SOURCE WATER ASSESSMENT AND
WELLHEAD PROTECTION PLAN
INCLUDING PRODUCTION WELLS SERVING
THE TOWN OF BERLIN AND THE TYSON FOODS BERLIN PLANT

Mayor and Town Council of Berlin
Worcester County, Maryland
ALWI Project No. WO7N140

1.0 INTRODUCTION

Advanced Land and Water, Inc. (ALWI) was retained by the Mayor and Town Council of Berlin ("Berlin" or the "Town") to develop a source water assessment plan (SWAP) and wellhead protection program for the Town of Berlin. The work was funded by and performed following technical guidance and advice received from the Water Supply Program of the Maryland Department of the Environment (MDE). MDE directed that this work also include the wellfield serving the Berlin plant of Tyson Foods (Tyson) because of an expectation of commingled wellhead protection areas and other factors.

ALWI Proposal No. WO7N140 was authorized by the Mayor and Town Council of Berlin. This source water assessment and wellhead protection plan then was developed pursuant to ALWI's contract with Berlin and MDE guidelines for Source Water Assessments and in cognizance of a Memorandum of Understanding between MDE and the Town (Appendix A).

1.1 PURPOSE AND BACKGROUND

At the outset of our work, we understood that one of the principal motivations concerned a desire to identify the probable source(s) and possible remedies for persistent groundwater contamination by low concentrations of gasoline constituents. This contamination has affected one of Tyson's three closely spaced production wells and historically, one of Berlin's wells. Tyson and municipal representatives reported that prior efforts to identify the source of the petroleum contamination have not been successful.

Berlin also benefits from this SWAP because the plan assesses the vulnerability of the aquifer (from both the aforementioned petroleum release and other sources) and provides recommendations to mitigate the risk of public health degradation due to contamination of the groundwater supply.

1.2 REGULATORY FRAMEWORK

The Safe Drinking Water Act (SDWA) of 1974 required the U.S. Environmental Protection Agency (EPA) to develop enforceable drinking water quality standards to protect public health. In 1986, amendments made to the SDWA strengthened provisions for the protection of underground sources of drinking water. These amendments included provisions for establishing Wellhead Protection Programs by individual states under "umbrella" EPA oversight. The EPA approved MDE's Wellhead Protection Program in June 1991. The 1996 Amendments to the SDWA required Maryland (and other states) to develop a SWAP. On an individual system basis, the SDWA provides guidance for an

approvable system-specific SWAP. Wellhead protection programs and system-specific SWAPs, therefore, are related in design and purpose.

ALWI's work was designed and executed following the 1999 MDE SWAP Guidance Document, sometimes also called the MDE SWAP Plan. We use the term "Guidance Document" herein. Authorized tasks included Wellhead Protection Area (WHPA) delineations, contaminant hazard identification, susceptibility analysis, and recommendations regarding the implementation and management of the WHPAs.

2.0 HYDROGEOLOGIC FRAMEWORK

Within ALWI's experience, a scientifically sound and well-reasoned WHPA delineation is key to effective wellhead protection. For this reason, we began technical work by evaluating the site-specific hydrogeologic framework underlying and surrounding the subject production wells. we used published information from the United States Geological Survey, the Maryland Geological Survey and the Worcester County Soil Conservation Service (an agency of the United States Department of Agriculture) to identify and describe the characteristics of the local hydrogeologic setting. As aforementioned, we also obtained records from MDE and the Town to help confirm specific information regarding the wells that are the subject of this SWAP.

2.1 SITE TOPOGRAPHY

According to the U.S. Geological Survey Berlin 7.5-minute series topographic quadrangle map, regional elevations range from mean sea level to 15 feet above mean sea level. In the study area, the land surface is nearly flat. In eastern Worcester County, many roads and highways appear to have been constructed at slightly higher elevations, with roadside drainage ditches to help mitigate roadway flooding during storm events. Roadway elevations are typically one foot higher than the surrounding cultivated fields. Drainage ditches, with maximum invert depths of approximately one foot, parallel these roads in most locations.

2.2 GEOLOGY/HYDROGEOLOGY

Berlin is located within the Atlantic Coastal Plain physiographic province, which is comprised of sub-horizontal sand, silt and clay layers that gradually thicken and dip in a southeasterly direction (Chapelle, 1985). In the Berlin area, the sediments of the Atlantic Coastal Plain are approximately 8,400 feet thick and unconformably overlie the schists and gneisses of the Piedmont physiographic province (Cushing and others, 1973). Accordingly, geologists have recognized that the sediments of the Atlantic Coastal Plain can be subdivided into aquifers and aquitards based on the spatial distribution of the sediments.

Cushing and others (1973) provides a summary of the local and regional hydrology and stratigraphy. The confined Manokin, Ocean City and Pocomoke aquifers are overlain by the unconfined aquifers of the Pleistocene series and Quaternary system, including the prolific Pleistocene and Columbia Group aquifers. Cross-sections presented within Weigle and Achmad (1982) illustrate the three-dimensional relationships of the deeper aquifers and their hydrologic isolation from the overlying Pleistocene aquifer. In the Berlin area, recognized subunits of the Columbia Group aquifer include (from the top, down) the Parsonsburg Sand, the Omar Formation, and the Beaverdam Sand (Denver, 1989). These generally consist of feldspathic sands and silts of Pleistocene age.

The distinction between the Pleistocene and Columbia Group aquifers was judged unimportant for this evaluation. For conservatism, we assumed that waters move between the named sub-units of these aquifers with little restriction. We treated them as a single, commingled aquifer, herein, absent data documenting their pervasive hydrologic separation or differences in their confining pressures or potentiometric surfaces.

All six subject wells are completed in the Pleistocene sands. These sands are believed to be of peri-glacial origin, and occasionally contain cobbles, gravels, and less commonly, silts and clays. Many prolific wells have been developed in these sands across the central and lower portions of the Delmarva Peninsula. For simplicity and conformance to language used on the water appropriation permits for the systems in question, herein we use the terms "Pleistocene Series/Sands/Aquifer" for these commingled stratigraphic and hydro-stratigraphic units.

The whole of regional drilling results indicate that the base of the Pleistocene aquifer is at a depth of approximately 90 feet below sea level and thus, the saturated thickness of the surficial aquifer is approximately 100 feet. It is important to realize that within this aquifer there often exist poorly mapped aquitard layers of minimal areal extent, both between the mapped formational units and within them, which may serve to perch or otherwise impede vertical groundwater flow. These local aquitards were negated for this evaluation. Principles of sedimentology and stratigraphy also suggest that the bottom of the Pleistocene may undulate in response to the spatial variability of its paleo-depositional environment. In some areas, the Pleistocene aquifer may be thicker due to the erosional scour in paleo-channels.

2.3 AQUIFER RECHARGE

Precipitation infiltrating the soil above the subcrop of the formation and/or via slow vertical leakage from overlying and underlying formations is the primary source of aquifer recharge to the deep production wells. The shallow wells likely are recharged by direct precipitation falling on land surface within their capture zones and in topographically upgradient areas.

2.4 NATURAL WATER QUALITY

Groundwater in the Pleistocene aquifer generally is considered suitable for consumption. Pleistocene aquifer water generally has favorable secondary (aesthetic) characteristics but locally may be high in nitrate from anthropogenic activity. Available laboratory analyses of samples from the production wells in Berlin typify local water quality conditions and suggest that the water from these wells is adequate for potable uses (Appendix B).

3.0 DELINEATIONS

A source water assessment area, or WHPA, is defined as the surface and subsurface areas surrounding wells through which contaminants are reasonably likely to enter the subsurface and move toward and reach the wellfield. For unconfined coastal plain aquifers of the type screened by both the Town and Tyson Foods, the 1999 MDE Guidance Document recommends that WHPA delineations be based on semi-analytical groundwater modeling (e.g., EPA's WHPA program) for determining travel-time dependent capture zones.

ALWI began its delineation work by researching whether unconfined[1] conditions exist. Available literature, drilling logs and pumping test results collectively indicate that all six-supply wells most likely are completed in an unconfined aquifer. Specific support for this determination is as follows:

1. Weigle and Achmad (1982) state, "Water in most of the Pleistocene aquifer occurs under water table conditions".

2. Overlying Holocene deposits extend to a depth of 40 feet and "...commonly... are unsaturated but permit water to percolate downward to underlying units" (Weigle and Achmad, 1982).

3. The MDE Water Rights Division interpreted unconfined conditions to exist in technical evaluations supporting recent water appropriation permit renewals. Specific evidence includes (1) an assigned storativity value of 0.1; (2) a technical memo discussing the absence of laterally continuous confining units both above and below the Pleistocene aquifer; and (3) the evaluation of water resources impacts from a hydrologic mass balance perspective in accordance with COMAR 26.17.06.05D(3) rather than from a regional aquifer drawdown management perspective as is required under COMAR 26.17.06.05D(4).

Our research of the local distribution of potentiometric heads present in the Berlin area also supported a determination that locally the Pleistocene aquifer is under unconfined conditions. On balance, the Maryland Geological Survey and the MDE Water Rights Division agree that unconfined conditions likely exist. Representative documents from the MDE Water Rights Division files, as well as certain well construction and testing records, are included in Appendix C. ALWI confirmed MDE's acceptance of this determination in correspondence with Mr. Norman Lazarus of the MDE Water Supply Program dated June 10, 2002 (Appendix A).

3.1 MODEL SELECTION

The semi-analytical model in most prevalent use in Maryland for delineating wellhead protection areas in unconfined aquifers is called the "Wellhead Protection Area Delineation Code" by Blandford and others (1993). This model informally is referred to as the "EPA WHPA Code" and is one of several semi-analytical solutions that predict aquifer behavior under a somewhat idealized set of assumptions that include the following:

1. Groundwater flow in the aquifer is time-independent; and

2. Groundwater flow occurs only in a two-dimensional plane.

[1] COMAR 26.04.02.01(43) defines "unconfined aquifer" as "an aquifer not bounded above by a bed of distinctly lower permeability than that of the aquifer itself and containing groundwater under pressure approximately equal to the atmosphere". Conversely, COMAR 26.04.02.01(8) defines a "confined aquifer" as an aquifer bounded above and below by beds of distinctly lower permeability than that of the aquifer itself and which contains and below by beds of distinctly lower permeability than that of the aquifer itself and which contains groundwater under pressure greater than that of the atmosphere". COMAR further states that the terms "unconfined aquifer" and "water table aquifer" are synonymous and that the terms "confined aquifer" and "artesian aquifer" are also synonymous.

Other assumptions govern application of the underlying algorithms and were first stated by Theis (1935)[2], except that the model can accept simple stream boundaries, barrier boundaries and areally constant recharge. Neither stream nor barrier boundaries were evidenced from the available literature, so these boundary capabilities were not used.

