Lanesboro SFH

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KARST AQUIFER INVESTIGATION

Lanesboro State Fish Hatchery

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The Lanesboro State Fish Hatchery is located in Fillmore County, MN approximately 1.5 miles southwest of the City of Lanesboro. The hatchery is operated by the Section of Fisheries, Division of Fish and Wildlife, of the Minnesota Department of Natural Resources (DNR). Of the six existing trout hatcheries operated by the DNR, the Lanesboro facility is one of the largest, producing nearly 50% of all the trout stocked in Minnesota's public waters. Brown trout, rainbow trout, and brook trout are reared in earthen ponds and concrete raceways fed by water from two springs. The spring water is a constant 9°C which is an ideal temperature for rearing trout. Trout produced at the hatchery are released in public waters throughout the state.

Regional Geology and Hydrology

Fillmore County is in the area described as the Rochester till plain (Wright, 1972). Wright characterizes the area as a "nearly featureless pre-Wisconsin till plain" that is likely till of Kansan age. The landscape in the vicinity of Lanesboro lies in that part of the till plain which has been dissected by the Root River. In this area the topography is rugged; elevation differences between the valley floors and ridge tops are typically 300-400 feet. The hatchery itself lies in the watershed of Duschee Creek, a tributary of the Root River.

Southeastern Minnesota is underlain by the sedimentary Paleozoic rocks of the Hollandale embayment (Delin and Woodward, 1984). The hatchery springs (Main Spring is at the hatchery and Triple Spring is several thousand feet to the southeast of the hatchery) emanate from the Oneota dolomite of the Ordovician Prairie du Chien group. The Oneota is described by Delin and Woodward as a sandy, thin-to-thick-bedded dolomite which transmits water primarily through fractures, joints, and solution channels. Rapid groundwater flow through the karsted dolomites of the Prairie du Chien group have been described in Winona and Olmsted Counties in their geologic atlases (Balaban and Olsen, 1984; Balaban, 1988). These works also note the evidence of karst features such as sinkholes and disappearing streams in the Prairie du Chien group formations.

The fact that the springs are fed by karsted formations has been noticeable in terms of some water quality problems at the hatchery. After heavy rains or a mid-winter thaw the springs become quite turbid from silt. Along with the silt have come leaves, twigs, seeds, and even corncobs. The silt and debris are signs that surface runoff goes directly into the groundwater via a sinkhole or disappearing stream. Retired Hatchery Manager Russell Hanson, whose father ran the hatchery before him, stated that the sediment problem has been occurring for at least 40 to 50 years.

This silt causes a variety of problems at the hatchery. During periods of high turbidity the fish cannot be fed so growth rates are slowed. Other problems include the smothering of eggs by the silt, some incidents of bacterial gill disease, and increased maintenance and cleaning associated with silt removal from the raceways. Hatchery staff have, in the past, installed screens and a sedimentation basin to remove the silt but none of these measures have been effective.

From 1985 through 1988 a study of the groundwater quality of the Duschee Creek Watershed was conducted by the University of Minnesota Geology and Geophysics Department (Wheeler et.al., 1990). Part of this project included the monitoring of water quality at the hatchery spring. Since it was assumed that sinkholes were serving as the entry point for the silt laden runoff, this group attempted to locate sinkholes in the Prairie du Chien formation in the Duschee Creek Watershed. Four sinkholes in all were located.

In order to determine if these sinkholes were connected to the hatchery a fluorescent dye, approved for water tracing by the United States Geological Survey, was flushed down the sinkholes. Water samples were then collected at the hatchery. Of the four sinkholes tested only one (MN23:D0024), with a drainage area of approximately one square mile, had a positive detection at the springs. In order to prevent runoff from entering this sinkhole, the landowner built a berm around it to divert runoff. Despite this effort, the siltation problem at the hatchery continued.

Division of Waters Investigations

Division of Waters (DOW) staff became involved with attempting to solve the hatchery's water quality problems in the spring of 1991. It was decided that DOW field staff should study the hydrology of the Duschee Creek basin and locate sinkholes and stream sinks which could carry surface water into the karst formation feeding the hatchery springs. This effort was undertaken due to the continuation of the turbidity problem.

Through the observations of Norrin Storlee, a local landowner, a previously unknown stream sink was located on the intermittent west branch of Duschee Creek in Section 11, T102N, R10W (Figure 1). This sink was approximately a third of a mile to the east of the sinkhole investigated by Wheeler. As this branch of Duschee Creek only flows during periods of high runoff, which correlates with periods of high sediment loads in the hatchery springs, the consensus among DNR and U of M staff was that this stream sink could be a major contributor of sediment to the hatchery springs. It was inventoried as MN23:B0062 (B62) in the Minnesota Cave and Karst index kept by the University of Minnesota.

In order to locate other sinkholes and stream sinks, DOW staff contacted landowners and obtained permission to field survey most of the watershed of the west branch of Duschee Creek. With the exception of one valley running southwest from the SW¼ of Section 11, all of the main stem and tributary valleys were field checked. No obvious sinkholes or stream sinks were found.

In order to determine if B62 was indeed carrying surface runoff to the hatchery springs DOW and U of M staff ran two dye traces. The first was on October 15, 1991. Approximately 3Kg of Rhodamine WT (C.I. Acid Red 388) were flushed into the sinkhole with 1900 gallons of water supplied by the Lanesboro Fire Department. Samples were taken at regular intervals at Main and Triple springs at the hatchery; at Gribbens Mill spring; and the Duschee Creek headwaters spring. Dye was only detected at Main and Triple springs.

