-15A, DC-15B and DC-16 (Figure 5-22), and DC-17A and DC-17B (Figure 5-20). The reason for the widespread decline on this date is unknown, but it was presumably the result of groundwater withdrawals from local well(s). Despite a one-half inch rainfall on May 31, water levels declined by a foot or more at several wells on that date: DC-5A and DC-5B (Figure 5-18), DC-6B (Figure 5-19), and DC-17A and DC-17B (Figure 5-20).

Detailed Analysis

Because it produced a large water level response at all 17 monitored wells, the May 7 and 8, 1994 (0.6") rainfall event was selected for detailed analysis. The water level data were scrutinized for the onset of a response to the precipitation event. The onset times (i.e., time of first water level increase) and corresponding water levels were noted for the 17 wells. Also noted were the maximum water level attained and the time of the maximum for each monitored well. From these data, the duration and magnitude of the water level rise were calculated for each of the 17 wells. The data are presented in Table 5-3.

The 0.6" rainfall resulted in water level increases that ranged from 2.07 feet (DC-1D; Figure 5-21) to at least 9.45 feet (DC-6A; Figure 5-19). Had the transducer capacity not been exceeded at DC-3A, the well would likely have shown an additional water level rise of approximately eight feet, for a total response of 16 feet at that location (Figure 5-23). (The eight-foot estimate was derived from an inspection of the steep slopes on each side of the flat portion of the graphed curve on Figure 5-23.) At most well clusters, the rise in water levels was less in the deeper well(s). The exception was at well cluster DC-7R, where the water level in the "B" well rose slightly more than the "A" well (Figure 5-24). Had the transducer capacity not been exceeded at DC-6B, the well may have shown a water level rise slightly greater than that at DC-6A (Figure 5-19). Water levels rose for an average of about 35 hours at most locations (Table 5-3). The exceptions were wells DC-7RA, DC-7RB, DC-17A, and DC-17B, where water levels rose relatively quickly in the early hours of the response, then rose much more slowly to the maximum levels (Figures 5-24 and 5-20). Water levels in these four wells rose for an average of 60 hours.

After attaining peak levels, water levels declined more rapidly in the Onondaga and Falkirk wells (generally the A and B wells) than in the Camillus and Syracuse wells (generally the C and D wells). Compare, for example, the water level graphs for wells DC-1A and DC-1B, with the graphs for wells DC-1C and DC-1D (Figure 5-21). Another illustration is provided on Figure 5-22; compare the water level graphs for the relatively shallow wells DC-15A and DC-16 with the response for well DC-15B. The most rapid declines were recorded in the Onondaga and Falkirk wells at DC-6A and DC-6B (Figure 5-19).

Onset times were examined for geographic and stratigraphic patterns that might provide insight regarding system recharge mechanisms. Of particular interest was an evaluation of the roles of two recharge mechanisms: diffuse recharge by direct infiltration of precipitation, and concentrated recharge by sinking streams. The first well in which rising water levels were recorded was DC-3A (a "shallow" open-hole well), at about 12:45 a.m. on May 8, 1994. Precisely when the rainfall began is unknown. The last well to respond was DC-7RA, some 16 hours later (Table 5-3). If diffuse recharge by infiltration is the dominant recharge mechanism, water levels should have begun to rise at about the same time across the network of monitored wells. Because this did not occur, it seems apparent that direct infiltration of rainfall plays only a minor role in system recharge in the Study Area. Supporting the argument that groundwater recharge is largely controlled by area-wide effects related to sinking streams are the following observations: 1. several well pairs (DC-1, DC-7R, DC-15) maintain an upward hydraulic gradient throughout at least part of the recharge events, and 2. the deeper B wells at two clusters (DC-5, DC-7R) responded to precipitation before the shallower A wells.

Onset times within a given well cluster often varied widely (Table 5-3). For example, the deeper wells (DC-1C and DC-1D) at well cluster DC-1 responded approximately seven hours after the shallower wells (DC-1A and DC-1B) at the well cluster. On the other hand, wells DC-6A and DC-6B responded together.

It is interesting to note that the water level in DC-3B did not rise for nearly seven hours after the water level began rising in DC-3A. Additional evidence of poor hydraulic communication between the strata penetrated by these two wells is provided on Figure 5-13, which shows head differences of up to 17 feet between DC-3A and DC-3B.

Water levels rose in the B wells at well clusters DC-5 and DC-7R before they rose in the A wells at those locations (the response delay was five hours and two hours, respectively). This order of response is consistent with system recharge by the influx of a groundwater mass, rather than by infiltration of rainfall.

Similar strata are monitored at DC-15A and DC-17A, and at DC-15B and DC-17B. Water levels began rising in DC-15B within three hours of rising in DC-15A. The difference in onset times at DC-17A and DC-17B was nearly eight hours. The onset time differences within and between well clusters indicate the presence of variable hydraulic properties at or between the well clusters, either vertically or laterally, or both.

An examination of the response onset times shown on Table 5-3 suggests that 16 of the wells may be sorted into eight groups consisting of one to four wells each. Wells within each group showed approximately equivalent onset times. (An onset time could not be determined for DC-1A because the water level in the well had declined three days earlier to an elevation below the transducer; see Figure 5-21.) The eight "response groups" and associated approximate onset times are shown on Table 5-4.

