

Jefferson County Foundation, Inc.

May 27, 2021

Sent via email to Info@jeffersoncountywv.org

Jefferson County Commission
124 E. Washington Street
Charles Town, WV 25414

RE: Proposed Zoning Map Amendment 21-2-Z

Dear Commissioners:

Progress and development are important, and we believe that appropriate zoning and land use planning are critical to successful progress and development of the County. Successful development must holistically evaluate the impact of any individual development with particular attention to the effects on natural resources and the environment.

We respectfully suggest that due to the environmental sensitivity of the land in question and the potential for negative natural resource impacts that this zoning change be denied and a fuller environmental investigation be undertaken before further rezoning of this area of the county take place.

This owner requested Zoning Map Amendment does not conform to the Comprehensive Plan. The evidence provided by the applicant when taken together with the balance of the Comprehensive Plan fails to fulfill the five criteria that would allow the County Commission to amend the Zoning Map despite its disagreement with the Comprehensive Plan. This proposed Zoning Map Amendment does not conform to the purpose of the Jefferson County Zoning and Land Development Ordinance or the West Virginia State Code on Zoning and Land Use. Therefore, we respectfully ask that you deny this Zoning Map Amendment request.

These points are more fully discussed herein below.

Comprehensive Plan

The Planning Commission staff found that this Zoning Map Amendment was not consistent with the Comprehensive Plan, *Envision Jefferson 2035* (CP).

“Staff finds that the request is not consistent with the Future Land Use Guide of the 2035 Plan because it is designated as Future Rural/Agricultural and is outside any Preferred Growth Area (PGA) or Urban Growth Boundary.”¹

¹ Staff evaluation of zoning proposal 21-2-Z, page 1

According to §8A-7-9(c) of the state code “... If the amendment is inconsistent, then the governing body with the advice of the planning commission, must find that there have been major changes of an economic, physical or social nature within the area involved which were not anticipated when the comprehensive plan was adopted and those changes have substantially altered the basic characteristics of the area.”

The development of one industrial entity and the related extension of utilities to that entity in the adjoining municipality is not a major change of an economic, physical or social nature within the area involved that were not anticipated when the Comprehensive Plan was adopted. In fact, the land within the area involved in the county has not changed in an economic, physical or social nature at all. The County enjoys sovereignty from the City of Ranson and is under no obligation to accommodate Ranson’s change in zoning by changing its own. It is clear that the majority of county residents oppose industrial development in this location. Because there has been no change in economic, physical or social characteristic of this area of the county since the Comprehensive Plan was approved, the zoning map amendment should be rejected.

In the CP under Urban Level Development Recommendations, it states, “Recognize that the County Commission has the authority to make land use decisions including Zoning Map Amendments based upon the finding of consistency with the Future Land Use Guide and the recommendations of this Plan; the County Commission may determine that petitions or decisions for zoning map amendments are consistent with the Comprehensive Plan if any of the following conditions are met after the entire Plan is taken into consideration:

- a. Economic Well-Being of the County; or
- b. Error or Under Scrutinized Property on the Future Land Use Guide; or
- c. Change in Neighborhood; or
- d. Any Other Circumstance that the Governing Body determines should have been considered when drafting the Future Land Use Guide; and/or
- e. Environmental impacts are considered.”²

The staff evaluation found clearly that this Zoning Map Amendment is inconsistent with the Future Land Use Guide. Therefore, to accept this zoning map amendment, the County Commission must determine that it is consistent with the balance of the CP by receiving “evidence and making a finding that the zoning map amendment is for the economic well-being of Jefferson County; or by finding that there is an error or under scrutinized property on the Future Land Use Guide; or a change in the neighborhood; or any other circumstance that may have been missed when considering the Future Land Use Guide; and/or that environmental impacts have been considered.”³ When critically evaluated, the evidence presented by the

² Envision Jefferson 2035 Comprehensive Plan, Page 30.

³ Envision Jefferson 2035 Comprehensive Plan, Land Use Classifications as shown on the Future Land Use Guide, page 26.

applicant does adequately fulfill any of these five findings. Further, they demonstrate why this land should not be rezoned as requested.

Negative Environmental Impacts

The land to be considered for rezoning is exquisitely environmentally sensitive and as the Comprehensive Plan instructs these impacts should be considered. The groundwater at the site is easily contaminated by surface activities due to the unique hydrogeology of the area. It also causes this pollution to be rapidly carried to large portions of the county's groundwater, multiple surface streams, the Opequon Creek, Shenandoah River, and the Potomac River, endangering drinking water for large portions of the county, and the water sources the agriculture, tourism, and equine industries rely on. When the environmental impacts are considered, it is obvious that this land should not be rezoned for industrial use.