Breakthrough time was approximately 8.5 hours which was very similar to that found by Wheeler for the time from sinkhole D24. Peak dye concentrations reached 20 parts per billion (ppb) and dye persisted above background levels for approximately two weeks (Figure 2). This long "tail" on the recovery curve mimicked the time lag of silt in the springs after a runoff event. Given that, and the fact that B62 has a nine square mile drainage area, DOW and U of M staff concluded that B62 was likely the major input point for runoff water entering the karsted bedrock.

The October 1991 trace was done with an artificial input of water from a fire truck. We decided that in order to learn more about the conduit system feeding the springs it was desirable to repeat the trace under natural conditions (i.e. during a period when the west branch of Duschee Creek was flowing). Early in the morning on June 16, 1992, the farm site near B62 received 1.6 inches of rain; on June 17th it received an additional .6 inches of rain in the early hours of the morning.

We checked B62 on the morning of the 17th; the west branch had a flow of approximately .5 cfs. The water was brown from its high sediment load and all of the flow was disappearing into B62. Based on the fresh debris line on the channel banks it appeared that flows had been 4 to 5 times greater earlier in the day with all of it going into B62.

At 1100 hours on the 17th we injected 2.35 kg of 20% Rhodamine WT into B62. Sampling at 15 minute intervals began at Main and Triple springs at 1800 hours on the 17th and continued on a less frequent basis for the next twelve days. Results of this trace are shown in Figure 3.

By examining and comparing the dye recovery curves in Figures 2 and 3 some deductions can be made about the structure of the conduit system which connects to Main and Triple springs. In a relatively simple conduit system, the dye recovery curve will have a single peak (Mull etal, 1988). In the case where the curve has more than one peak (polymodal), it is an indication that the conduit system is branched or braided (Smart, 1988). The dye recovery curve from the October 1991 trace in Figure 2 is clearly polymodal. Based on that and the similar results found by Wheeler it was assumed that there was a braided conduit system carrying runoff water to the hatchery springs.

The results of the June 1992 trace indicate that the conduit system is not braided. Since this trace was done under a natural flow regime it is more likely to provide an accurate assessment of conduit morphology and time of travel parameters. The polymodal pattern may have come from flow through fractures in the bedrock above the conduit system.

The June 1992 dye recovery curve is not, however, similar to other unimodal recovery curves. Other work done in southeastern Minnesota (Mohring, 1983) demonstrated that dye is flushed out of those conduits after 1 to 3 days. At the Lanesboro spring, the dye continued above background levels for over 10 days after input. While the rapid time to leading edge, T_L, of the dye cloud (approximately 10 hours) indicates a well-developed conduit, the long tail suggests that there is some type of fracture system coincident with it.

While both Main and Triple Springs had approximately the same peak concentrations, the time to peak dye concentration, Tp, and the T_L were slightly different during the June 1992 trace. The Tp for Main Spring was 11¼ hours while for Triple Spring it was 12 hours. The T_L for Main was 10 hours and for Triple it was 10¼ hours. Since these springs are approximately ¼ mile apart it is obvious that at some point the conduit system splits between the two. Two potential explanations for this phenomenon are either that the point where the conduit split is closer to Main than Triple or that the conduit feeding Triple is physically smaller resulting in lower velocities hence slightly longer travel times.

SITE REMEDIATION

With the positive connection between B62 and the hatchery springs established the next step was to determine what type of remediation could be done at the site. B62 lies in the streambed at a point where the stream meanders against a rock face on the west wall of the valley. Inside the meander was a broad alluvial terrace with enough area to allow for the construction of a diversion channel.

On May 7, 1992, the DNR - DOW geophysics crew ran three seismic refraction lines across the terrace to determine depth to bedrock in order to evaluate the feasibility of constructing a diversion channel. Figures 5 through 8 show the locations of the seismic lines and the layer profiles for each line. The depth to bedrock ranged from 18 to 28 feet below land surface. Based on those results it was decided by DNR staff to proceed with the planning necessary to construct a diversion channel.

Stream bed profiles and channel cross-sections were obtained by the DNR - DOW hydrographics unit survey crew on October 26, 1992. The crew discovered that there was approximately 2 feet of fall in the stream bed through the meander. Channel length through the meander was 500 feet giving a streambed slope of .4%.

During the summer of 1992 the landowner applied to the Fillmore Soil & Water Conservation District (Fillmore SWCD) for cost-share assistance. At that time the SWCD had access to a special grant for sinkhole diversions which was administered by the State Board of Water & Soil Resources (BWSR). This funding would pay for 75% of the cost of a project with the landowner picking up the other 25%. It was agreed on by the SWCD, BWSR, DNR, and the landowner that the DNR - Section of Fisheries would pay the landowner portion.

In order for the DNR to legally pay the landowner's portion, it had to either acquire the stream corridor in the area of concern or get an easement on it. After several months of negotiation between DNR staff and the landowner, he donated a 5 years ~~permanent~~ easement to the Department. The easement allows the DNR - Section of Fisheries to construct and maintain a diversion channel at the location of the sinkhole and allows for access to the site. In addition to the easement, a DNR - DOW Protected Waters Permit was also necessary in order to work in the stream. That permit (#93-5097) was issued on July 14, 1993 to the DNR - Section of Fisheries.

The BWSR retained the services of Barr Engineering in Minneapolis for the design work of the diversion channel and sinkhole sealing. The channel was designed with earthen banks at a 3:1 slope with a layer of rock armor on the streambed. Design specifications also called for rock riprap at the head of the diversion channel and at a point upstream where there was severe bank erosion. Due to the two feet of fall through the diverted reach, a rock drop structure was placed in the channel. This structure serves to dissipate the stream energy and act as a ford crossing for farm machinery. The diversion channel and sinkhole filling work were completed in early October 1993. Aside from some variations in riprap and channel armor siting, the channel basically was built as designed.