The initial focus is on the "A" series of relatively shallow, open-hole wells. Table 5-4 shows that DC-3A, located in a closed topographic depression 500 feet southeast of Mud Creek, responded first. The next well to respond, nearly three hours later, was DC-6A, located farther downstream along, and 100 feet northwest of, Mud Creek. Approximately two hours later, water levels began to rise in wells DC-16 and DC-17A, located west and east of Mud Creek, respectively. Two hours later, DC-15A responded, followed by DC-5A, after an additional three hour delay. Both of these wells are located west of Mud Creek. More than six hours later, water levels began to rise at DC-7RA, located east of Mud Creek and just west of Church Road.

This complex sequence of rising water levels is not easily interpreted. An analysis was made of potentiometric heads for the eight A wells at a time approximately 4¼ hours after water levels first began to rise in DC-3A. This analysis showed a southeasterly groundwater flow direction. The potentiometric heads 12 hours later indicated that the groundwater flow direction was shifted slightly to the east-southeast. DC-3A was the only well that showed a substantial water-level increase by that time. The response at this well suggests that it intercepts fractures more directly connected to an area of concentrated recharge (sinking stream).

Large ponds are known to form at two locations along Mud Creek when the creek is at or near its highest stage (elevation). One pond is located 3000 feet southwest of the spill site, between the Dolomite Products Company quarry and the LeRoy Airport, and the other is located just southeast of the spill site. It is postulated that the creek loses substantial amounts of water to the subsurface beneath these ponds. Water was observed to be seeping into the ground at the south pond in April 1992. Water in the Mud Creek channel between this pond and the north-south railroad spur has also been observed seeping into the ground at several times during the course of the RI. Information regarding the stage of Mud Creek during the analyzed precipitation event is, unfortunately, lacking. However, the peak water levels that were attained in the monitored wells during the precipitation event were 10 feet or more below the elevation of Mud Creek near the spill site. This suggests that the creek was not flowing in the vicinity of the spill site at any time during or following the event. If the creek flowed as far north as the south pond, groundwater recharge may have been occurring at that location. Whether DC-3A is hydraulically connected to the south pond is unknown.

Among the wells near Mud Creek, DC-3A had the lowest initial head, and was the first to show a water level rise. The last wells to respond (DC-15A and DC-5A) had the highest initial heads (Table 5-3). The wells with the lowest initial heads also generally showed the greatest rise in water levels, while those with the higher initial heads generally showed the least rise. This indicates that groundwater moved preferentially into the areas of lower head (pressure), consistent with the physical laws describing groundwater flow.

The "B" wells are generally screened in the Falkirk member of the Bertie Formation. DC-1B and DC-6B were the first to respond to the precipitation event, approximately two hours after water levels began rising at DC-3A. DC-5B was next, nearly three hours later. Less than two hours later, DC-3B responded. DC-7RB was the last of the Falkirk wells to respond. An analysis was made of potentiometric heads for the five B wells at the time when water levels first began to rise in DC-1B. This analysis showed an east-southeasterly groundwater flow direction. Thirty-four hours later, the potentiometric heads indicated that the groundwater flow direction had shifted to southward, from DC-6B toward DC-3B, in response to the buildup of a large lateral hydraulic gradient between these two locations. Apparently the fractures that facilitate a rapid water level increase at DC-3A do not extend downward into the B well at that location. The low head that usually characterizes the Falkirk in well DC-3B (Figure 5-13) also suggests that vertical permeability is low at this location. Downward leakage of groundwater into the Falkirk would not likely occur at the rate necessary to produce the observed water level increases (Table 5-3). This implies that transmission of groundwater in the Falkirk at DC-3 was confined to bedding planes and/or fracture zones limited to the Falkirk, not through fractures in the overlying strata. However, the concurrent response to the precipitation event at wells DC-6A and 6B indicates that vertical permeability is good between strata penetrated by these wells. This suggests that the relatively low head that usually exists in the Falkirk at DC-6 (DC-6B; Figure 5-9) is not indicative of hydraulic isolation, but of downward groundwater flow from the Onondaga into the Falkirk.

An interesting response was observed at DC-5 and DC-7R, where water levels rose in the Falkirk before they rose in the overlying strata. Similar to DC-3B, this suggests that groundwater transmission in the Falkirk is restricted to bedding planes and fractures limited to that unit.

Four of the monitored wells are screened in the Camillus and Syracuse Formations. DC-1C (Camillus) and DC-1D (Syracuse), and DC-15B (Syracuse) responded within minutes of each other, although more than 10 hours after water levels first increased at DC-3A. DC-17B, the last of the deep wells to respond, did so before water levels rose in the shallower DC-7RA and DC-7RB wells. Recharge to the hydrogeologic system, even at depths as great as 180 feet (DC-15B; Figure 5-22), occurred with surprising speed. This rapid response demonstrates the extent to which deep strata are hydraulically linked with shallower strata in the vicinity of Mud Creek.

5.4 HYDRAULIC PROPERTIES OF THE HYDROGEOLOGIC SYSTEM

Slug tests were performed in all 55 monitoring wells in order to calculate estimates of in-situ hydraulic conductivity (K). Test results generated from both the Hvorslev, and Bouwer and Rice analytical methods are presented in Table 5-5 (duplicate of Table 2-5). All references to K-test results in the text are those produced by the Hvorslev method. The tested stratigraphic intervals are also shown on Table 5-5. The tested interval corresponds to the screened interval for screened wells. In open-hole wells, the tested interval corresponds to the length of the water column or the thickness of the "saturated" zone at the time of the test. K values ranged from 1.6×10^{-6} (DC-4A) to 4.8×10^{-2} cm/sec (DC-13B). Thus, the permeability of the bedrock zone tested at DC-13B is 30,000 times greater than that at DC-4A. Only one-third of the wells yielded K values below 10^{-3} cm/sec. Most of these lower-K wells were the relatively shallow, open-hole wells ("A" wells). The deeper wells generally yielded K values in the 10^{-3} to 10^{-2} cm/sec range. The shallow, open-hole (or "A" series) wells generally monitored the Devonian - Onondaga and Bois Blanc Formations, while the deeper screened wells generally monitored portions of the Silurian - Akron, Bertie, Camillus, and Syracuse Formations.