Of course, semi-analytical models such as the EPA WHPA Code are mathematical simplifications of more complex hydrogeologic systems. The degree to which semi-analytical models such as WHPA can be relied upon for defensible predictions of the fate and transport of potential contaminants in the subsurface depends on the (1) quantity and quality of raw data available; and (2) degree to which the simplifying assumptions inherent in the chosen analytical solution plausibly mimic naturally occurring conditions. Users of this document should be aware of the simplifying assumptions inherent in the model selected; application of a more robust model and/or a change in assumed conditions could yield differing and possibly more accurate results.

3.2 PARAMETERIZATION

Key input parameters include aquifer transmissivity, porosity, pumping rate, hydraulic gradient and saturated thickness. Initial input parameters and data sources for each of these parameters were as follows:

1. **Transmissivity** - Transmissivity values were derived from the time-drawdown relationships in available pumping test data using standard semi-logarithmic analyses (e.g. Cooper and Jacob [1946]). Results were compared to the 1997 findings of the consultant engaged by Tyson Foods (Stephens Environmental; hereafter the "Stephens report") and to those published by Weigle and Achmad (1982). From these sources, we found the following:

   - The range of potential transmissivity values is large, ranging from approximately 5,000 ft^2/day to 30,000 ft^2/day.

   - Most derived values clustered between 10,000 ft^2/day and 20,000 ft^2/day, with an overall arithmetic mean of approximately 15,000 ft^2/day.

   Based on the overall range of transmissivity values, the findings of the Stephens report, and our observation that values approximating 15,000 ft^2/day were supported by those pumping tests of longer duration and higher flow rate (suggesting behavior more representative of the whole aquifer), 15,000 ft^2/day was the value selected for use.

2. **Porosity -** Unconfined aquifers on the Atlantic Coastal Plain typically have effective porosities that range from 20% to 30%. Values obtained from the Stephens report indicate a porosity of 25% is representative for this area of the Coastal Plain. No differing data arose from a review of the available regional literature; 25% was used consequently.

[2] Theis (1935) developed analytical equations of groundwater flow. Use of these equations and their derivatives requires assumptions that the aquifer of interest is homogeneous, isotropic, infinitely laterally extensive, fully penetrated by well(s) pumping at 100% efficiency (i.e., without well loss), that it receives no recharge and that the well screens the entire thickness of the aquifer.

3. **Pumping Rate (Per Subject System**) - ALWI used the present annual average allocations reflected on the Berlin and Tyson MDE Water Appropriation Permits to assign pumpage to each wellfield. The Town is allocated an annual average withdrawal of 500,000 gallons per day (gpd) under Water Appropriation Permit No. WO80G004 and Tyson Foods recently was allocated an annual average withdrawal of 1,000,000 gpd under Permit No. WO56G005. For Berlin and Tyson Foods, three wells are lumped together under one appropriation for each permittee. In such circumstances, our experience suggests that division of the total allocation on a well-by-well basis to mimic operational use patterns, results in the greatest overall defensibility.

4. **Pumping Rate (Individual Subject Wells)** - No hard data exist from which to estimate the individual or combined sustainable yields of the individual wells in terms of management tools typically employed for such evaluations (e.g., peak demand, system redundancy in terms of the requirements of COMAR 26.03.02.03(2)B, classical aquifer pumping tests, long- term water level monitoring during sustained operations, etc.). Therefore, we interviewed water systems operations personnel to learn how each individual well was operated, and to assign sub-components of the overall appropriations on a well-by-well basis. Those interviews suggested the following use practices:

   - Tyson Foods - Tyson personnel indicated that all three-production wells are relied upon equally.

   - Berlin - Town water operations representatives indicated less programmed use for Municipal Well No. 1, such that the relative withdrawal from that well constituted only approximately 20% of the overall total (rather than one third, if all three Berlin wells were used equally).

   Withdrawal rate assignments were then made, accordingly. Neither Berlin nor Tyson contemplate future increases in withdrawal rates[3] from the wells subject to this SWAP. Therefore, we did not assign flow rates other than as suggested by present appropriation permits and operational strategies.

5. **Pumping Rate (Other Appropriators in Area)** - ALWI used publicly available records to identify other large water appropriation permittees near the subject wells. We theorized that the capture zones associated with groundwater withdrawals by those permittees could perturb the resultant capture zone delineations for the subject SWAPs. Two such permittees were identified: the Peter Richardson farm and Ocean City Ice and Seafood Company. The final WHPA model was executed in a manner incorporating permitted withdrawal rates for those single-well appropriators as well.

6. **Hydraulic Gradient -** Table 1 reflects an average gradient of 0.0014 feet/ft toward the east-southeast, based on maps within Weigle and Achmad (1982) and Cushing, Kantrowitz and Taylor (1973). ALWI assumed that the Pleistocene aquifer discharges to the coastal bays bordering the Atlantic Ocean with flow lines generally sub-orthogonal to the trend of the coastline. Horizontal variance and imprecision in this flow direction was considered to be 30 degrees based on shallow

[3] Berlin has longer-term plans for a new municipal supply well to support moderate and longer-term growth. Likely, this well will be located somewhere north of US Route 50 and west of US Route 113, but its site has not been finalized and its projected yield remains unknown.

monitoring well networks maintained near streams in other locations[4]. Accordingly, the width of Zone 2 partially is a function of this directional uncertainty and its possible seasonal fluctuation (Figure 1). Better data could result in the widening, narrowing and/or rotational movement of Zone 2 by (perhaps) as much as several degrees.

7. **Saturated Thickness of Aquifer** - ALWI selected 75 feet to represent the saturated thickness of the Pleistocene aquifer system as published by Weigle and Achmad (1982) and supported by information within the Stephens report.

8. **Annualized Groundwater Recharge Rate -** Table 1 reflects an annualized groundwater recharge rate derived from local stream gauging data. The assigned value correlates closely with information in the Stephens report and unpublished baseflow separation data provided via email by Mr. Patrick Hammond of the MDE Water Rights Division.

The physical location of WHPA boundaries is dependent on the model parameters selected. None of the parameters are known with precision and assumptions are many and various. Some key assumptions included:

- Theis assumptions are met (i.e., that the aquifer is homogeneous, isotropic and of infinite lateral extent); that actual withdrawal rates mirror water appropriation permits exactly;
- Impervious surfaces and stormwater management practices do not effect areal recharge rates or groundwater flow paths;
- Groundwater appropriation permits reasonably reflect actual usage amounts on an annualized basis;
- The local groundwater regime is not affected by distant pumping; and
- The assignments of ambient flow direction and gradient are not themselves biased by local pumping effects.

3.3 MODEL EXECUTION AND ZONAL DESIGNATIONS

Guidance from MDE and EPA publications extols the primary virtue of the zonal designations within WHPAs being a gradational increase in the degree of land use restriction as commensurate with increased risk of water quality degradation should a release occur. This division allows for varied protective measures for the water supply depending on the likelihood and immediacy of the hazard posed to the wells.

ALWI numbered each zone, from inner to outer. Lower numbers connote greater risks of adverse water supply impacts due to contamination occurrences.

[4] Three shallow monitoring wells located in the floodplain of Herring Run were gauged and monitored quarterly for several years. During dry periods, groundwater flow was perpendicular to Herring Run. However, during wet periods groundwater flow rotated down gradient approximately 30°.

1. **Zone 1** - Shown in red on Figure 1, Zone 1 was delineated using the EPA WHPA code as a one-year time-of-travel capture zone around each of the wells.

2. **Zone 2 -** Shown in blue in Figure 1, Zone 2 is the ten-year time-of-travel based capture zone within the Pleistocene aquifer, from which water could flow into the wells during the course of a decade.

Execution of the WHPA model initially returned long and narrow cylindrical WHPAs for 1- and 10-year reverse particle tracks with the wells, themselves, as release points. To account for dispersion effects within the model's inherently simple algorithm, and to better identify the area upgradient of a 100-foot circle surrounding the wells (as opposed to upgradient of merely the wells, themselves), ALWI re-ran the model with particles tracking in reverse from a 100-foot circle surrounding each well. Doing so provided more of a "teardrop" shape to each of the resultant wellhead protection areas (and to the exclusion areas around the private water appropriation permittees in the area). Doing so also seemed more conservative insofar as potential groundwater contaminants present or traveling within 100 feet of any of the wells were treated as though they entered or could enter the well.

3.4 CONSIDERATION OF UNCERTAINTY

For the reasons set forth herein, ALWI then widened the generated "teardrops" associated with each WHPA to consider spatial uncertainty. The notion that the teardrops should be widened was supported by model trials in which Tyson's pumping rates were temporarily reduced and the long-axis of the Berlin WHPAs was observed to have rotated clockwise between 10 and 30 degrees in response.

To maintain appropriate conservatism in light of the many unconstrained assumptions, ALWI further accounted for spatial uncertainty in WHPA boundary location by:

1. Widening the westward extents of the individual delineated areas approximately 10 degrees counterclockwise (toward the west southwest) and approximately 20 degrees clockwise (toward the northwest).

2. Extending the 1-year capture zones 100 feet around each well in all directions, regardless of the delineation; and

3. Extending the 10-year capture zones to encircle and encompass the 1-year capture zones by an additional 200 feet around each 1-year WHPA in all directions.

We then merged areas of overlapping protection to achieve singular WHPAs to the degree supported by the delineations. Similar approximations were performed with regard to the private water appropriation permittees otherwise within the delineated area.

3.5 SENSITIVITY ANALYSIS

Sensitivity analyses suggest that the size, shape and orientation of the delineated areas are most sensitive to variations in pumping rate and transmissivity. Other parameters also incorporate assumptions but the associated potential for systemized error seems less significant (i.e., setting aquifer thickness equal to screen height seems plausible).

3.6 DELINEATION RESULTS

Figure 1 summarizes the results of the delineation. The delineated areas were reviewed and approved by MDE.

Three distinct 1-year capture zones are interpreted, but the 10-year capture zones overlap and merge to form a single protection area. Each of the WHPAs stretches further to the west than to the east, reflecting a generally west-to-east direction of ambient groundwater flow. Herein, we name the Zones 1A, 1B, 1C (north-to-south) and 2. Certain facts and observations regarding each zone are as follows:

ATTRIBUTE	ZONE 1A	ZONE 1B	ZONE 1C	ZONE 2
Production Wells within Zone	Berlin 2, Tyson 1-3	Berlin 1	Berlin 3	Richardson; Ocean City Ice and Seafood[5]
Zonal Area (acres)	88	6	9	699
Est. percentage impervious	31%	28%	22%	25%
Predominant land use	Industrial	Low/Med. Density Residential	Low/Med. Density Residential	Agricultural cropland
Est. Percentage in Berlin/Tyson Corporate boundary	50	100	100	25

4.0 CONTAMINANT THREATS AND SUSCEPTIBILITY ASSESSMENT

ALWI identified existing and potential contaminant sources within the WHPA. The techniques used for identifying a hazard included spatially indexed database reports, regulatory inquiries, field observations and personal interviews.