As mentioned earlier, when the sinkhole was excavated, no large crevices in the bedrock were found. The large openings directly below it terminated after several feet. That coincided roughly with the contact between the Willow River dolomite to the New Richmond sandstone. The original plans called for geotextile fabric to be placed directly over the bedrock opening with large rock on top of the fabric. Since the sinkhole was on the New Richmond sandstone no opening was encountered, the fabric was placed on the sandstone at the bottom of the excavation.

The variations of the sinkhole filling design were approved by representatives of all the agencies involved. Detailed drawings and material specifications for all phases of the engineering designs and survey work are under Appendix 1 attached to this report.

SUMMARY

As of this writing, this effort to protect and enhance the water quality at the Lanesboro State Fish Hatchery is working. During February 1993 there were two significant runoff events due to a mid-winter thaw. In previous years such events would have led to turbid water at the hatchery; with the diversion of flow from the stream sink B62, the springs stayed clear.

This project demonstrated several different concepts. It proved, yet again, that the use of fluorescent tracers is a valuable tool for understanding the dynamics of a karsted aquifer. Second, it demonstrated that engineering solutions in karst are possible given the proper physical setting and the proper interpretation of that setting by the staff involved. Third, it proved that staff from a variety of state and local agencies can come together to make a project like this work.

ACKNOWLEDGEMENTS

I would like to acknowledge the assistance and cooperation of the following individuals on this project for without them it would not have come to pass: Darryl Brekke of the Fillmore County SWCD; E. Calvin Alexander, Kate Withun, and Betty Wheeler of the Geology and Geophysics Department of the University of Minnesota; Eric Mohring of BWSR; Edwin Stork of DNR - Section of Fisheries; Evan Drivas and Jay Frischman of DNR - Division of Waters; Art Kalmes of Barr Engineering Company; Jim Cooper, my supervisor at DNR-Waters, who encouraged me to work on this project; and perhaps most of all, Roger Kalsrud, the person who owns the land who gave us access and donated an easement in order to allow us the opportunity to protect the Lanesboro Hatchery springs.

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Duschee Creek Watershed

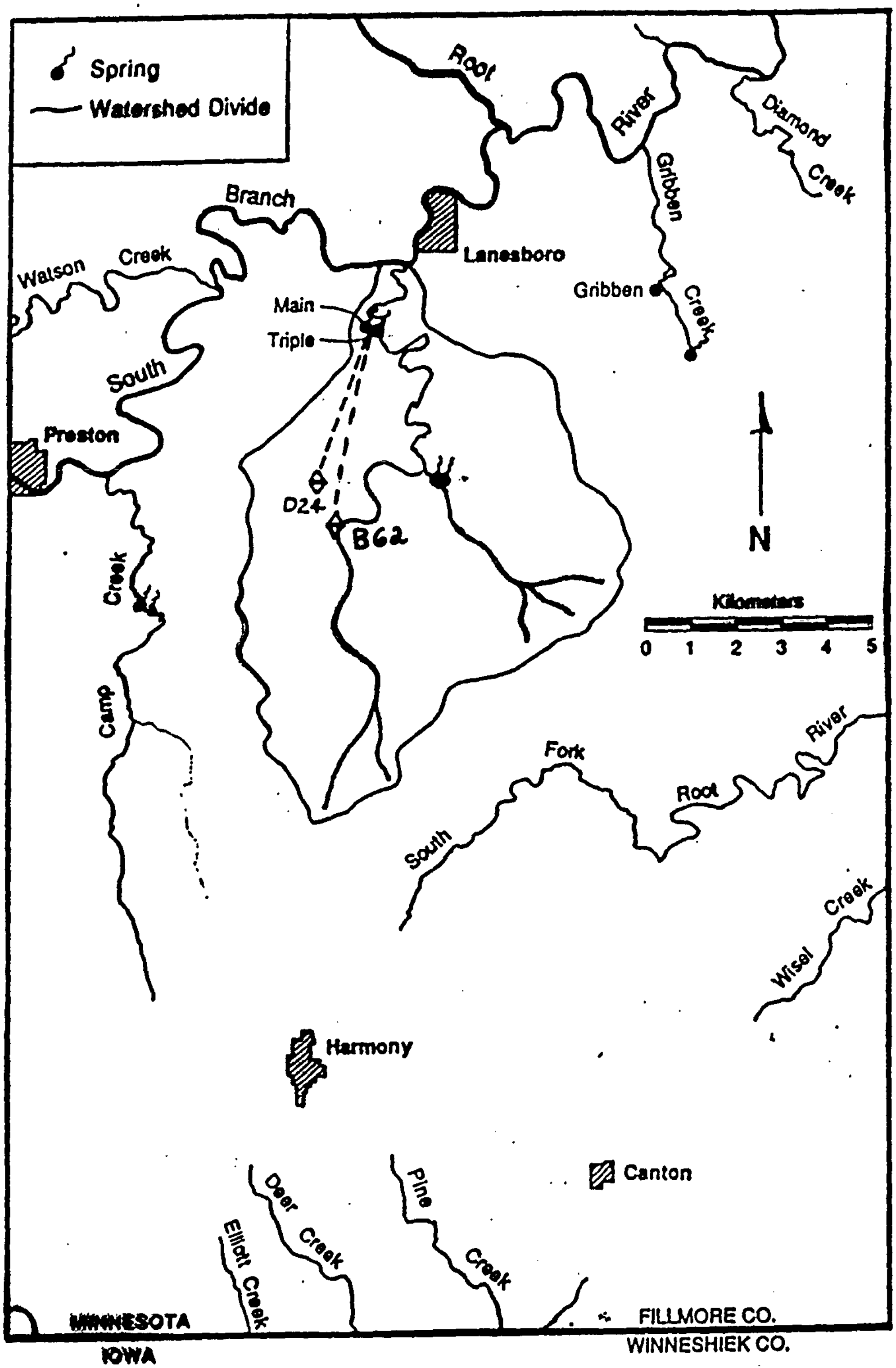


Figure 1 (Wheeler et al)