While these K values are relatively high, particularly for bedrock strata, they are consistent with the many hydrogeological observations documented in this report. These observations include bedrock core analysis, borehole caliper and video logs, and routine and continuous water level monitoring. These analyses together portray a dynamic aquifer system that is capable of transmitting a large amount of groundwater in a relatively short period of time. Rocks of the lower Camillus Formation stand out in this regard.

Several wells that were screened in heavily fractured bedrock responded erratically to the introduction of the slug of deionized water during the K-test. The water level in these wells exhibited rapid oscillations after the introduction of the slug. The results are nevertheless considered to be representative of the hydraulic conductivity of the tested strata. Refer to the note on Table 5-5 for the identity of these wells, and to Appendix L for water level response graphs for all listed wells. Complete test results for each well are available to the Department upon request.

Groundwater occurs in, and migrates within and along, bedding planes and steeply dipping joints and fractures in the Onondaga limestone and Akron and Bertie dolomites. Some of these openings have been enlarged by dissolution. However, the "rubbleized" appearance of portions of the underlying Camillus Formation suggests that some mechanism other than the mere solutioning of joints and fractures has affected the rock. Throughout the Study Area, the lower 40 or so feet of this argillaceous dolomite is extensively broken, and has a "punky" or corroded appearance. This appearance and the mechanism of "rubbleization" may be a result of the dissolution of evaporite deposits. This portion of the investigated geological section has the greatest potential to transmit large quantities of water.

Cluster DC-6 exhibits the highest overall K value among the six, four-well clusters nearest the spill site (i.e., DC-1 through DC-6). Cluster DC-3 has the lowest overall K of this group of wells. The caliper logs and video observations in these borings are consistent with these comparative results (Appendix I). Dissolution along bedding planes is more extensive throughout the Onondaga, Bois Blanc and Bertie Formations at DC-6, as compared to DC-3. The caliper and video data also show that the Camillus Formation at DC-6 has fewer and thinner competent zones than at DC-3.

Table 5-6 shows the same data as Table 5-5, except that the results are grouped by stratigraphy (tested interval) rather than by well cluster. The 55 wells have been assigned to six stratigraphic groups. The first group (Group 1 = 15 wells) includes all of the relatively shallow, open-hole wells, plus DC-11A, a screened well that is open to equivalent strata. Group 1 includes the two most closely-spaced wells in the Study Area in which the same stratigraphic interval was K-tested (lower Clarence - upper Falkirk): DC-15A and DC-16. The K values of these wells, which are 170 feet apart, differ by a factor of 33, providing an indication of the variability of hydraulic properties within a limited volume of rock. DC-15A has the highest K value among the Group 1 wells.

The second group of wells (Group 2 = 12 wells) is screened primarily in the Falkirk member of the Bertie Formation, possibly with some screen extension into overlying strata. The third group of wells (Group 3 = 10 wells) is screened primarily in the upper Camillus Formation, possibly with some screen extension into the overlying Falkirk. Group 4 includes five mid-Camillus wells. Seven wells screened primarily in the lower Camillus, and six wells screened primarily in the upper Syracuse, comprise Groups 5 and 6, respectively. The geometric mean K values progressively increase with the geologic age of the rocks: the Group 6 wells (Syracuse Formation) are 100 times more conductive than the Group 1 wells (Onondaga Formation - upper Bertie Formation). There is very little difference in the geometric mean K values of rocks in Groups 2, 3, and 4 (all are close to 2.5 X 10^{-3} cm/sec). Groups 5 and 6, likewise, feature similar mean K values (approximately 9 x 10^{-3} cm/sec).

Major bedding planes in carbonate rocks often extend for thousands of feet or even miles. Geological evidence gathered during the course of this investigation suggests that such openings are effective conduits for groundwater flow in the Study Area. The caliper logs show that bedding plane fractures are present at the same stratigraphic level in the lower Onondaga Formation at drilling locations up to 2.5 miles apart (DC-4 and DC-12), and at intermediate locations as well. An apparently extensive bedding plane fracture in the Williamsville dolomite has been identified at the four drilling locations where the unit is present (DC-8, DC-9, DC-10, and DC-12). The Williamsville bedding plane fracture is the source of the perched water at well cluster DC-8.

A set of steeply-dipping fractures has been identified near or at the top of the Falkirk, and in the middle portion of the unit, at most drilling locations. The mid-Falkirk fractures at DC-1 have narrow apertures such that the caliper tool detected no variations in borehole diameter in the interval. (This fracture set was identified at DC-1 through core and borehole video analysis.) The caliper tool responded to the mid-Falkirk fractures at the other well clusters, particularly at DC-7R, DC-10, and DC-12. At these locations, the fractures are solutioned such that five- to eight-foot-thick fracture zones are present. It is interesting that, despite the difference in fracture size or frequency, the K values are only marginally higher at DC-10 and DC-12, as compared to DC-1 (Table 5-6). The Falkirk fractures are developed to a much greater extent at DC-7R than at DC-7, which is located 410 feet to the north. The K value for DC-7RB (Falkirk) was 2.4 x 10^{-2} cm/sec, the highest hydraulic conductivity of any Group 2 well.