4.1 POTENTIAL POINT SOURCE CONTAMINATION HAZARDS

The Guidance Document suggests that the following potential contamination point sources be inventoried and mapped:

- Sites/facilities that hold groundwater discharge permits;
- Land disposal sites, such as landfills, certain less formal refuse disposal areas, and trenched sludge disposal sites;
- Active[6] underground storage tanks (USTs), including release sites and fuel lines;
- Coal mining areas (none exist near Berlin); and

[5] The Richardson and Ocean City Ice and Seafood wells have large (over 10,000 gpd) groundwater appropriation permits associated with each. Each of these wells was included in the original draft Zone 2, and later excluded when the WHPA computer model was re-executed to include the pumping effects of these two wells. Approval of this redelineated WHPA was received through correspondence with MDE dated December 27, 2002.

[6] Users of this document should be aware that former USTs, whether regulatory closure has been achieved or not, need not be mapped per the MDE SWAP Guidance Document.

- Areas prone to salt water intrusion (could also be considered a non-point source in certain settings, depending on the scale of the study).

Herein, we collectively term these "SWAP-classifiable point-source hazards". ALWI began the process of identifying these by acquiring a spatially indexed list of sites within and near the WHPA from Environmental Data Resources, Inc. (EDR). Among other sites[7], the EDR listing provides spatially indexed information on regulated landfills, UST and leaking UST facilities, petroleum release sites, and regulated dumpsites (Appendix D).

Certain types of SWAP-classifiable point source hazards are not listed within the EDR database. ALWI made direct verbal and written inquiry to appropriate Worcester County and MDE personnel regarding the potential presence of nearby groundwater discharge permittees and trenched sludge disposal sites. Neither circumstance proved to be a concern in the WHPA, nor in the surrounding area.

4.2 FIELD RECONNAISSANCE AT/NEAR WELLHEADS

ALWI's field reconnaissance indicated that all six production wells appeared to possess good physical integrity at the wellheads, though no subsurface or invasive work of a confirmatory nature was performed. No confirmed sources of existing, direct contamination to the wells or aquifer within the WHPAs was confirmed by the results of the site reconnaissance. The following summarizes are our observations at and proximal to each subject well; referenced photographs are contained within Appendix E:

1. **Berlin Well No. 1** - This well is situated in an area of Town typified by mixed residential and electrical power generation uses. This wellhead was in good condition without obvious perforations or direct contaminant entry pathways. The mounting for the turbine pump precludes direct access to the bore (Photograph No. E-l). The well is housed within a room of a small block building that has a concrete floor, with floor drains exiting through a sidewall, and with perforations between the poured slab of the floor and the purposeful sidewall. Lubricating oil and turbine oil were stored in blue plastic drums in an adjoining room. Large-capacity above-ground storage tanks (ASTs) for fuel oil were located outdoors within approximately 100 to 200 feet of the wellhouse (Photograph No. E-2), as was a large diesel-fueled generator for a backup municipal power supply. Some of the surrounding residential homes also appeared to have small capacity fuel oil ASTs. Fire hydrants were visible in all directions; no private wells appeared to be nearby.

2. **Berlin Well No. 2** - This wellhead is situated in an area of Town typified by mixed residential (to the south) and industrial (to the north) land uses. Truck parking areas and a grain mill are on contiguous properties (Photograph No. E-3), but the position of the wellhouse at the base of the water tower (Photograph No. E-4) appears to preclude a likely accidental vehicular collision. This wellhead was in good condition without obvious perforations or direct contaminant entry pathways. The mounting for the turbine pump precludes direct access to the bore. The well is housed within a room of a small block building that has a concrete floor. Chlorination and pH

[7] The EDR listing also provided other information (e.g., facilities where hazardous waste is generated), not specifically germane to this SWAP as set forth in the Guidance Document.

control is provided on-site; sacks of treatment chemicals are stored on pallets. ALWI observed active railroad tracks nearby, apparently for the shipment of grain products. Fire hydrants were visible in all directions; no private wells appeared to be nearby.

3. **Berlin Well No. 3** - Observations generally were similar to those made in the other two buildings (Photograph No. E-5), but the well is in a more residential area seemingly less prone to contamination from stored liquids or other less compatible land uses. Chlorination supplies were stored in an outdoor shed, where an accidental spill could result in a release to the surrounding shallow subsurface through the grassy lawn. Fire hydrants were visible in all directions; no private wells appeared to be nearby.

4. **Tyson Wells** - All three wells terminate indoors in dedicated maintenance areas or sheds (Photograph Nos. E-6 through E-8). Hazardous materials and petroleum products used in Tyson's plant operations appeared to be stored elsewhere, not within 100 feet of the wellheads. ALWI did observe ponding near one of the wellheads on the day of our reconnaissance. Likely, this was a one-time occurrence and was not representative of regular conditions.

Within the Zone 1 delineated areas, ALWI judged it appropriate to perform a more exhaustive visual reconnaissance than required by the 1999 SWAP guidance document. The visual reconnaissance focused not only on SWAP-classifiable point source hazards but also on (1) loose well caps; (2) agricultural equipment and supplies storage, use and disposal practices; (3) petroleum products storage, use and disposal practices; (4) dry cleaning operations; and (5) other facilities that generate, use, store or dispose of hazardous materials or petroleum products not specifically SWAP-classifiable. Salient observations are incorporated within the descriptions enumerated above.

4.3 FIELD RECONNAISSANCE THROUGHOUT WHPAS

In part guided by the EDR report for completeness, ALWI performed a visual reconnaissance of publicly accessible portions of each WHPA to observe facilities or land use practices potentially constituting a SWAP-classifiable point-source contamination hazard. In addition, we physically observed each wellhead to the degree exposed and observable without excavation, confined-space entry, or other exposure to unusual personal hazards. Pertinent observations were as follows, with the corresponding letters cross-referenced to the map (Figure 1) and Table (Table 2):

A. **Mobil/Cheers/Alpha Beverages/Ocean Petroleum** - ALWI observed visual evidence of UST storage at what currently is a Mobil station. Signage at the site and/or the EDR report also provide the names "Cheers", "Alpha Beverages", and "Ocean Petroleum" for this facility. Observations were typical of a functioning gasoline station (with a liquor store inside). On-site USTs are located approximately 825 feet west of Tyson Well No. 1 with a reported, combined gasoline capacity of 10,000 gallons. USTs previously removed from this location held kerosene and gasoline. No evidence of monitoring or remediation equipment could be observed.

B. **Tyson Foods** - Two 275-gallon ASTs were observed on the parcel occupied by Tyson Foods. One of these tanks was placarded as containing kerosene while the other held waste oil. The EDR report lists Tyson Foods as an open Oil Control Program (OCP) case where groundwater contamination occurred because of a motor/lube oil release. Whether the release came from these ASTs is unknown. EDR indicates that there was a clean up performed. However, the case remains open. The ASTs are located approximately 250 feet from the nearest well.

C. **Berlin Health Department/Worcester County Senior Center** - A single, 1,000-gallon heating oil UST is in use at this facility, according to EDR. This address is listed as a closed OCP case, where a heating oil UST was removed/abandoned without any incident of a leak or spill. ALWI did not observe vents or fill caps at this facility, suggesting the possibility that the UST has been removed but the case was not properly closed with the MDE Oil Control Program. For conservatism, we have mapped this site as a potential SWAP-classifiable point-source contamination hazard.

D. **Venable's Cleaners/Marion's Used Furniture Store** - Venable's Cleaners is a dry cleaning facility with classical solvent-based garment cleaning and processing on premises. One large AST was observed at the rear of the property with the word "DANGER" written across it (Photograph No. E-9). We also observed a UST vent on-site (Photograph No. E-10). According to the EDR report, two USTs remain in use; one holds 1,000 gallons of heating oil and a second holds 550 gallons of an unidentified substance.

E. **Evans Dump Site** - ALWI observed an informal refuse disposal area on a property owned by Royce W. and Barbara M. Evans, directly west of Tyson Foods, within the western periphery of Zone 1A. Most of the disposed materials consisted of junked vehicle parts and components of old machinery. No stressed vegetation was observed from the nearby public highway, and no other information was available.

F. **Seitz Automotive** - Potentially hazardous materials and possible USTs were located at Seitz Automotive, which was situated on the parcel directly east of Tyson Foods, along Maryland Route 346 and also within Zone 1A. A dark fluid was observed to emanate from the garage area and flow across the land surface to a shallow gully between the Seitz and Tyson properties. Several 55-gallon drums could be observed commingled with vehicles and junked vehicle components behind the building. Late during the course of its work, ALWI received anecdotal reports that this facility formerly may have been used for the retailing of gasoline.

G. **King's Pub and Restaurant** - The EDR report listed King's Pub and Restaurant as having a 26-year old, 550 gallon heating oil UST on premises. We observed no vent or fill at this location, again suggesting the possibility of incomplete regulatory closure rather than an actual UST. No other information was available.

H. **Berlin Volunteer Fire Company** - ALWI observed possible UST vents at the Berlin Volunteer Fire Company located at 214 N. Main Street. This location was listed in the EDR report as having two USTs, 29 years old, with heating oil (1,000 gallons) and diesel fuel (550 gallons). No other information was available.

I. **Batailles/Rainbow Florist/Stephen Falck Construction, Inc.** - Two, 1,000-gallon USTs are in use at this facility, according to EDR. One of the USTs reportedly contains gasoline, while the second contains an unknown product. The on-site structure bears architectural resemblance to a 1950s - 1960s gasoline service station (Photograph No. E-11). ALWI observed a monitoring well cover located in the south-facing parking lot. Certain areas on the east side of the building appeared suggestive of recent UST removal work.

J. **Wainwright Service Station** - Gasoline and other petroleum products are stored in USTs and

retailed at this facility. Automotive service operations also occur on-site, based on visual observations from public rights-of-way. EDR reports three USTs on-site: one contains 8,000 gallons of diesel fuel and two contain a total of 16,000 gallons of gasoline. Also based on the EDR report, Wainwright's was the previous site of a still open leaking UST investigation, and as of 2002, free-phase liquid hydrocarbon ("free product") was being periodically hand-bailed from a monitoring well as a remedial measure.

K. **Berlin Florist** - The EDR report listed the Berlin Florist located at 3 Pitts Street as being a closed OCP case, having an in-use heating oil UST and having a removed/abandoned heating oil UST. Only the storefront was observable, as other commercial properties were adjacent to the establishment. We observed no vent or fill at this location, however, the rear of the building was not observable from any public rights-of-way. No other information was available.

4.4 PERSONAL INTERVIEWS OF OPERATIONS AND MANAGEMENT PERSONNEL

ALWI interviewed Berlin and Tyson Foods operational personnel, and others knowledgeable of Tyson facilities and operations to gain a better understanding about the historic experiences associated with the subject wells in terms of overall performance and possible contamination occurrences/problems. Direct contact with representatives of the MDE Oil Control Program is left as a recommendation.

Both Berlin and Tyson water operations personnel spoke of historic Volatile Organic Compounds (VOC) in certain wells, specifically benzene within Berlin Well No. 2 and Tyson Well No. 1. No other persistent VOC occurrences were reported. From these interviews, the following information was obtained:

- Periodic trace occurrences of benzene and possibly other similar VOCs have been detected at various times through the 1990s.