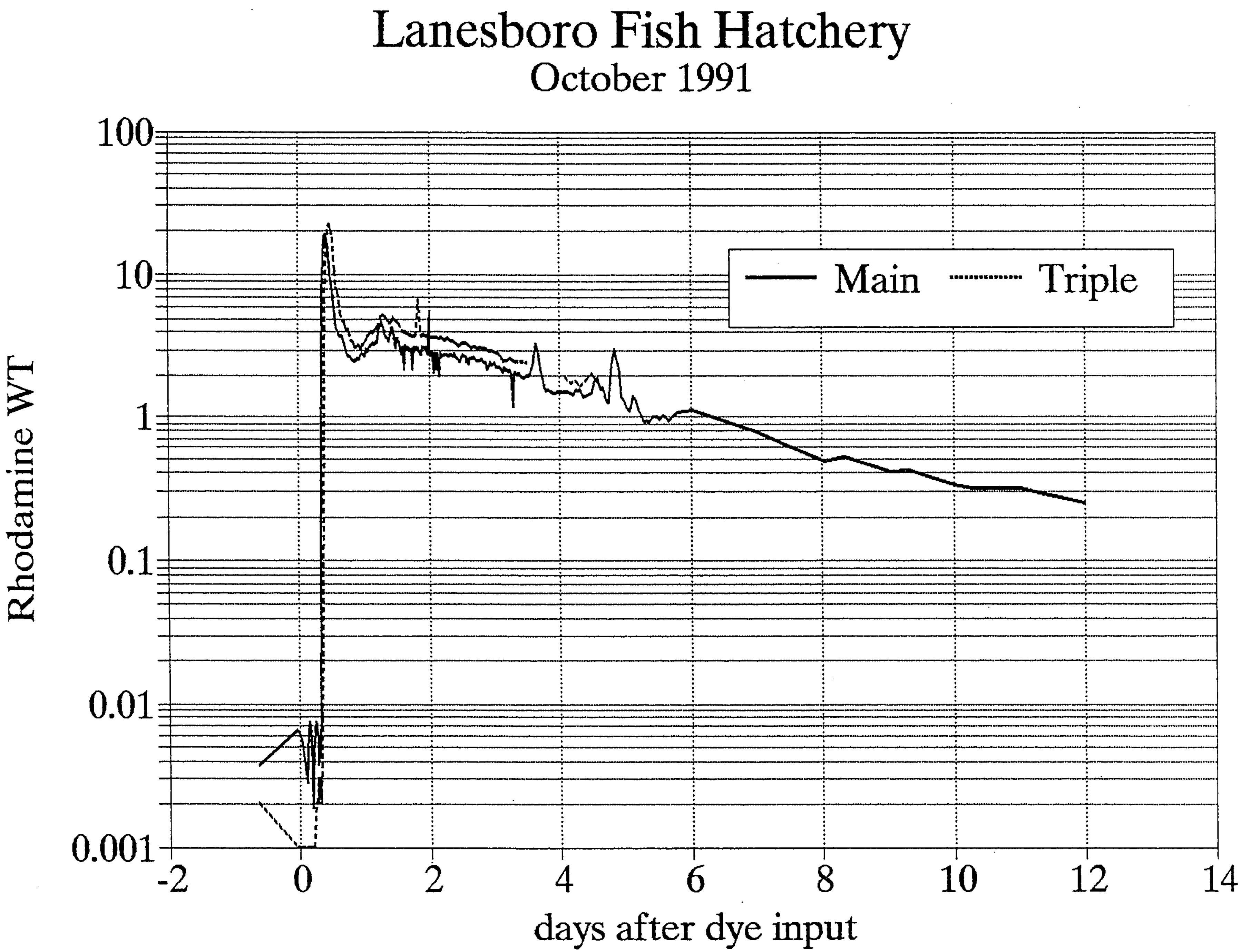
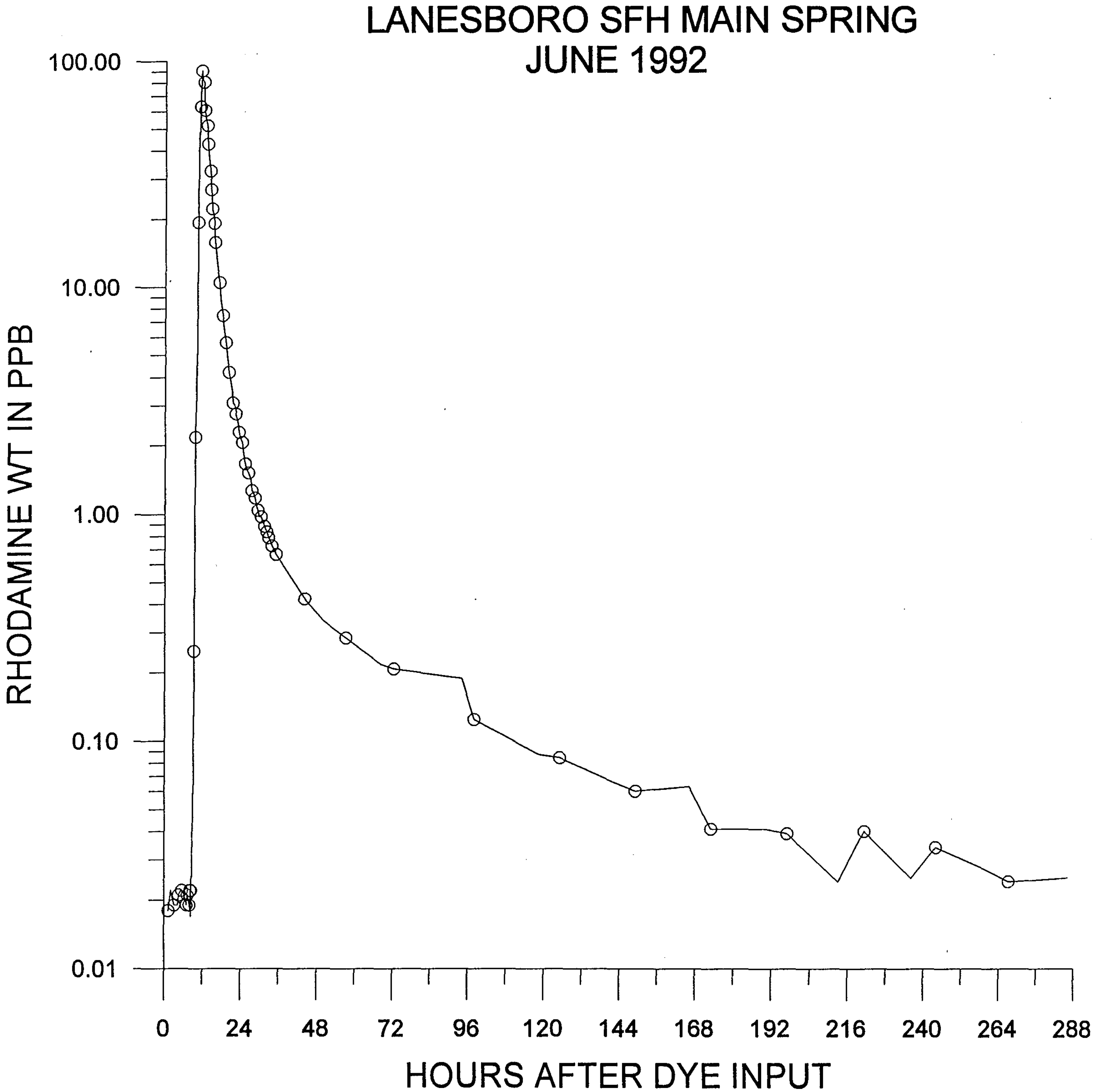