5.5 GROUNDWATER FLOW

This section focuses on the interpreted direction of groundwater flow in three groups of strata during low and high water level conditions. The three groups are the Onondaga-upper Bertie, the Falkirk member of the Bertie Formation, and the lower portion of the Camillus Formation. Water level measurements approaching seasonal water level lows were taken on August 15, 1994. The highest water levels that were observed were measured by the NYSDEC project manager at well cluster DC-12 and in all wells west of Church Road, on March 24, 1994. The water levels for these two dates are compiled in Table 5-7.

Water level elevations were used to create potentiometric surface maps that provide an indication of the direction of groundwater flow. Groundwater is assumed to flow from regions of high potentiometric (hydraulic) head to regions of low head. This assumption is not necessarily valid in all cases. For example, a low head in a specific area may indicate that it is hydraulically isolated from a region of high head. Flow between two such areas would not occur, despite the presence of a driving force (i.e., the hydraulic gradient). In addition, fractures with high conductivities may divert water in directions other than those depicted by potentiometric lines.

The maps are interpretive, and should be considered as a guide to general flow directions, particularly in the area east of Church Road, where the well density is relatively low. It is important to realize that, on a local scale, groundwater flow directions are likely to be extremely complex and unpredictable. They are also sensitive to the lateral and vertical distribution of hydraulic head, which can change in a matter of hours during a storm event. (Of course, the distribution of contamination in the groundwater provides the most reliable, long-term evidence of general flow patterns.) The following discussion is focused on seasonal, extreme water level conditions. Particular water level responses during the transition between the extremes may be short-lived, but may nevertheless be highly significant relative to the mobilization and migration of contamination near the spill site.

5.5.1 Groundwater Flow Within the Onondaga-Upper Bertie Stratigraphic Units

The potentiometric surface map for the Onondaga-upper Bertie interval is based on water level measurements in 11 of the "A" series of relatively shallow, open-hole wells (including DC-7 and DC-16). The interval includes the Nedrow member of the Onondaga Formation and underlying rocks as deep as the lower portion of the Falkirk member of the Bertie Formation. The water levels in the three open-hole wells that intersect perched water-bearing zones (DC-2, DC-4, DC-8) are not relevant for determining regional flow directions, and were not considered in map preparation.

Because the open-hole intervals are as long as 85 feet (DC-7RA), it is possible that some boreholes may intersect water-bearing zones of unequal hydraulic heads. If the existence of such a condition in a well was recognized, the water level would be inappropriate for use in determining flow directions. Except for some of the deeper open-hole wells, none of the wells are likely to link zones of different head. Therefore, flow analysis was performed for this extremely important (and highly reactive) hydrogeological zone.

<u>Low Water Conditions</u> (August 15, 1994)

Two open-hole wells were dry during low water conditions (DC-7RA and DC-10A). Water levels measured in a group of 9 wells form the basis for the following discussion. The water levels ranged from 710.81 feet amsl (DC-6A) to 668.46 feet (DC-12A), a range of more than 42 feet. Note that nearly all of the head loss (at least 37 feet) occurs in the area between DC-3A and DC-7RA at Church Road (Figure 5-25). The loss is related to unknown bedrock conditions. A fracture zone lying parallel and/or proximate to Mud Creek may act as a groundwater drain to the northeast, and out the Mud Creek valley. Farther to the east, the potentiometric surface, based on only two data points, appears to be nearly flat (DC-7RA = <670.50 feet; DC-12A = 668.46).

The hydraulic head distribution in wells screened in this group of strata suggests that groundwater flows toward the east-southeast in the area between the spill site and Church Road. The flow direction is difficult to ascertain in the area east of Church Road, given the low density of data points (wells). Indications are that flow in this area during low water level conditions is in an easterly direction, and at lower velocities than might prevail in the area to the west of Church Road where lateral hydraulic gradients are higher.

The vertical hydraulic gradients in the "shallow" strata were strongly downward in four of the five well clusters where the Falkirk was screened in the "B" well. The gradient was approximately four feet between the "A" and "B" wells at DC-5 and DC-12, and approximately 15 feet for comparable well pairs at DC-3 and DC-6 (see Figures 5-12, 5-16, 5-13, and 5-9, respectively). These data suggest that groundwater may seep downward from the Devonian strata into the Silurian strata during low water conditions. Whether this actually occurs depends on the vertical permeability of the strata. Such seepage could account, at least partially, for the sharp head loss in the area between Mud Creek and Church Road. The vertical hydraulic gradient in the "shallow" strata at DC-1 (the spill site) was less than one foot (Figure 5-6). There should be little downward leakage at this location under such a low hydraulic gradient.

<u>High Water Conditions</u> (March 24, 1994)

Groundwater flow directions were very different in the vicinity of the spill site during high water levels as compared to low water levels. The shape of the potentiometric surface during high water conditions (Figure 5-26) is not the same as during low water conditions (Figure 5-25). This occurs primarily as a result of significant changes in head relationships between two pairs of wells: Whereas hydraulic heads were relatively higher in wells DC-6A and DC-17A than in wells DC-3A and DC-7RA, respectively, during low water levels, the relationship was reversed during high water levels (compare Figures 5-25 and 5-26). Thus, the east-southeasterly groundwater flow direction in the shallow strata in the area of these wells during low water conditions changed to a northeasterly flow direction, during high water conditions.