- Trace concentrations of benzene persist in Tyson Well No. 1 through mid 2003 sampling data. Concentrations in Berlin Well No. 2 became undetectable by sometime in the late 1990s, roughly at the time that Tyson increased their water consumption. Both Tyson and Berlin personnel share the perception that Tyson's higher-rate pumping caused the reduction in benzene concentration in Berlin Well No. 2. Both theorize that the concentration of benzene in Berlin Well No. 2 would increase if Tyson's groundwater withdrawals reduced or stopped.

- The source of the benzene and other related VOCs remains unconfirmed. Different theories exist. Some Berlin operations personnel believe that the original source may have been retail petroleum operations that formerly existed on commercial property located between Tyson Well No. 1 and Berlin Well No. 2. Tyson personnel generally believe that an automotive service business immediately east of the plant, doing business as Seitz Automotive (Photograph Nos. E-12 and E-13), may be the source based on rumored historical gasoline USTs formerly located there and/or continued automotive service and salvage operations.

- Tyson engaged an environmental consultant to design and execute a soil boring program near Well No. 1 in an effort to identify the direction of contamination migration onto the Tyson property. The findings were inconclusive; no copy was available for ALWI's use and integration herein.

- During the two-year period over which this Plan was prepared, Tyson announced plans to close its Berlin plant. Shortly, thereafter, in August 2003, ALWI was advised of possible plans for the purchase of the Tyson plant by a third party. Entities engaged by that third party performed a real-estate due-diligence environmental assessment of the Tyson plant, and reportedly identified one or more UST(s) not previously identified by Tyson (Location L on Figure 1; Site L in Table 2). One of these UST(s) reportedly was of 5,000 to 10,000 gallons in capacity, was situated near the western property line of Tyson, and contained "Bunker Six[8]" fuel oil. Whether additional USTs and/or other contamination was found and/or addressed as a component of pre-acquisition due diligence work in 2003 (or since) remains unknown and speculative. Neither the Town nor ALWI were provided an opportunity to review and integrate documentation of the Tyson environmental assessment; such reports usually are confidential.

To all interviewees, ALWI suggested that Mobil/Cheers/Alpha Beverages/Ocean Petroleum (Location A on Figure 1; Site A in Table 2) might be the source based on its recent history of gasoline releases, upgradient location of both affected production wells and continuing retail operation. We explained our belief that benzene, when in higher proportion than other gasoline constituents and other regulated VOCs, suggests a relatively fresh and nearby release. Whether another source(s) exists in the area remains possible, but unconfirmed.

That the detections have persisted for a decade suggests an ongoing release, as opposed to a single-event spill. Even if leaking USTs had been located at a nearer facility, they would have been out of operation and likely removed years ago. As such, we believe that neither represents a disproportionate source for benzene absent natural attenuation effects and commingling with other, less volatile gasoline components. Seitz Automotive possibly could accidentally release benzene because of automotive service and light salvage operations that are ongoing there (or, for that matter, from historic petroleum retailing), but likely only in combination with a wider gamut of chlorinated and heavier VOCs.

4.5 NON-POINT SOURCE CONTAMINATION HAZARDS AS SUGGESTED BY LAND USE

The 1999 MDE SWAP Guidance Document suggests consideration and mapping of the following classifications of land use within the wellhead protection delineated areas: agriculture; forest; residential; industrial; commercial; public lands and mined lands. ALWI obtained land use Geographical Information Systems data for the WHPA for these and other related land uses, from the Maryland Department of Assessments and Taxation. The results are shown in color on Figures 1 through 4.

ALWI found that a large portion of Zone 1A is designated industrial. Mixed commercial and residential land uses cover most of the other Zone 1 regions. Zone 2 is typified primarily by agricultural cropland where non-point source contamination by nitrates, phosphorous and other agricultural byproducts is envisionable. However, ALWI's observations did not suggest over-application of fertilizers or pesticides. Pertinent acreages and percentages are listed in the table in Section 3.6. Tables 3 and 4 list owners of non-residential lands within each Zone, grouped and cross-referenced by land use designation and zone.

[8] Bunker Six is a heavy and viscous healing fuel used in industrial operations. The long-chain aliphatic hydrocarbons present within such a fuel differ from the aromatic/VOC constituents found in the on-site wells.

5.0 CONTAMINANT SUSCEPTIBILITY ASSESSMENT

ALWI completed a quantitative contaminant susceptibility assessment in accordance with the 1999 MDE SWAP Guidance Document.

5.1 PROCEDURES

ALWI first acquired and reviewed available water quality information from Berlin and Tyson, and identified analytical results exceeding 50% of the respective Maximum Contaminant Level (MCL) for that compound. We then considered these results in the context of the results of the contamination hazard reconnaissance to identify specific potential sources of contaminants, which may contribute to a condition of susceptibility.

ALWI completed a review of available groundwater quality records to support an assessment of groundwater susceptibility as described in the 1999 MDE SWAP Guidance Document. To perform this records review, ALWI reviewed available electronic databases of water quality analyses provided by MDE, along with an in-person review of more recent records covering the period between database acquisition (June 2002) and the completion of this Plan (December 2003). ALWI compared these to published MCLs (in COMAR 26.04.01 as of the date of authorization of this work) for the indicated compounds.

ALWI reviewed the data in the furnished electronic databases in accordance with the following step-wise procedure:

1. **Filter Records and Other Materials** - The databases were filtered to isolate only public water supplies subject of the presently authorized study. The databases as furnished contain information specific to treatment plants, not to individual wells. Where more than one well shares a treatment plant (e.g., Tyson), well specific information generally was not available on which to base a well-specific evaluation of susceptibility. The groundwater samples represented in the databases, therefore, were composite rather than well discrete for Tyson. Records obtained from the in-person file review performed in December 2003, and via facsimile from MDE were incorporated into the analysis.

2. **Consider Chemical Classes** - The furnished databases contained analytical records for inorganic compounds including radiological species, VOCs and semi-volatile compounds. Each chemical class was considered separately for each well (Berlin) and treatment plant (Tyson). MDE previously determined that the subject wells are not susceptible to cyanide and asbestos, through EPA-approved monitoring waivers based on the overall hydrogeologic setting. According to MDE, the Berlin wells and Tyson Well No. 3 have been determined not to be under the influence of surface water through testing. Therefore, they are judged not susceptible to protozoa. Considering similarities in well construction and the overall hydrogeologic setting, protozoan susceptibility for Tyson Well Nos. 1 and 2 seems equally unlikely. Bacteriological testing records support this assertion. Virus susceptibility remains unknown, though doubtful considering existing chlorination practices and the absence of documented bacteriologic violations.

3. **Identify "Exceedance" Instances** - For this susceptibility assessment, we defined an "exceedance" as a singular test result indicating presence of a specific analyte in a concentration

at or exceeding 50% of the respective MCL. For a prior, similar project, MDE verbally confirmed that a concentration of precisely 50% of a given MCL should be considered an exceedance. This step began by sorting the database on a well-by-well (plant for Tyson) basis by analyte and concentration.

4. **Assess Frequency and Relative Percentage of Exceedance Instances** - The water quality data were evaluated in comparison to 50% of each respective MCL, for the subject wells for which data were furnished. The number of times that a given analyte was detected in a concentration greater than 50% of its respective MCL then was easily discerned in terms of overall frequency, percentage of total number of samples, and date range of exceedance. Then, for conformance with the MDE SWAP guidance document, only those contaminants with 50% of the MCL equaled or exceeded in 10% or more of the overall respective sample results were further evaluated.

5. **Data Quality Assurance Through File Review at MDE** - On December 10, 2003, ALWI reviewed hard copy water quality data at the MDE offices in Baltimore, Maryland to assure that our findings accurately reflected the whole of the water quality records available at that time. We verified the accuracy of the databases MDE had previously furnished[9] and augmented them with more recent information.

5.2 RESULTS

The available data support an interpretation that Berlin's wells are not susceptible to regulated contaminants at this time. However, ALWI determined that the Tyson wells are susceptible to the following groundwater contaminants (Table 5):

1. **Benzene** - The benzene susceptibility seems the most serious condition, as (1) benzene concentrations have also approached or exceeded the MCL at the Tyson wells on eleven occasions and (2) the concentration of benzene at Tyson has been as high as 0.014 mg/L, or nearly three times the MCL of 0.005 mg/L (Table 5). Benzene also was detected at or above the 50% MCL in Berlin Well No. 2, but not since April 8, 1998, possibly because of Tyson's large withdrawals during the period 1998-2003. Benzene is a volatile, aromatic hydrocarbon that is a principal constituent of gasoline. Its presence in wells often indicates a fresh or continuing release of gasoline to groundwater. A discussion of the potential source(s) and implications of this finding is presented in Section 6.1.1 of this report and elsewhere herein.

2. **Nitrates** - A nitrate concentration of 5.37 mg/L was detected for composite water withdrawn from the Tyson wellfield as recently as 2002 (Table 5). Nitrates are inorganic compounds that arise from the fertilization of farm fields and other related practices generally of agricultural origin. Nitrates also can arise from sewage storage and disposal systems. The Berlin wells were found not to be susceptible to nitrate contamination because the most recent occurrence of nitrate exceedance was in 1994 and l995. The nitrate concentrations for the Berlin wells possibly could have been attenuated, in recent years, as a result of the large withdrawals made at the Tyson plant since approximately 1997. A rise in nitrate concentration in one or more Berlin wells, possibly up

[9] Records predating 1998 were not observable during the time of the review and consequently the accuracy of said records cannot be guaranteed. MDE advises that these older records have been archived and are available for review. This review was not required for the completion of this SWAP.

to or exceeding the concentrations detected at Tyson has and thus connoting susceptibility, could occur if Tyson's withdrawals are reduced or cease.

Other gasoline constituents also have been detected, but in concentrations below MDE's quantitative susceptibility criterion:

1. **Other Regulated Gasoline Constituents** - Ethylbenzene and Toluene were detected in the Tyson wells, but not at or above 50% of the respective MCLs.

2. **Unregulated Gasoline Constituents** - Methyl Tertiary Butyl Ether (MTBE) was detected in Berlin Well Nos. 2 and 3, as well as in the Tyson wells. MTBE is a water-soluble octane enhancer used as an unleaded gasoline additive since approximately 1980. MTBE sometimes is diagnostic of groundwater contamination from a point-source gasoline spill. In some cases MTBE now is believed to be present nearly ubiquitously, partially because of its high water solubility. Some researchers now believe that airborne MTBE may fall with precipitation and may leach into the subsurface with percolating stormwater, for example. The US EPA has issued a drinking-water advisory of 20 to 40 micrograms per liter (μg/L). None of the samples collected reflected a higher concentration than 6.8 μg/L.