Lanesboro Fish Hatchery
October 1991
Main
Triple
Rhodamine WT
100
10
1
0.1
0.01
0.001
-2
0
2
4
6
8
10
12
14
days after dye input

Figure 2



LANESBORO SFH MAIN SPRING
JUNE 1992
100.00
10.00
1.00
0.10
0.01
RHODAMINE WT IN PPB
0
24
48
72
96
120
144
168
192
216
240
264
288
HOURS AFTER DYE INPUT

Figure 3

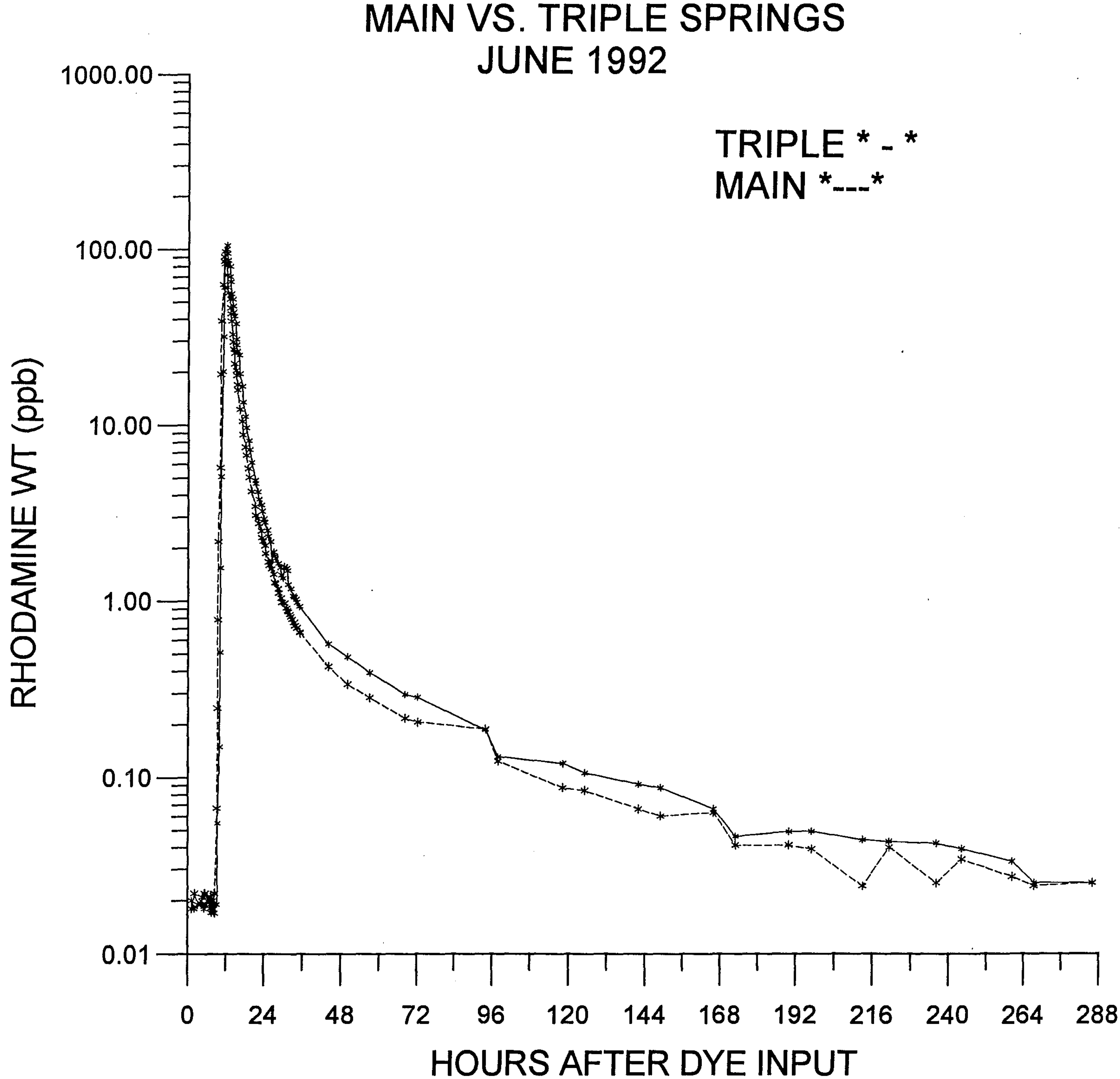
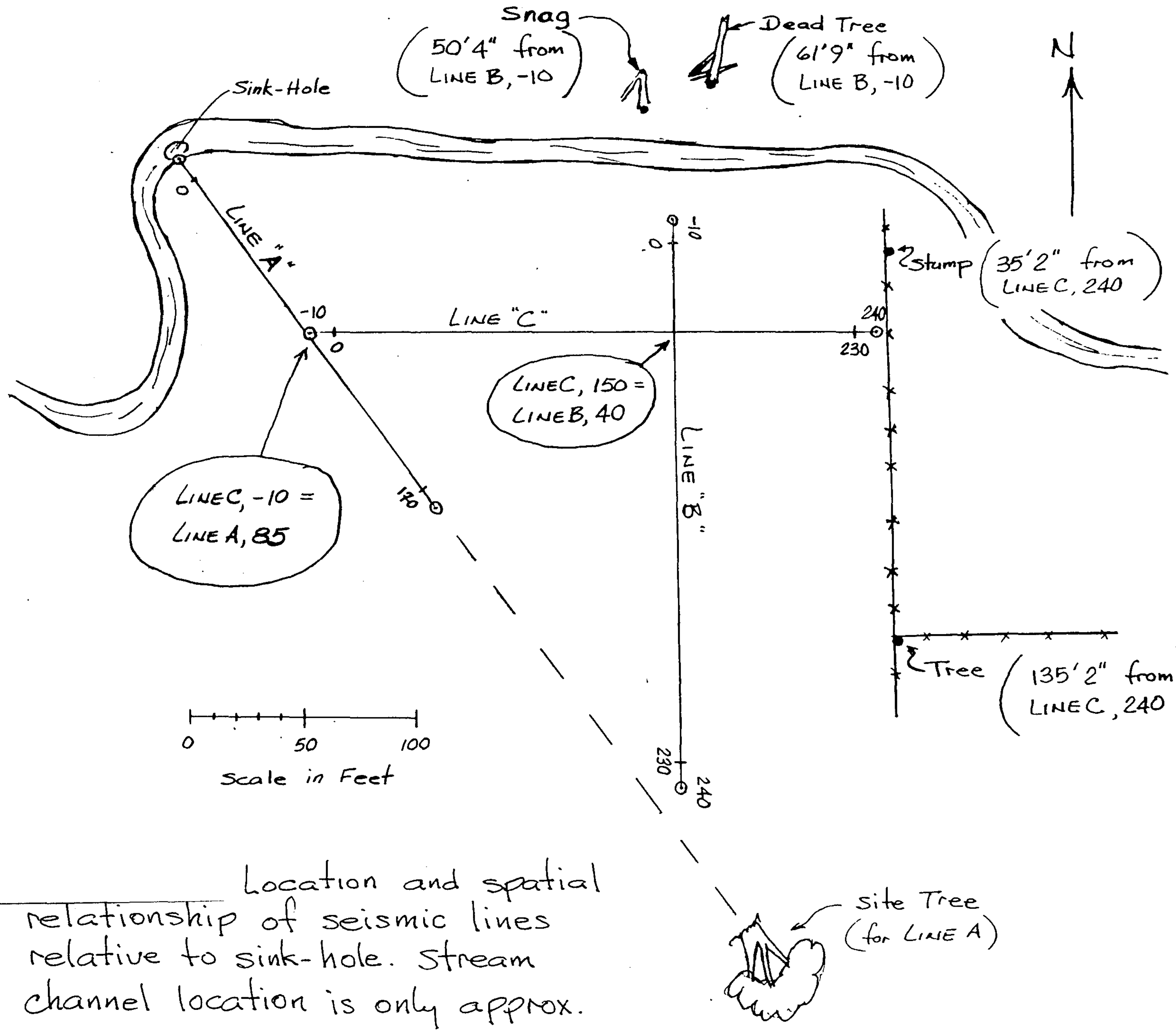
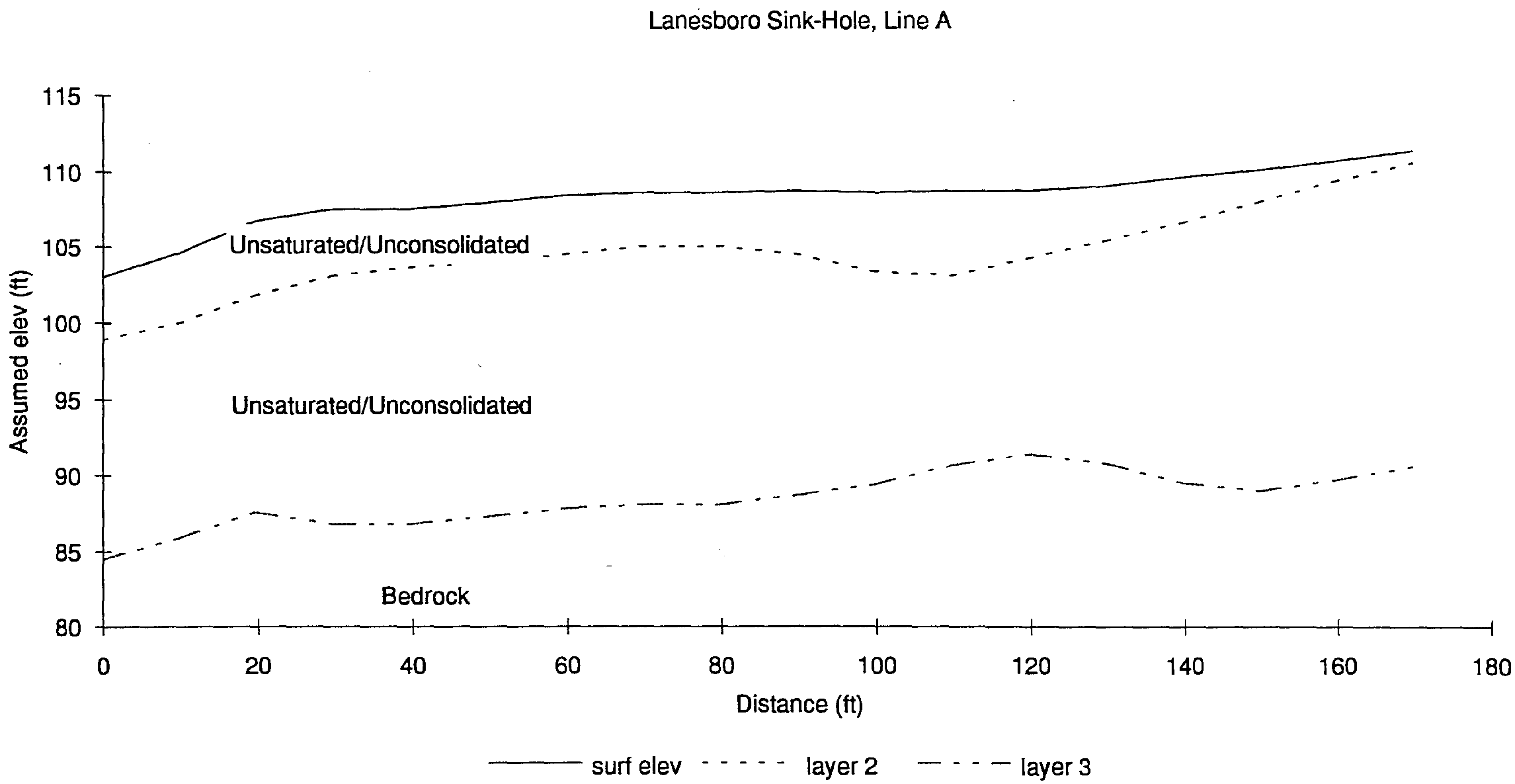