The high water conditions potentiometric surface map (Figure 5-26) is based on water level measurements made in a group of 10 wells. A measurement at DC-10A is the only water level missing from an otherwise complete (non-perched) set of "A" well measurements. Water levels in this group of wells ranged from 736.99 feet amsl (DC-3A) to 715.08 feet (DC-12A). The head range of nearly 22 feet is about one-half of the range observed in this group of wells during low water conditions (42+ feet). The water level at DC-3A was nearly 30 feet higher in March, whereas a nearly 47-foot increase occurred at DC-12A. Note that the 10-foot head loss in the area between wells DC-3A and DC-7RA was a much smaller portion of the 22-foot total than the relative head loss observed between the same wells in August (37+ feet of 42 total feet) when water levels were low (compare Figures 5-25 and 5-26).

The contours in Figure 5-26, as drawn, suggest the presence of a groundwater mound beneath the southern of two ponds along Mud Creek, as discussed previously. There are no monitoring wells in the area to confirm the interpretation of such a mound. However, aerial photographs from April

7, 1993 show this area to be flooded, thereby creating a large pond. Based on actual observations of surface water infiltrating the rock in this area, it is reasonable to assume that such a mound will exist during high water conditions. The extent, magnitude, and duration of the feature are unknown. The mound is superimposed on a water table that is elevated on a regional scale by a presumed influx of groundwater from losing streams located at the west end of the Study Area and from a recharge belt along Route 5 (Figure 5-1). Another groundwater mound may exist during high water levels farther downstream along Mud Creek, south of Gulf Road and southeast of the spill site. Evidence of this mound is provided by the high groundwater levels in wells DC-1A, DC-3A, DC-5A, DC-6A, DC-15A, and DC-16 (Figure 5-26). Aerial photographs from March 31, 1992 show a large pond in this area, thereby supporting the concept of a mound in this area during high water conditions. Groundwater recharge related to either, or both, of these mounds may be responsible for the flatter slope on the potentiometric surface to the east of Mud Creek during the March 1994 period of high water.

The potentiometric surface in the area east of Church Road (Figure 5-26) exhibits a component of dip in an east-southeasterly direction. The 12-foot dip, derived from only two data points (DC-7RA = 726.76 feet; DC-12A = 715.08 feet), exceeds the slope of the potentiometric surface observed in August 1994 during low water conditions. The data also indicate that, while the potentiometric surface was becoming flatter with rising water levels to the west of Church Road, it was steepening to the east of this road.

The hydraulic head distribution during periods of high water suggests that groundwater flows beneath the spill site in a northeasterly direction toward the Mud Creek gorge. As suggested on Figure 5-26, Mud Creek is a losing stream farther to the south (upstream), where groundwater is interpreted to flow radially outward from a mound, but primarily toward the east and northeast. The direction of groundwater flow is difficult to ascertain in the area east of Church Road because of the low density of data points (wells). Indications are that flow in this area during high water level conditions would generally be in an easterly direction, and at somewhat higher velocities than during low water level conditions.

With the exception of gradients in well clusters DC-1 and DC-12, the vertical hydraulic gradients were lower during high water levels. The gradient at DC-1 was nearly three feet (Figure 5-6), whereas the gradient at DC-12 was particularly high (11 feet; Figure 5-16). The gradients in the shallow rock were directed downward at all well clusters except DC-7R (Figure 5-3). The upward gradient at that location may be indicative of an influx of deeper groundwater into the local area during storm events. Thus, with the exception of DC-5 (where the downward gradient is very low) and DC-7R, the data suggest that groundwater may seep downward from the Devonian strata into the Silurian strata during both high and low water conditions. Whether this actually occurs depends on the vertical permeability of the strata. The downward seepage would occur at a lower rate during periods of high water levels. There is probably little downward leakage at DC-5 at these particular (high) water levels.

5.5.2 Groundwater Flow Within the Falkirk Member of the Bertie Formation

The potentiometric surface map for the Falkirk member of the Bertie Formation is based on water level measurements in many wells of the "B" series of screened monitoring wells. The screened intervals primarily include the Falkirk member, but at many locations, several feet of overlying strata are also screened in the same well.

<u>Low Water Conditions</u> (August 15, 1994)

Water levels measured in a group of 11 wells form the basis for the following discussion. Well DC-8B was dry during low water conditions, indicating that the potentiometric surface was below 686.60 feet amsl (equivalent to the well bottom elevation) at that location. Water levels in the remaining 10 wells ranged from 706.75 feet amsl (DC-5B) to 646.99 feet (DC-14A), a range of nearly 60 feet. The head loss was 34 feet between wells DC-5B and DC-7RB at Church Road. Similar to the shallower "A" series of wells, the potentiometric surface sloped steeply to the east in the area west of Church Road, and sloped gently eastward from Church Road to Spring Street (Figure 5-27).

Although the total head loss in the deeper set of wells west of Church Road was nearly the same as in the shallower set of wells, water levels were higher farther to the east in the shallower wells (compare Figures 5-25 and 5-27). Water levels in DC-3A and DC-6A were at least as high as in wells closer to the spill site (Figure 5-25). Water levels in the deeper "B" wells at these two locations, however, were well below those in wells to the west (Figure 5-27). The reason(s) for the low water levels in the Falkirk at DC-3 and DC-6 are unknown. The hydraulic gradient is downward between wells DC-3B and DC-3C (Figure 5-13). For this reason, the groundwater in the Falkirk near DC-3 could have been moving into deeper strata along steeply dipping fractures, perhaps in the vicinity of Mud Creek. Similar downward movement could not have been occuring in the Falkirk at DC-6, because the head was higher in the underlying upper Camillus at the time (Figure 5-9). The Falkirk at DC-6 may have been "dewatered" into the Mud Creek gorge at a more rapid rate than overlying strata, which would result in a more rapid lowering of the pressure (head) in the Falkirk. The higher hydraulic conductivity in DC-6B (relative to DC-6A) suggests this possibility (Table 5-5).