5.3 UNCERTAINTY

Certain areas of unconstrained uncertainty remain, and appear associated with the following:

1. Water samples were not collected and analyzed as a component of this SWAP.

2. The water quality databases that were used to support this assessment revealed sometimes irregular sampling intervals. MDE advises that the SDWA regulations are such that different contaminants are sampled at different intervals and provide MDE with the authority to reduce the frequency of sampling based on the occurrence of a contaminant in the water supply and geology.

6.0 WHPA MANAGEMENT AND PLAN IMPLEMENTATION MEASURES

Chapters 1 through 5 of this report constitute the Source Water Assessment for Berlin and Tyson, as required under the 1996 Safe Drinking Water Act amendments. We have delineated a multi- zone WHPA, wherein varying protective measures may be considered for implementation depending on the degree and immediacy of hazards potentially posed to the subject wells.

Chapter 6, below, constitutes a set of recommendations for implementing the goals of a wellhead protection plan focused on hazard reduction, risk mitigation and proactive management of the groundwater resource from a water quality perspective. Specifically, we propose a variety of measures focused on the proactive mitigation of future contaminant hazards, including corrective and preventative actions, land use and ordinance-based controls, upgraded treatment, and public education and outreach programs. In developing management and contingency recommendations, ALWI considered the comparative economic feasibility of each measure and presented these for public comment at a workshop meeting held on April 8, 2004 (Appendix A).

6.1 CHEMICAL HAZARD REDUCTION STRATEGIES

As discussed in Section 4.6 and summarized in Table 5, the Tyson wells are susceptible to benzene and nitrate-nitrogen. Both benzene and nitrate-nitrogen likely are of anthropogenic origin, suggesting that appropriately conceived and executed strategies may mitigate the hazard and/or reduce risk of contamination. Mere acceptance of the presence of anthropogenic contaminants (and treating the water as necessary, should concentrations increase) need not be the only solution.

6.1.1 Benzene

Source reduction often is effective in lowering the concentration of anthropogenic VOCs in shallow groundwater. Benzene most commonly is a principal gasoline constituent; only MTBE exceeds it in terms of groundwater solubility of the major VOC constituents of gasoline. Experience suggests that leaking gasoline UST facilities and associated appurtenances constitute potential sources. Remnant soils in contact with such leaking equipment can constitute secondary yet still important sources even after a UST is removed. The presence of benzene in concentrations disproportionate to other major gasoline constituents (e.g., ethylbenzene, toluene, xylenes, etc.) suggests a comparably fresh release.

Experience also suggests that in public water service areas, owners of leaking UST facilities often successfully obtain regulatory closure for leaking UST systems based (perhaps solely) on the absence of free product but often still with moderate to high concentrations of dissolved-phase VOCs remaining in unexcavated soils and unremediated shallow groundwater. Given these trends, it seems possible that one or more regulated UST site(s), with closure recently secured based on the relative freshness of the benzene release, may constitute a lingering source. Such a source, once identified, could be remediated further.

The location of such a recently closed and regulated UST site would need to be upgradient of Tyson Well No. 1 during present pumping conditions. It would need to be closer to Tyson Well No. 1 than to Tyson Well Nos. 2 and 3 (based on the reported absence of benzene in raw water samples collected from those wells). Furthermore, it would need to be upgradient of Berlin Well No. 2 during conditions of reduced withdrawals from Tyson Well No. 1. Only in this way could one explain the historic contamination of Berlin Well No. 2, but its decrease in benzene concentration since the late 1990s when Tyson increased its Well No. 1 withdrawal rate.

Three identified potential sources appear to have the combination of proximity to the affected wells and the alleged historic benzene source. These are the commercial property between Tyson and Berlin Well No. 2, Seitz Automotive, and Cheers/Mobil. As aforementioned, Tyson commissioned an environmental consultant to make soil borings and perform other evaluations to identify the source, but the limited results made available to ALWI were inconclusive (possibly because of limited boring depths and/or low ambient concentrations of benzene). One of the other two sites may not have had regulated USTs; the other may have retailed petroleum historically but not recently. Based on present information and within the intrinsic limitations of this SWAP, the commercial property and Seitz appear unlikely to be the source of quantities of benzene sufficient to constitute a persistent contamination hazard over the era of stringent UST regulation that persisted over the last decade.

Cheers/Mobil possesses the upgradient location, continuity of source, and known history of release. That it has secured regulatory closure for historic UST releases does not automatically verify the

absence of a potential continuing source in the form of benzene-saturated soils that may remain buried on or near the site of those formerly leaking USTs. Municipal interests may wish to consider contacting the MDE OCP to request an additional evaluation and/or reconsideration of regulatory closure for Cheers/Mobil in light of the continuing benzene susceptibility at Tyson Well No. 1 and the absence of a second, equally plausible explanation.

Work following reopening of the Cheers/Mobil OCP case should include a groundwater quality assessment to depths of 100 to 130 feet on that site and on lands along Old Ocean City Road between Cheers/Mobil and Tyson. Should the cooperation of the MDE Oil Control Program in ordering such an evaluation fail to be secured for any reason, ALWI would recommend that the beneficiaries of this assessment consider funding such an evaluation. We further recommend that the Town be afforded the opportunity to review and comment on the methodology proposed and be afforded full access to all data and findings.

6.1.2 Nitrate – Nitrogen

Nitrates can arise from both point and non-point sources. Food processing and poultry waste handling are understood to be business practices in which Tyson is engaged. ALWI recommends that Tyson critically evaluate its protocols for handling, storing and disposing of such wastes. Perhaps through improved practices a possible risk of groundwater infiltration by process and rinsate water can be reduced. Systematic sampling of aqueous waste streams on-site may help to identify those particularly laden in nitrates. Of course, it is acknowledged that such efforts may fail to identify correctible practices and the nitrates present may be from off-site sources entirely.

Other potential point sources of nitrate contamination to the aquifer are (1) the wastewater storage lagoon just northeast of the WHPA and (2) other wells.

1. **Wastewater Lagoon** - If the lagoon is not lined now, consideration should be given to budgeting for an evaluation of its infiltration capacity and lining it as necessary. A cost-benefit analysis weighing pond lining against denitrification could be of benefit, should nitrate concentrations climb to a level warranting treatment.

2. **Private Wells** - Berlin representatives identified certain private wells believed still to exist; these are shown on Figure 1. If present and particularly if casing and/or grout integrity is compromised, such wells potentially constitute short-circuit pathways for the downward migration of nitrate-laden stormwater into the aquifer. Municipal Ordinance No. 1996-1, Chapter 77 of the Berlin Code, and specifically the Worcester County Plumbing Code incorporated by reference, prohibits cross-connections. Under an associated right-of-entry, that also may need establishment by ordinance, the Town should regularly inspect the premises of well owners for evidence of cross-connections and other practices and facilities suggestive of a direct and/or immediate groundwater contamination hazard (i.e., leaking tanks, stressed vegetation, etc.). Consideration should be given to amending Ordinance No. 1996-1 and/or Chapter 77 of the Berlin Code to give the Town the right-of-entry (as necessary) to take investigative actions it judges appropriate. The Town then would have the ability to submit a list of wells that are determined to present an acute groundwater contamination hazard to the Worcester County Environmental Program. The Worcester County Environmental Program, as specified in COMAR 26.04.04.11.(2), then may condemn, abandon and seal such wells.

3. **Voluntary Abandonment of and/or Hazard Management Near Existing Private Wells** - ALWI recommends a community outreach program to encourage owners of existing wells in the WHPA and served public water, to abandon and seal those wells, pro-actively. Regressive water use pricing (e.g., a discount in the per gallon cost over 50,000 gallons per quarter) that would make lawn irrigation affordable could be considered as a means to encourage abandonment of the shallow wells. The Town also should develop a community awareness program for (1) appropriate nitrate and phosphorous management techniques; and (2) the consequences of accidental and/or inappropriate waste disposal and/or groundwater contamination.

4. **Community Outreach to Agricultural Land Owners and Tenant Farmers in Zone 2** - Berlin should implement a WHPA-wide community outreach and awareness program, concentrating on agricultural landowners and users in the WHPAs. ALWI recommends that assistance be solicited from local agricultural extension officials in contacting and educating affected parties as to the consequences of certain incompatible operations and land use practices.

5. **Restrictions on New and Expanding Industrial and Commercial Operations** - ALWI recognizes the importance of poultry and grain processing to the local economy. Also recognized is industrial zoning across much of Zone 1A, some of which is under-utilized at present. We recommend that owners and developers of poultry and grain processing operations within the WHPAs be required to develop, submit for approval and operate within the constraints of nutrient discharge Best Management Practices developed in cooperation with Town and MDE officials. Such requirements should apply to new operations, and existing operations that seek to expand or change facilities in a manner otherwise requiring local, county or state permitting.

6.1.3 Other Chemical Hazards

ALWI recommends that the Town establish and maintain a program for household hazardous waste collection days. Consideration should be given for allowing property owners outside Town boundaries but within the WHPA to participate. We also recommend that informal refuse disposal practices in the WHPA cease. Any dumping areas or informal vehicle storage area should be cleaned up to the degree financially feasible. "No dumping" signs should be posted near refuse disposal areas and in other prominent locations along major thoroughfares transecting the WHPA.

6.2 LAND USE CONTROLS

Zonal WHPA designations provide the ready means for scaling land use controls with distance from wellheads. ALWI generally recommends decreasing restrictions in land uses with increasing distance from the wellheads, such that Zone 1 is the most restrictive. Generally, in Zone 1 no new contaminant hazards would be allowable and facilities with existing hazards should be required to mitigate the hazard by using the most protective technology possible when upgrading or replacing systems. In Zone 2, new hazards could be allowable if appropriately protective technology was incorporated in the design of the facility.

As customized for Berlin, specific recommendations for incorporation are provided below. The order of these recommendations reflects ALWI's judgment of their relative importance:

1. **No New Wells on Private Property in the Town** - Applicable Berlin and Worcester County codes and ordinances effectively prohibit wells within the Town for purposes other than lawn

irrigation. ALWI recommends that the applicable ordinance(s) be further modified to prohibit new wells in the WHPAs. Ideally, un-needed wells in the WHPAs should be abandoned and sealed as well.

2. **Wellhead Maintenance on Town Property** - One of the greatest threats to water supply contamination occurs at the wellhead. The best protection against this risk is achieved through wellheads that are maintained in good physical condition, that lack perforations, grouting cracks, gaps or other pathways for the rapid downward migration of surficial liquids. ALWI also recommends continued protection of the wellheads from vehicular hazards and grading to redirect stormwater away from the wellheads. Since these wells are screened in an unconfined aquifer, special consideration should be given to storm drain labeling and sign postage near the production wells. Water treatment chemicals should be stored using a means that provides for secondary containment should leaks or spills occur. Appropriate signs prohibiting dumping should be posted throughout Zone 1 to the degree feasible.