MAIN VS. TRIPLE SPRINGS
JUNE 1992
TRIPLE * - *
MAIN *---*
RHODAMINE WT (ppb)
1000.00
100.00
10.00
1.00
0.10
0.01
0
24
48
72
96
120
144
168
192
216
240
264
288
HOURS AFTER DYE INPUT

Figure 4



Location and spatial relationship of seismic lines relative to sink-hole. Stream channel location is only approx.

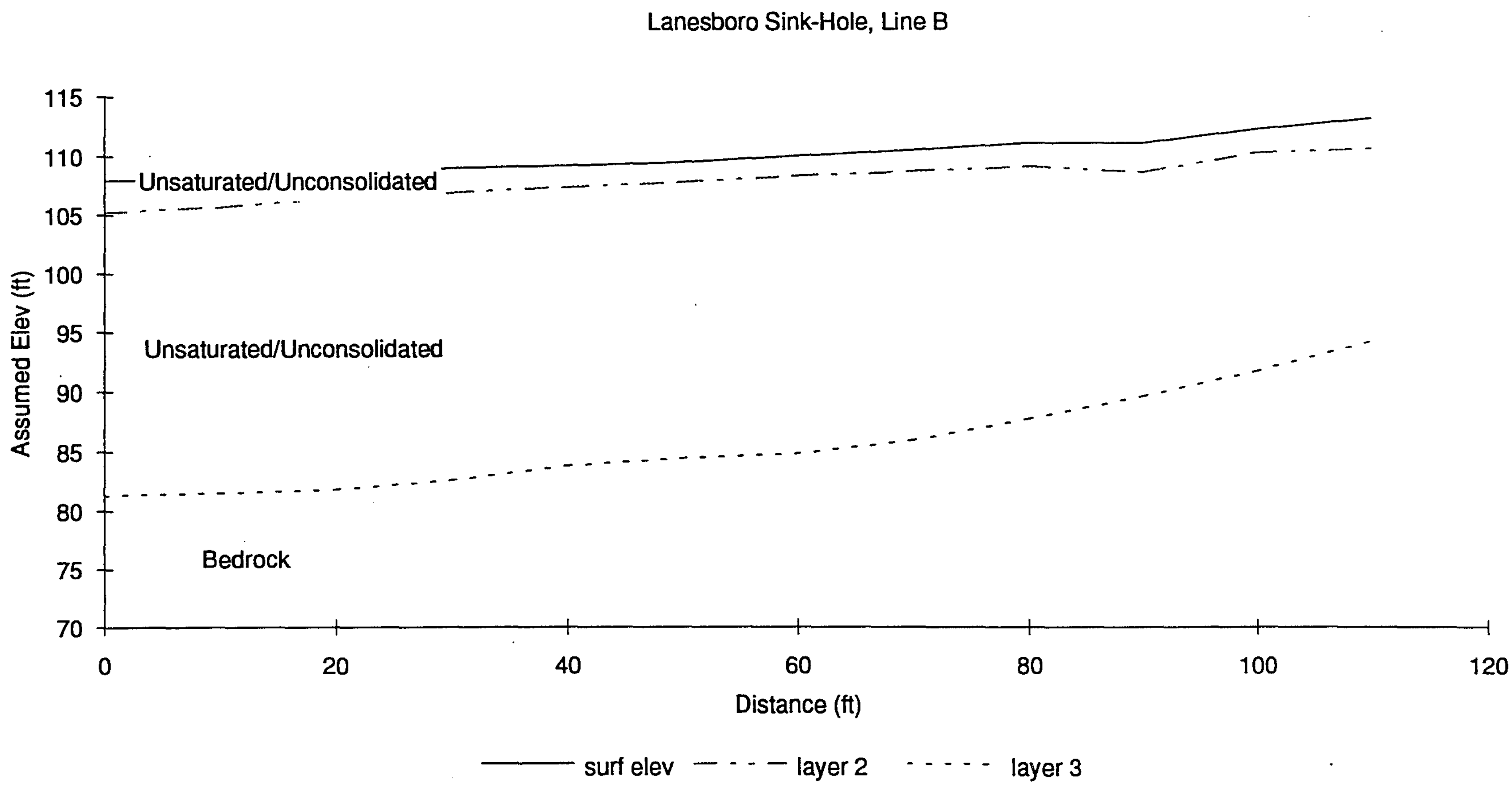
Figure 5 (DNR-DOW Geophysics)