An interesting situation occurs at cluster DC-7R where the head at DC-7RB (672.57 feet) is greater than the well bottom elevation of DC-7RA (670.5 feet), which was dry on August 15, 1994. This indicates that the Falkirk in the vicinity of DC-7R must not contain vertical fractures that would allow upward movement of water into strata penetrated by the "A" well. The caliper log (Appendix I) indicates the presence of such an unfractured zone at a depth of 96 to 101 feet below the ground surface.

The hydraulic head distribution in the strata monitored by this group of wells suggests that groundwater flow directions ranged from northeasterly near DC-1, DC-2, and DC-4, to southeasterly in the area between DC-3 and DC-6. A small portion of the northeasterly flow may have ultimately discharged at springs in Falkirk outcrops in the Mud Creek valley, e.g. SPR-20 and SPR-20A. The southeasterly flow is interpreted to have ultimately discharged via Falkirk outcrops or springs near the headwaters (south end) of Spring Creek. Flow directions east of Church Road may be far more complex than the necessarily simplistic presentation on Figure 5-27. It is possible for groundwater in any stratigraphic unit to move stratigraphically higher or lower through any fracture connecting strata of different hydraulic head.

High Water Conditions (March 24, 1994)

Groundwater flow directions in this group of strata were very different in the vicinity of the spill site during periods of high water levels as compared to periods of low water levels. The shape of the potentiometric surface (Figure 5-28) has been altered by significant changes in relative head relationships in the wells located to the west of Church Road. While hydraulic heads rose by about 29 feet in wells DC-1B, DC-5B, and DC-6B, they rose far less (about 15 feet) in wells DC-2B and DC-4B, and far more (about 50 feet) in wells DC-3B and DC-7RB. Thus, the steep eastward hydraulic gradient that was evident during low water levels was drastically reduced during high water level conditions.

The potentiometric surface map (Figure 5-28) is based on water level measurements made in a group of eight wells. Because this was a limited, unscheduled round of water level measurements taken by the NYSDEC project manager, measurements were not made in Falkirk wells DC-8B, DC-10B, and DC-14A. Water levels in the measured group of eight wells ranged from 736.1 feet amsl (DC-5B) to 703.86 feet (DC-12B). The head range of approximately 32 feet is about one-half of the 60-foot range observed in this group of wells during low water conditions. Note that there was only a nine-foot head difference between DC-5B and DC-7RB, well below the 34-foot difference observed between the same wells in August when water levels were low (compare Figures 5-27 and 5-28). Also note the sharply lower water levels in DC-2B and DC-4B (721-722 ±), as compared to DC-1B (733 1/2 ±). Water levels in these three wells were within one foot of each other during the August 1994 round of measurements.

The potentiometric surface in the area east of Church Road (Figure 5-28) exhibits a component of dip in an east-southeasterly direction during high water conditions. The 23-foot dip, derived from only two data points (DC-7RB = 727.46 feet; DC-12B = 703.86), exceeds the nine-foot slope of the potentiometric surface observed in August 1994, during low water conditions (Figure 5-27). Whereas the potentiometric surface was becoming flatter with rising water levels to the west of Church Road, it was steepening to the east of this road. This same phenomenon was observed in the "A" series of wells (Figure 5-26).

The hydraulic head distribution suggests that groundwater in the Falkirk beneath the spill site may have been flowing in a northerly direction toward the abandoned General Crushed Stone Company quarry. The top of the Falkirk is within 10 feet of the quarry floor, while the head at DC-2B was about five feet above the floor of the quarry. Note that DC-4B was potentially downgradient of the spill site during this round of water levels. In addition to the apparent northerly flow beneath the spill site, Figure 5-28 also shows that groundwater in the Falkirk at well clusters DC-3 and DC-6 may have been flowing northeasterly toward the Mud Creek gorge.

The direction of groundwater flow is difficult to ascertain in the area east of Church Road, because of the low density of data points (wells). Indications are that flow in this area during high water level conditions was in an east-northeast to east-southeast direction, and at higher velocities than during low water level conditions. The suggested east-northeast flow may be directed toward Falkirk outcrops or springs north of the Mumford Fish and Game Club and a private residence on Flint Hill Road (Monroe County), and within the nature trail system on the Genesee Country Museum property. The east-southeast flow may be directed toward Falkirk outcrops or springs near the headwaters (south end) of Spring Creek.

With the exception of the strong downward gradients from the perched water-bearing zones at well clusters DC-2 and DC-4, the vertical hydraulic gradients were lower during high water levels. The vertical gradient was directed downward into the Falkirk at DC-3B, DC-5B, and DC-12B (Figures 5-13, 5-12, and 5-16 respectively). The gradient was upward at DC-7RB (Figure 5-3). At DC-1, DC-2, DC-4, and DC-6 (Figures 5-6, 5-7, 5-8, and 5-9), the lowest heads were in the Falkirk ("B") wells. All of these conditions were the same during low water levels except at DC-1 and DC-2, where the upper Camillus had the lowest head, and the gradients were downward into the Falkirk. The strongest gradients were at DC-2 and DC-4 from the perched water-bearing zones above, and the high pressures in the underlying upper Camillus. The upward gradient at DC-7RB (as well as DC-7RA) may be indicative of an influx of deeper groundwater into the local area during storm events.