3. **Fuel Storage and Vehicular Servicing In Zone No. 1** - We recommend against new underground fuel storage facilities in Zone No. 1. The only exception that could be considered would be the installation of underground tanks as self-contained AST units within sealed subsurface vaults (as opposed to traditional UST installation methods). Such installations would exceed, rather than merely comply with MDE UST design requirements. The circumstance of high-capacity fuel oil storage near Berlin Well No. 2 is regrettable, but not easily solved. Conversion of the municipal electrical generating station from fuel oil reliance to natural gas reliance should be explored. If fuel oil storage remains necessary, ASTs incorporating the most advanced technology for leak detection and secondary containment should be used. Consideration also should be given to relocating general vehicular maintenance and service operations to a paved facility further from this wellhead.

4. **Lessen Petroleum Risks from Other Sources** - UST and AST facilities, such as Venable's dry cleaning operations and Wainwright's, pose potential risks of groundwater contamination of the drinking water aquifer. Berlin may wish to consider contacting the MDE OCP and request that they pursue a more aggressive remedial strategy at Wainwright's. Un-needed monitoring wells at the Berlin Florist should be abandoned and sealed in accordance with applicable regulations. Venable's should be encouraged to convert to a more environmentally friendly non-solvent dry cleaning process, as several are newly available on the market. Natural gas service for Berlin should be pursued, and property owners in the WHPAs should be encouraged to convert from fuel oil use when natural gas becomes available. A low-interest loan or grant may be a vehicle to help accomplish the recommended conversions both at Venable's and at other property owners.

5. **Adopt Town of Berlin Ordinance No. 2002-08** - Berlin should consider adopting its draft wellhead protection ordinance (Appendix F) and Worcester County should consider adopting a similar ordinance for those WHPA areas outside Berlin’s jurisdiction. After a close comparison, we believe that the Town’s draft ordinance addresses the property rights of the owners of industrially-zoned land within the WHPA with greater overall sensitivity and flexibility. Such a flexible approach would render the ordinance less subject to protracted debate, appeal and revision. This flexibility affects those “principal [land] use activities that involve the manufacture, storage, use, transport, or disposal of hazardous materials.” The MDE Model Ordinance suggests that such activities be prohibited in Zone 2, while the Berlin draft ordinance proposes these uses be conditional. The final Ordinance should accurately reflect the final version

of this Plan (e.g., title, date, etc.) and its contained figures, tables and appendices.

6. **Consider Certain Modifications to Draft Town Ordinance No. 2002-08** - Certain provisions of the draft ordinance are more restrictive than the MDE model ordinance. In general, local provisions more restrictive than corresponding MDE guidelines may be subject to lengthy debate or challenge, and may be difficult to defend considering the absence of groundwater susceptibility associated with the existing Berlin wells. Specific recommendations follow:

   - **Zone 1** – Generally, we recommend that no new contamination hazards be allowed in Zone 1, and that existing facilities upgrade using the most protective best management practices (BMP) available when otherwise upgrading anyway (e.g., during a facility renovation or expansion). A BMP for USTs would be the use of ASTs at the ground surface or in accessible, sealed subsurface vaults. MDE-compliant USTs themselves should not be judged to be BMPs for fuel storage.

   - **Properties Split Between Zones** - Many properties are split by zonal boundaries. For greater long-term defensibility and implementation ease of the ordinance, Berlin should consider not adjusting the boundaries to follow parcel boundaries. Rather, development could be spatially arranged on a given parcel as necessary to afford the flexible co-existence of development with the water-quality intentions of the plan. To do otherwise (i.e., to adjust the zones to follow existing parcel boundaries) may increase challenges and/or implementation difficulties.

   - **Zone 2** - The Ordinance as drafted appears adequate to afford necessary and appropriate protections.

   We recommend that applicable provisions of the MDE Model Ordinance be followed with respect to impervious surface creation and groundwater recharge maintenance. MDE specifications also should be followed regarding the permeability of lagoon liners; in this case the local ordinance is substantially less restrictive and may not adequately protect from nitrates.

7. **Notify Worcester County Planning and Zoning Department** - Municipal officials believe that some development pressure exists in the WHPAs. Development should preferentially be focused and directed to lands outside the WHPA to the degree feasible, as this is necessary for both recharge area preservation and water quality protection. Future land uses outside the corporate limits of the Town are under the approval jurisdiction of the Worcester County Department of Planning and Zoning. ALWI recommends that the County be furnished a copy of this Plan and requested to manage the review and approval process for future land uses outside the Town limits but otherwise within the WHPA, in accordance with the recommendations herein.

8. **Use Discretion in Roadway and Parking Lot Deicing** - Restrictions in the use of conventional road salt should be predicated on existing sodium and chloride concentrations in the shallow aquifer. A wise precaution would involve the use of non-chemical abrasives to replace salt usage in Zone 1.

9. **Perform Code Inspection** - Berlin should embark on a program of periodic plumbing inspections to identify and require the correction of cross-connections. This program would also help to identify other visual evidence of inadequate and/or improper maintenance that could

contribute to either a groundwater or a distribution system contamination hazard.

6.3 CONTINGENCY PLANNING

According to MDE wellhead protection guidance documents, an effective contingency plan should have six key components: inventory of threats; design of response; assignment of responsibilities; identification of resources (logistical, technical, and financial); periodic review and updates; and public awareness. Threats have been inventoried and public awareness measures are suggested earlier in this document.

ALWI suggests the following step-wise procedures for implementation in the event of an acute threat of water supply contamination:

1. **Confirm Source / Notify Owner / Reduce Threat** - Berlin should verify the nature, source and degree of contamination within the aquifer and/or water supply system. The owner(s) (i.e., potentially responsible party) of the leak or spill should be identified and then notified so that corrective action can be taken. At the same time, contamination threat reduction measures should be evaluated and implemented to mitigate degradation of the water supply and any associated health risks (e.g. distribution system flushing, sampling, spill clean-up, equipment maintenance and cleaning as necessary).

2. **Notify Customers / Reduce Demand** - The detection of contamination warrants public notification before the contamination reaches customer connection(s) to the service. Depending on conditions observed, it may be necessary to advise customers to reduce demand, boil water or in a worst-case scenario, refrain from unnecessary water supply usage (e.g. use bottled water for cooking and drinking, bathe "at your own risk", etc.).

3. **Retrofit for Treatment** - If detected, the degree and nature of contamination may necessitate treatment prior to distribution (centralized treatment) or treatment within each household (point-of-use treatment). A quick cost evaluation of the treatment process options would aid in the decision-making process.

4. **Develop Alternative Water Source** - ALWI anticipates that careful monitoring and contingency planning herein will largely preclude catastrophic water supply problems. In the event that water quality within production wells degrades beyond effective treatment (or should the cost of treatment prove to be exorbitant) alternative sources of water may need consideration. We would further recommend construction of a new supply well in one of the deeper freshwater aquifers. To limit interference potential and improve aesthetic quality, consideration could be given to developing the replacement supply in the deeper Manokin aquifer and/or in hydrogeologically favorable areas that may be identified north of U.S. Route 50. The new well should be constructed in a manner to isolate the newly penetrated aquifer from overlying contamination (i.e., adequate grouting, casing to screened interval, etc.).

Close cooperation of the following entities would be necessary for the timely and cost-effective address and resolution of a potential contamination occurrence: the Town, the Worcester County Health Department and MDE. Berlin should establish a financial reserve to fund contingencies and should remain abreast of MDE grant programs regarding the same. A list of contact names, addresses, telephone, fax and pager numbers should be developed and kept current. Copies should be

provided to Berlin (facilities and administrative personnel), Worcester County (the Department of Public Works, Emergency Response and Environmental Health), the U.S. Department of Agriculture's extension agents based in Salisbury, MD, and MDE (including Water Supply Program and Emergency Response). The list should be reviewed and updated annually for currency.

6.4 POTENTIAL FOR CHANGES IN WHPA DELINEATION OR PLAN ELEMENTS

Future increases in pumping rates, if achievable, or changes in the distribution of withdrawals may draw waters from areas not previously within the capture zones and may require an increase in the size of the WHPAs. In addition, actual long-term operational capacities may differ from projections made based on limited operational data. There is no substitute for accurate long-term testing, and such testing can be designed and executed cost-effectively using existing pumps. Absent such data, however, contingency plans should be developed and implemented to address the possible gradual onset of future supply shortfalls (whether or not growth in Berlin water demand occurs) as follows:

1. **Conserve Water** - ALWI recommends the use of ultra low-flow plumbing fixtures in all newly constructed facilities in the service area.

2. **Plan for Shortfalls** - As periodically necessary based on drought conditions or future supply/distribution issues of a transient nature, a means to place all Berlin customers under water use restrictions should be developed (i.e., either voluntary or mandatory water conserving measures depending on the severity of the low supply condition). Of course, new hydrogeologic data could also refine the delineations.

3. **Future Groundwater Supply Wells to Tap Deep, Confined Aquifers**- During the course of its work, ALWI came to understand that longer-range plans may exist to develop additional groundwater supply wells for the Town. From a wellhead protection perspective, greater overall insulation from surficial contamination risks is achieved if such well(s) is/are screened in deep, confined aquifers rather than again in the shallow, unconfined aquifer. We recommend that the Town install and accept such deeply screened wells, only.

7.0 CONCLUSIONS

In preparing the conclusions enumerated below, ALWI has utilized its best level of effort consistent with its professional standards, present scientific judgment and knowledge. We have upheld accepted industry practice and prepared this report within the budgetary and work scope limitations set forth in its contract with Berlin. Subject to this provision and the assumptions and exclusions specified and mutually agreed in ALWI's contract with Berlin and/or referenced herein, ALWI's conclusions follow:

1. **WHPA Delineation -** ALWI delineated a two-zone WHPA following methods prescribed and approved by MDE. The results are shown pictorially in Figure 1. In performing the delineation, conservatism was preserved without undue sacrifice in the utility of the Plan. The technical work supporting the delineation should be reviewed triennially and updated as necessary.

2. **Contamination Hazards** - ALWI identified and catalogued existing and potential contaminant hazards in each WHPA zone. Berlin's wells are not susceptible to regulated contaminants, as of the date of this Plan. The Tyson wells are susceptible to both nitrates and benzene. The nitrates

are believed to originate from non-point agricultural operations, but may also originate from on-site chicken processing. The benzene may originate from a nearby gasoline station and convenience store (Alpha Cheers). Though this remains unverified, no equally plausible source was identified. Not all hazards are equal in immediacy, proximity and condition. Hazards are mapped on Figure 1.

3. **Management Tools and Contingency Plans** - Herein, ALWI also presents several suggestions for proactive management and risk reduction of a future contamination occurrence in the WHPA. Generally, these center on source reduction, risk awareness, emergency and contingency planning programs.

8.0 RECOMMENDATIONS

This wellhead protection plan is intended to be a dynamic document, requiring regular updates and refinements to continue to fulfill its goals of defensibility and usability. In light of the information presented herein, ALWI offers the following recommendations:

1. **Periodically Review and Update Delineation** - The delineations herein are predicated on a nested set of assumptions regarding the local and regional hydrogeologic framework. Changes in the magnitude and distribution of groundwater withdrawals, both from the system's production wells and from other nearby wells, could change the delineation. The possible reduction or cessation in Tyson's withdrawals would change the delineations substantially. The availability of additional hydrogeologic data could allow refinement of the existing delineation work. ALWI recommends that the delineation work be checked and re-verified upon verification of the future plans for use of the Tyson wells, and triennially thereafter.