Layer profile for Line A, Lanesboro Sink-Hole investigation.

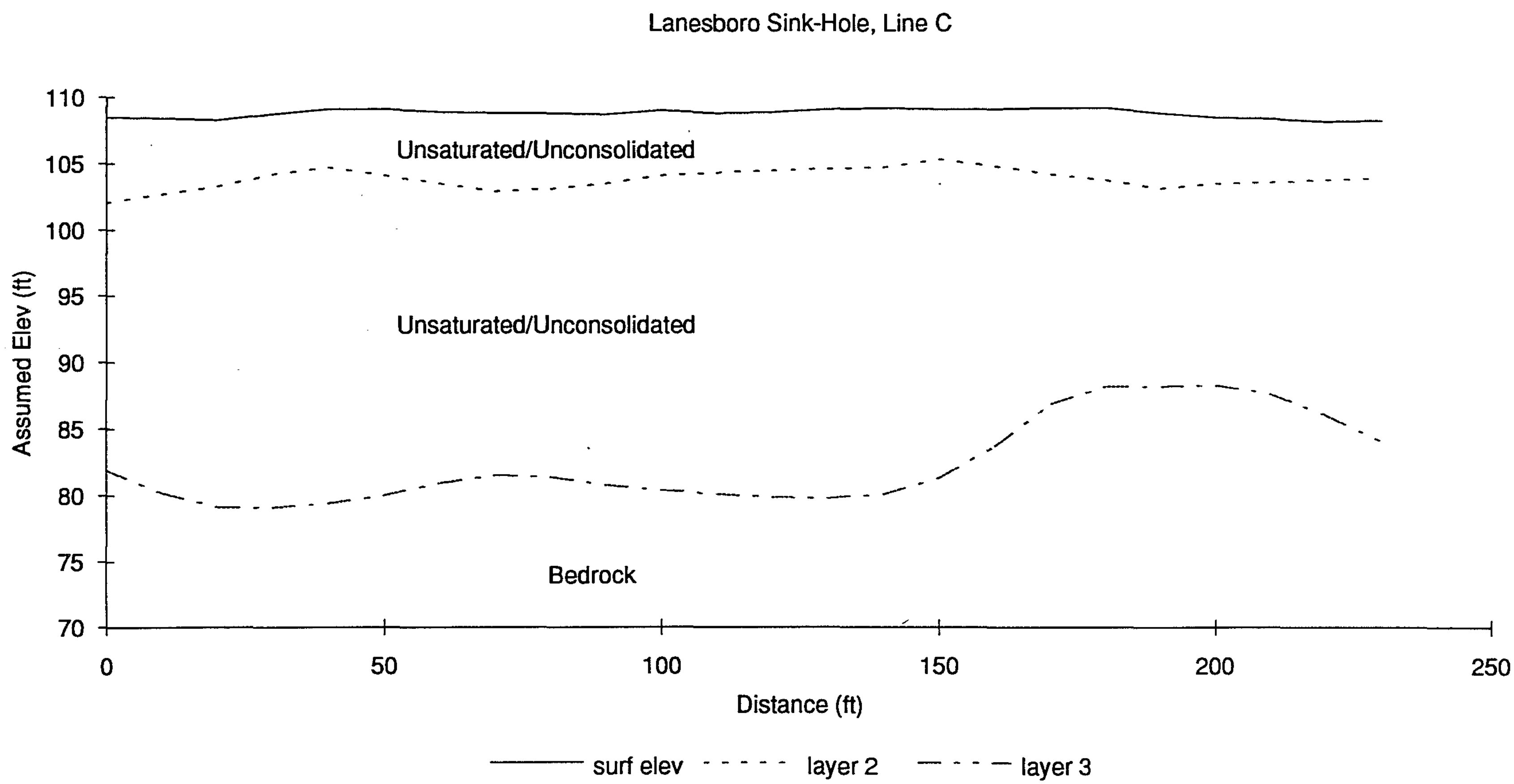
Figure 6 (DNR-DOW Geophysics)

LANBOROB.XCS



Layer profile for Line B, Lanesboro Sink-Hole investigation.

Figure 7 (DNR-DOW Geophysics)



Layer profile for Line C, Lanesboro Sink-Hole investigation.

Figure 8 (DNR-DOW Geophysics)