5.5.3 Groundwater Flow Within the Lower Camillus Formation

The potentiometric surface map for the lower portion of the Camillus Formation is based on water level measurements in many wells of the "D" series of screened monitoring wells and two "B" wells (DC-9B and DC-13B). The screened intervals primarily include the lower Camillus, but at a few locations, several feet of the underlying Syracuse Formation are also screened in the same well.

<u>Low Water Conditions</u> (August 15, 1994)

Water levels measured in a group of 14 wells form the basis for the following discussion. Measurements ranged from an estimated 708.5 feet amsl at well cluster DC-4, to 636.81 feet at well DC-13B, a range of approximately 72 feet. The head loss in the lower Camillus was approximately 36 feet between well clusters DC-4, and DC-7R at Church Road. The lower Camillus water levels at these two locations are estimates based on the heads in shallower and deeper wells: DC-4C and DC-4D, and DC-7RC and DC-7RD (refer to Appendix P-1). Similar to the shallower (A, B, and C) series of wells, the potentiometric surface exhibited a steeper eastward slope in the area west of Church Road, and a more gentle eastward slope between Church Road and Spring Street (Figure 5-29).

The 36-foot head loss in the deep set of wells west of Church Road was nearly the same as in the three shallower sets of wells in the same area. Water levels in the lower Camillus wells differed only slightly from the water levels in the overlying Falkirk member. Notable exceptions occurred in DC-3D, DC-4D, and DC-6D, where water levels were higher than in the Falkirk at the same locations, and at DC-5D, where the water level was lower. These vertical hydraulic gradients and their potential significance have already been discussed. The net result is that the potentiometric surface map for the lower Camillus (Figure 5-29) is similar to the Falkirk map (Figure 5-27).

The hydraulic head distribution in the wells screened in these strata suggests that groundwater flow directions ranged from northeasterly near well clusters DC-2 and DC-4, to southeasterly elsewhere west of Church Road. The northeasterly flow north of Gulf Road probably discharged at springs located in the Camillus at the northeast end of the Mud Creek gorge. The original southeasterly flow west of Church Road is interpreted to have ultimately discharged via Camillus outcrops near the confluence of Spring and Oatka Creeks in the Village of Mumford. Water levels measured in wells screened in shallower strata (DC-10D, DC-11B, DC-12D, and DC-14B) were considered when drawing the isopotential lines for the area east of Church Road. This was possible because of the excellent vertical communication between screened intervals at these locations, as demonstrated by the water level graphs for these clusters.

<u>High Water Conditions</u> (March 24, 1994)

The potentiometric surface map depicting high water conditions (Figure 5-30) is based on water level measurements made in a group of seven wells, all located to the west of Church Road. Water levels in this group of wells ranged from an estimated 738.5 feet amsl at well cluster DC-4, to approximately 727.5 feet at well cluster DC-7R. Water level measurements were not taken in lower Camillus wells located to the east of Church Road (DC-8D, DC-9B, and DC-13B).

The contrasting patterns of water levels in the lower Camillus during high water conditions in comparison to low water conditions is generally the same as in the shallower well sets in the Study Area. The estimated head difference in the lower Camillus between well clusters DC-4 and DC-7R was reduced to 10 feet during high water, in comparison to a 36-foot difference during low water (Figure 5-29). Despite the flattening of the lateral hydraulic gradient, groundwater flow directions are interpreted to have been substantially the same during both high and low water conditions.

The hydraulic head distribution suggests that groundwater in the lower Camillus beneath the spill site may have flowed in a northeasterly direction toward the Mud Creek gorge. Figure 5-30 indicates that, south of the spill site, the direction of groundwater flow may have been in a southeasterly direction. As previously stated, water level measurements were not made in the lower Camillus wells east of Church Road on March 24, 1994. Such measurements were, however, made during periods of somewhat lower water levels (for example, on April 11, 1994). These data suggest that, in the area east of Church Road, the groundwater flow direction in these strata during high water conditions is similar to the flow direction during low water (Figure 5-29).

5.6 OVERVIEW AND SUMMARY OF HYDROGEOLOGIC CONDITIONS

The hydrogeology of the Study Area is strongly influenced by the complexity of surface and subsurface conditions. Some of these conditions remain consistent with time, and others vary significantly in relation to climatic and seasonal changes. Examples of some of the stable conditions include the presence of perennial streams bordering the Study Area, the topography of the Study Area, the southerly dipping bedrock strata and the relatively higher terrain to the south of Route 5. However, the unique nature of bedrock conditions, both at the surface and at depth, provides an even greater influence on the surface and subsurface hydrogeologic regime, particularly in the vicinity of Mud Creek. The existence of several sinking streams to the southwest and southeast of the Site, and the sinking nature of Mud Creek upstream of the Site, has an effect on both the surface and subsurface hydrology of the Study Area. The effect varies depending on the season of the year and in response to the stage of the streams, i.e. either flowing on the surface or in the subsurface. Local quarrying operations exert a significant influence on the hydrogeologic system near the west end of the Study Area. This influence is dependent upon the season of the year and on stone production schedules. During the winter, or off season, water floods portions of the quarry floors. In the spring, the operating quarries west and southwest of the Site are dewatered to allow full scale production of stone products. Dewatering continues as necessary during the summer and fall.