2. **Periodically Review and Update Contamination Hazard Inventory** - The inventory of contaminant hazards presented herein represents ALWI's best understanding of the local point-source hazards as of 2003. Land uses can change rapidly. ALWI recommends that the contaminant hazard inventory herein be updated when the disposition of the Tyson property becomes known, and triennially thereafter.

3. **Management Tools -** ALWI herein suggests that local ordinances and protective covenants, combined with community awareness and public outreach measures likely afford the desired level of WHPA management. These measures should be periodically reviewed for effectiveness and adjusted based on local conditions and issues.

9.0 SELECTED REFERENCES

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Table 1: Inputs For WHPA Code Delineations

Well	Gradient (ft / ft)	Areal Recharge (ft / day) gpd/ac	Pumping Rate Cu ft / day gpd [1]	Aquifer	Porosity	Transmissivity Sq ft / day gpd/ft	Saturated Thickness (ft)
Berlin Well 1	0.0014	0.004 / 1,300	13,370 / 100,000	Pleistocene	0.25	15,000 / 110,000	**75**
Berlin Well 2	0.0014	0.004 / 1,300	26,740 / 200,000	Pleistocene	0.25	15,000 / 110,000	**75**
Berlin Well 3	0.0014	0.004 / 1,300	26,740 / 200,000	Pleistocene	0.25	15,000 / 110,000	**75**
Tyson Well 1	0.0014	0.004 / 1,300	44,121 / 333,000	Pleistocene	0.25	15,000 / 110,000	**75**
Tyson Well 2	0.0014	0.004 / 1,300	44,121 / 333,000	Pleistocene	0.25	15,000 / 110,000	**75**
Tyson Well 3	0.0014	0.004 / 1,300	44,121 / 333,000	Pleistocene	0.25	15,000 / 110,000	**75**

[1] Based on the total Water Appropriation Permit for each source

Table 2: Point Source and Potential Contamination Hazards
Berlin Wellhead Protection Area

Label [1]	Owner	Address	Regulated Entity	Data Source [2]	Nature of Hazard [3]	WHPA Zone [4]
A	Charles W. Lord	9923 Old Ocean City Blvd	Mobil/Cheers/Alpha Beverages/Ocean Petroleum	1 & 2	LUST/UST	1
B	Hudson Foods, Inc.	9943 Old Ocean City Blvd	Tyson Foods	1 & 2	LUST	1
C	Calvin B. Taylor Banking Co.	107 Williams St	Berlin Health Dept./Worcester Co. Senior Center	2	UST	2
D	William W. & Sandra H. Venable	206 Williams St	Venables Cleaners/Marion's Used Furniture Store	1 & 2	UST	2
E	Royce W. & Barbara M. Evans	9814 Main St	Informal Vehicular Disposal Area	1	Hazardous Waste	1
F	Oak-Kwang & Soon Ae Park	11013 Old Ocean City Blvd	Seitz Automotive	1	UST/Hazardous Waste	1
G	Calvin B. Taylor Banking Co.	19 Broad St	King's Pub and Restaurant	2	UST	2
H	Berlin Fire Company	214 N. Main St	Berlin Fire House	1 & 2	UST	2
I	Donald W. Palmer & Linda Williams	101 Williams St	Batailles/Stephen Falck Construction Inc./Rainbow Florist	1 & 2	UST	2
J	Roland L. & Rose Marie Wainright	18 Broad Street	Wainwright Service Station	1 & 2	LUST/UST	2
K	Berlin Florist	3 Pitts St	Berlin Florist	2	UST	2
L	Hudson Foods, Inc.	9943 Old Ocean City Blvd	Tyson Foods	3	UST	1

[1] **Label:** Letter label corresponds with properties marked on Figure 1

[2] **Data Source:** 1 - Field Reconnaissance; 2 - Environmental Database Listing (see report); 3 - Interview

[3] **Nature of Hazard:** LUST = Leaking Underground Storage Tank; UST = Underground Storage Tank

[4] **WHPA Zone:** 1 - Property located within 1-year time of travel zone; 2 - Property located within 10-year time of travel zone

Table 5: Quantitative Groundwater Susceptibility Analysis
Town of Berlin and Tyson's Foods Supply Wells

General Location / Owner	MDE Plant No.	Common Treatment Plant Name	Individual or Composite	Compound Detected > or = to 50% of MCL	Units	MCL[1 & 2]	> or = 50% MCL[3]	% Exceedance	Time Period (> or = 50% MCL)	Max. Conc. Detected	Period of Record
Berlin	**1**	**Power Plant Well**	Indiv.	Nitrate	mg/L	10 (0)	5 (2)	14	1994-1995	6	1993-2002
Berlin	**2**	**Franklin Well**	Indiv.	Nitrate	mg/L	10 (0)	5 (1)	7	1994	6.1	1993-2001
				Benzene	mg/L	0.005 (0)	0.0025 (1)	8	1998	0.0043	1996-2000
Berlin	**3**	**Maryland Ave Well**	Indiv.	Nitrate	mg/L	10 (0)	5 (1)	9	1995	5.8	1993-2001
Tyson's	**1**	**Wells 1, 2 and 3**	Composite	Nitrate	mg/L	10 (0)	5 (1)	6	2002	5.37	1993-2002
				Benzene	mg/L	0.005 (9)	0.0025 (4)	30	1999-2002	0.014	1991 & 1999-2003

[1] Methyl tert-Butyl Ether (MTBE) was detected in Berlin wells 2 and 3, as well as in the Tyson's wells. Though the US EPA has issued a drinking-water advisory of 20 to 40 micrograms per liter (µg/L), none of the samples collected detected a level higher than 6.8. As a result, none of the wells have been interpreted as susceptible to MTBE.

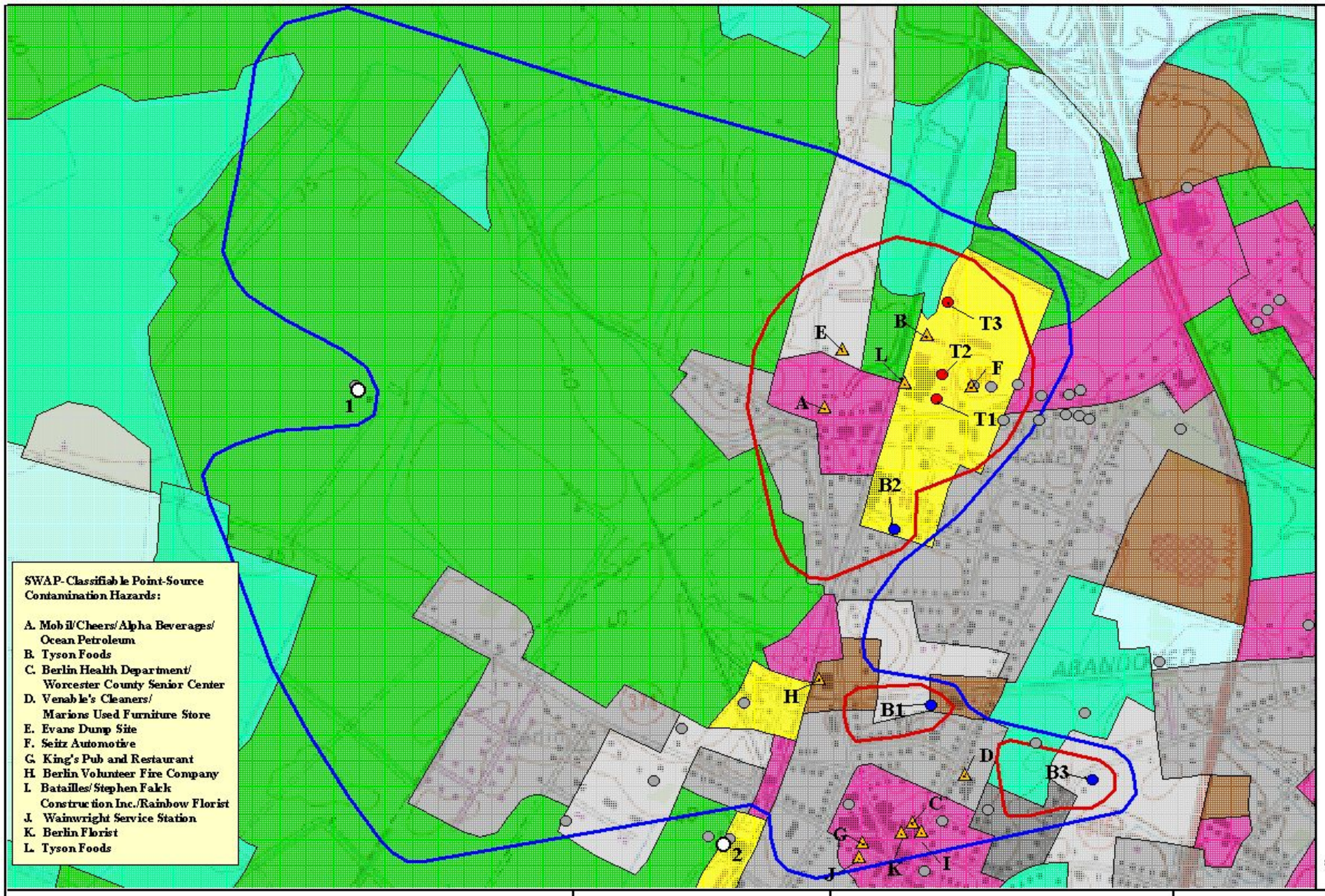
[2] The number in parantheses indicates the number of times measeurements were detected at or above the MCL or 50% of the MCL.

[3] The Maryland Department of the Environment (MDE) supplied database of analytical records also indicated conditions of susceptibility with respect to Di(2-Ethylhexyl) phthalate in 1995 (50% of the MCL). Phthalate also was detected in laboratory blanks and does not represent actual water quality in Berlin's water supply. ALWI disregarded this finding, consequently.

[4] A rise in nitrate concentration, possibly up to or exceeding concentrations connoting susceptibility, could occur if Tyson's withdrawals are reduced or cease.