It is apparent from historical and recent evidence that groundwater beneath the Study Area, to a depth of at least 180 to 200 feet, flows generally to the east toward Spring Creek. Because of this, the contaminant plume has migrated a distance of approximately four miles in somewhat less than 20 years. This fact is apparent from the analytical results generated from EPA/DOH sampling in the early 1990s and from the comprehensive sampling program conducted during the remedial investigation. The results of this sampling indicate that not all areas downgradient of the spill site have been impacted. This is due to the fact that the movement of the groundwater and TCE contamination is controlled by a complex and variable set of both horizontal and high angle fractures in the bedrock. As such, the groundwater and TCE flow is not necessarily uniform or predictable throughout the Study Area, and may change during periods of varying water levels and potentiometric head relationships. While some "uniformity" has been demonstrated by the relative consistency of both the locations of and the analytical results from both contaminated and uncontaminated sampling points, complete uniformity and/or predictability throughout the Study Area should not be inferred from these results.

In order to understand the groundwater regime at the spill site and in the Study Area, the concept of a single hydrogeologic system was adopted, taking into account the fact that groundwater and contaminant movement within the system would be fracture-controlled and, as indicated above, not uniform or predictable. The hydrogeologic system was analyzed in both vertical and horizontal segments. These segments were determined on the basis of direct observation of natural conditions, e.g., the potential influence of the Mud Creek and Spring Creek valleys, and by information obtained from clusters of monitoring wells installed at various locations throughout the Study Area.

The Mud Creek valley is a significant topographic feature near and downstream of the spill site and exerts a strong influence on the flow of groundwater and contaminants in the subsurface. It is evident that Mud Creek influenced the migration of TCE and contaminated groundwater at the time of and shortly after the derailment/spill. It is also evident, from the data collected during the RI, that this feature continues to influence the movement of groundwater, and the mobilization and migration of the TCE that remains in both the surface soils and the bedrock beneath the spill site. Similarly, the location and influence of Spring Creek at the easterly end of the contaminant plume is significant with respect to providing a potential termination point for the plume.

It has been determined that the bedrock beneath the spill site and Study Area contains both high angle and horizontal fractures that can readily transmit groundwater. Water level measurements collected over a 10-month period indicate that the bedrock underlying the spill site and Study Area contains features that inhibit groundwater movement as well as features that transmit water readily. Both of these conditions are demonstrated by the water level measurements collected in the wells located at and in the immediate vicinity of the spill site. Groundwater levels in the Study Area are at their highest in the spring and drop throughout the summer to their lowest levels in the late summer and early fall. Groundwater in the vicinity of Mud Creek behaves dynamically in the spring, with Mud Creek responding rather dramatically to the influx of both groundwater and surface water from either or both snowmelt and precipitation events. The dynamic behavior of groundwater and surface water in the vicinity of Mud Creek in the spring is due, in part, to the fact that the groundwater levels have approached their highest level by slow recovery and rise over the winter months. With the addition of the springtime influx of groundwater, the water levels in the already full basin rise rapidly and overflow onto the land and to the northeast out the Mud Creek valley. Spring Creek's discharge, on the other hand, remains relatively stable throughout the year in response to a base level flow provided by numerous springs.

The discussion of analytical results presented in Section 6.0 provides an indication of how the general pattern of groundwater movement has influenced the relative levels of TCE at many of the locations sampled during the RI. A more focused discussion of groundwater movement and contaminant migration is presented in Section 7.0. An understanding of the mechanism(s) of mobilization and migration of the plume is also critical to the evaluation of alternatives to remediate, i.e., to remove or control the remaining source of TCE and the dissolved phase plume.

6.0 ANALYTICAL RESULTS

6.1 HISTORICAL SAMPLING AND ANALYTICAL DATA

In 1991, the NYSDOH sampled a number of domestic wells located between the Village of Caledonia and the spill site. This sampling was conducted in relation to an investigation of contamination present in the Caledonia municipal wells located to the east of the village, and awareness of the LVRR derailment-related spill of TCE. As a result of this sampling, a number of domestic wells were found to be contaminated with TCE. The sampling program was expanded to include locations in a three county (Genesee, Livingston and Monroe) area between the spill site and the villages of Mumford and Caledonia. Additional wells containing traces or elevated levels of TCE were discovered within this area, and extending from Gulf Road/Flint Hill Road (Monroe County) on the north to Route 5 on the south. Appendix B (Volume III of this RI) contains tables of historical TCE sampling results by NYSDOH and three county health departments in 1991 and 1992 (Tables B-G = Genesee, B-L = Livingston and B-M = Monroe). Tables B-G2, B-L2 and B-M2 also contain the results of DUNN's initial domestic well sampling conducted in December 1992. Refer to Section 6.2.2. for more details of this sampling event. Although not "historical" in the context of this subsection, Tables B-G3 through B-M4 present the TCE results for all domestic well sampling conducted by NYSDOH and DUNN in 1993 and 1994.

6.2 INITIAL RI (PHASE B) SAMPLING AND ANALYTICAL DATA

6.2.1 Initial Environmental Sampling and Analytical Data

An initial round of environmental sampling took place in December 1992, as part of a preliminary assessment of Site and Study Area conditions. Environmental samples were collected from drainageways (surface water, sediment), ponds (surface water, sediment), springs and seeps. These samples were collected from areas or specific locations suspected of being contaminated, as well as areas expected to be free of contamination. These areas or locations consisted of potential contaminant migration pathways, potential groundwater discharge points and points expected to be outside the limits of contamination, thereby providing evidence of ambient or background conditions. A list of the initial environmental sampling locations and the reason(s) for their selection is as follows:

Location		**Reason(s)**
SED-1	Mud Creek valley upstream of "swallet"	To provide an indication of relict contamination resulting from historical impact of the spill on the Mud Creek valley upstream of the mainline railroad fill.

Note: This section of the valley was dry during sampling such that a companion surface water sample could not be collected at this location.