Table 5: Quantitative Groundwater Susceptibility Analysis
Town of Berlin and Tyson's Foods Supply Wells

Interprative Suceptibility (yes/no)
No [4]
No [4]
No
No [4]
Yes
Yes



SWAP-Classifiable Point-Source Contamination Hazards:

A. Mobil/Cheers/Alpha Beverages/ Ocean Petroleum
B. Tyson Foods
C. Berlin Health Department/ Worcester County Senior Center
D. Venable's Cleaners/ Marions Used Furniture Store
E. Evans Dump Site
F. Seitz Automotive
G. King's Pub and Restaurant
H. Berlin Volunteer Fire Company
I. Batailles/Stephen Falck Construction Inc./Rainbow Florist
J. Wainwright Service Station
K. Berlin Florist
L. Tyson Foods

N

Final Draft

EXPLANATION:

- Tyson Wells
- Berlin Wells
- 1 Richardson
- 2 Ocean City Ice and Seafood, Inc.
- Other Existing Wells
- Contamination Hazards
- 10-Year Time of Travel
- 1-Year Time of Travel

Land Uses Within SWAP Area:

Residential:

- Low Density Residential
- Medium Density Residential
- High Density Residential

Other:

- Commercial
- Industrial
- Agricultural (Cropland)
- Forest
- Institutional
- Other

Scale:

800 0 800 1600 Feet

Notes:
1. Base map imported from digital USGS topographic quadrangle map for Berlin, MD (photorevised 1981), provided by MapTech, Inc.
2. Land use catagories from MdPropertyView: 2001 Edition (Maryland Department of Planning).
3. Delineated SWAP areas from the International Ground Water Modeling Center's WHPA water modeling software (see report).
4. This figure is integral to a written report and should only be used in that context.
5. This figure is not intended to be used for boundary verification or survey control purposes.

Client:

Town of Berlin

PROJECT NO. WO7N140

Project:

SOURCE WATER ASSESSMENT AND WELLHEAD PROTECTION SERVICES

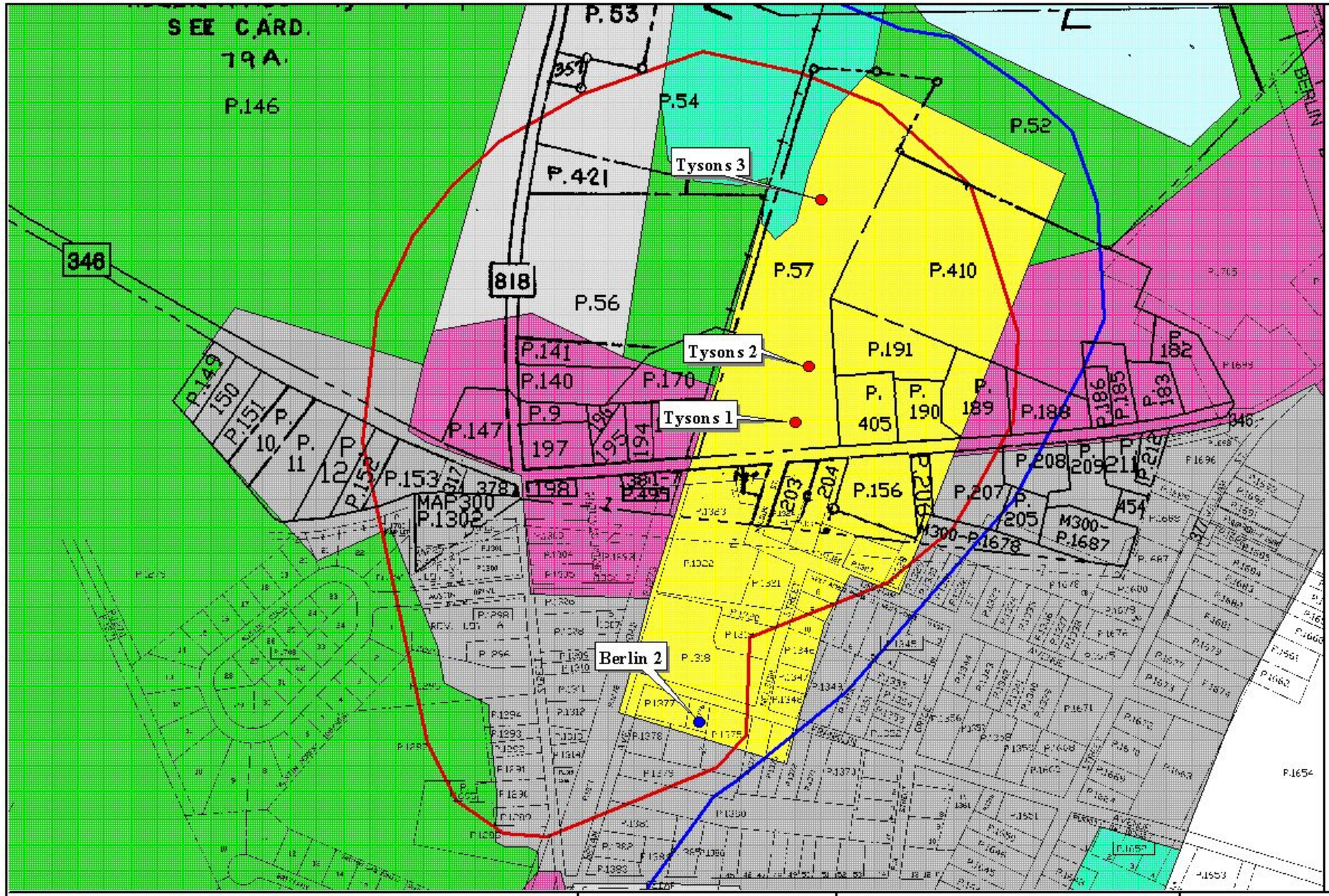
Berlin, Maryland

ADVANCED Land and Water, Inc. — Global Environmental Solutions

Figure 1:

Delineated SWAP Areas

January 6, 2004



Notes:

1. Land use catagories and tax map information from MdPropertyView: 2001 Edition for Worcester County, Maryland (Maryland Department of Planning).
2. Delineated SWAP areas from the International Ground Water Modeling Center's WHPA water modeling software (see report).
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Berlin, Maryland

Global Environmental Solutions
ADVANCED Land and Water, Inc.

Figure 2:

Tyson Area Property Boundary Map

January 10, 2003

Final Draft

N

EXPLANATION:

- Berlin Well 1
- 10-Year Time of Travel
- 1-Year Time of Travel

Land Uses Within SWAP Area:

Residential:

- Low Density
- Medium Density
- High Density

Other:

- Institutional
- Commercial

Scale:

100 0 100 200 Feet

Notes:

1. Land use catagories and tax map information from MdPropertyView: 2001 Edition for Worcester County, Maryland (Maryland Department of Planning).
2. Delineated SWAP areas from the International Ground Water Modeling Center's WHPA water modeling software (see report).
3. This figure is integral to a written report and should only be used in that context.
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SOURCE WATER ASSESSMENT AND WELLHEAD PROTECTION SERVICES

Berlin, Maryland

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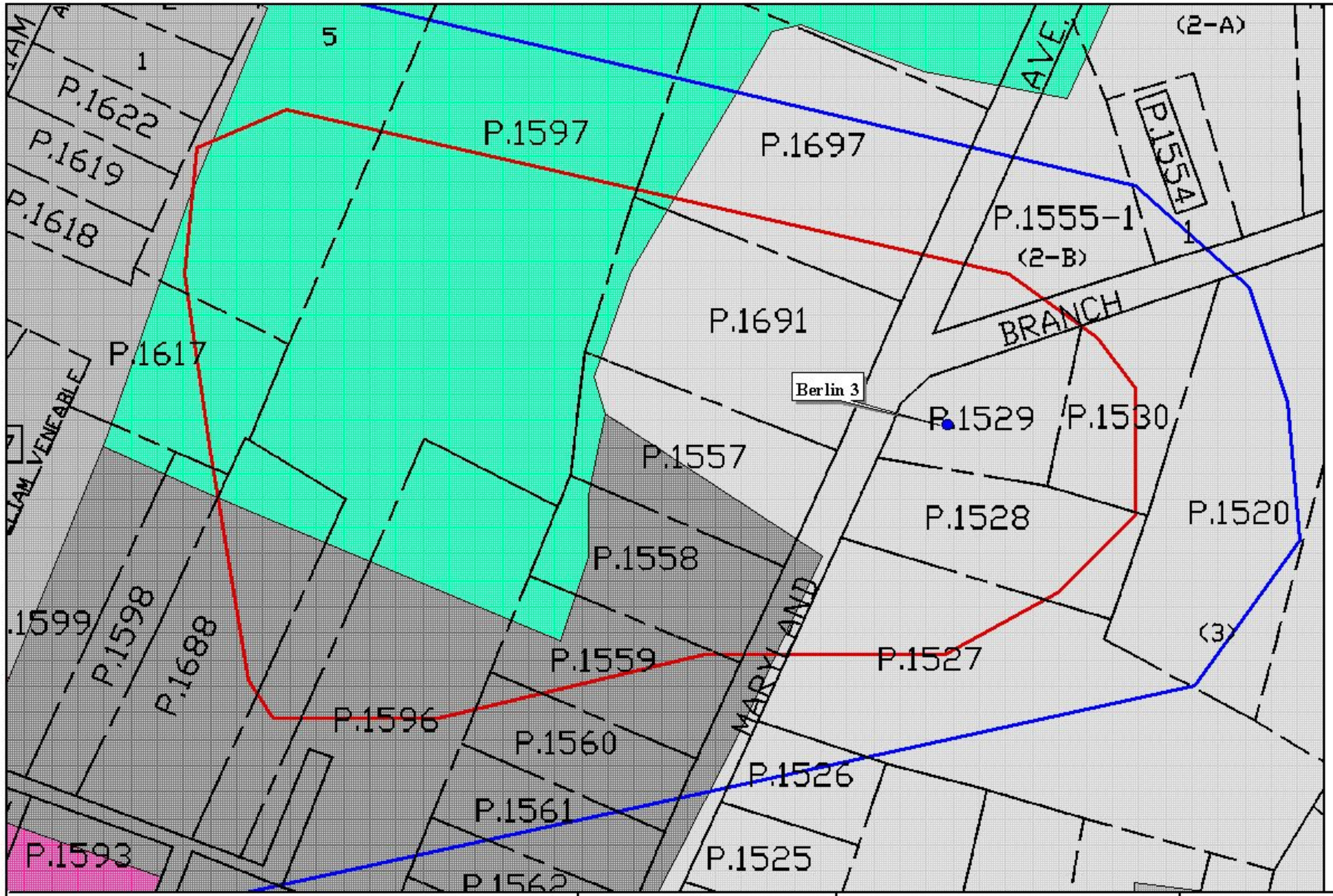
Global Environmental Solutions

Figure 3:

Berlin Well #1 Property Boundary & Land Use Map

January 10, 2003



Final Draft

N

EXPLANATION:

- Berlin Well 3
- 10-Year Time of Travel
- 1-Year Time of Travel

Land Uses Within SWAP Area:

Residential:

- Low Density
- Medium Density
- High Density

Other:

- Commercial
- Forested

Scale:

100 0 100 200 Feet

Notes:

1. Land use catagories and tax map information from MdPropertyView: 2001 Edition for Worcester County, Maryland (Maryland Department of Planning).
2. Delineated SWAP areas from the International Ground Water Modeling Center's WHPA water modeling software (see report).
3. This figure is integral to a written report and should only be used in that context.
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Berlin, Maryland

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Figure 4:

Berlin Well #3 Property Boundary & Land Use Map

January 10, 2003