For decades now, policy makers have been using "Aquifer Vulnerability" measures, of which karst is very high, to set land use and water resource protection policy.⁴ The guiding documents of the West Virginia Department of Environmental Protection (WVDEP) recognize this. The introduction to the WVDEP document *Stormwater Management Design in Karst Areas* states, "it is important to note that the potential for geological hazards, damage to infrastructure, and groundwater contamination is an ongoing concern when developing in these areas. And that best approach is to craft stronger comprehensive land use plans that direct new growth away from karst areas to more appropriate locations."⁵ Again, the WVDEP guidance documents agree. The Chesapeake Bay karst stormwater guidance document, which WVDEP cites in the *Stormwater Management Design in Karst Areas*,⁶ clearly states "the working group notes that while communities that incorporate this guidance into their development review process can reduce the incidence of infrastructure damage and groundwater contamination, there is always some inherent risk when development occurs on this sensitive terrain. Consequently, the best local approach is to craft stronger comprehensive land use plans that direct new growth away from karst areas to more appropriate locations." These policies recognize some types of land use can increase the amount of surface contamination and that in combination with high aquifer vulnerability the likelihood of groundwater contamination is much greater. It is short-sighted to rely on the WVDEP to protect natural resources and the environment despite environmentally poor development choices. These situations should be avoided with appropriate zoning.

⁴ Machiwal D, Jha MK, Singh VP, Mohan C. Assessment and mapping of groundwater vulnerability to pollution: Current status and challenges. *Earth-Science Reviews*. 2018 Oct 1;185:901-27.

⁵ Appendix C: Stormwater Management in Karst Area, in West Virginia Stormwater Management and Design Guidance Manual, Center for Watershed Protection, Inc, 2012, Nov; C1-C4

⁶ CSN Technical Bulletin no. 1, Stormwater design guidelines for karst terrain in the Chesapeake Bay watershed, version 2.0, 2009

Please see the further explanation of the environmental sensitivity of this land in Exhibit A. We have also included here for your review two expert reports made for the Foundation.⁷ While these reports focus on the Rockwool property, this property is immediately adjacent and according to the peer reviewed literature⁸ even more prone to sinkhole development and therefore more sensitive than the Rockwool property.

Negative Economic Impacts

While it is the goal to increase housing, business, and jobs in the county over time to meet the needs of our county, this does not mean that any development that includes areas for business and housing therefore provides positive benefit to the economic well-being of Jefferson County. In fact, due to the potential for groundwater contamination, this rezoning would pose a much greater danger to the economic well-being of the county than it would benefit. Groundwater is difficult or impossible to remediate once it is contaminated. If fouled in this location, it could have devastating long lasting effects on the ground and surface waters of the county and similar effects on our economy, health, safety, and welfare.

The majority of residents and businesses in Jefferson County rely on groundwater. Pollution of the groundwater would affect these residents and businesses severely. The cost to run utility water to all of these locations would be impractical and would not address the issues faced by businesses that rely on surface water. Groundwater is critical to the equine and agricultural industries, which are themselves critical to our local economy. The water quality of surface water is critical to the tourism industry in the county. Tourism is the largest industry in the county and works synergistically with the agriculture and equine industries to maintain a healthy local economy.

In addition to the environmental impacts, this zoning change would allow for development that would be detrimental to the economic well-being of the county because it would place very disparate noncompatible uses in close proximity, decrease the order and attractiveness of the area, increase congestion, and place high intensity housing distant from goods and services.

Due to the location in the middle of a Rural zone, residents of this area will have to travel long distances to grocery stores and other amenities. This will require car travel increasing carbon emissions and decreasing convenience and quality of life for residents. While the applicant claims there is easy access to multi-modal transportation, this is simply not the case. The bike path on Route 9 is more than a mile away, and once on the bike path, it is several miles to any necessities. This makes this mode of transportation impractical for almost anything other than exercise. In addition, travel by bike or on foot on Route 480 into Kearneysville from this

⁷ <https://www.jeffersoncountyfoundation.org/wp-content/uploads/2020/08/2020-RAN5-project-expert-witness-report-on-hydrogeology.pdf> and <https://www.jeffersoncountyfoundation.org/wp-content/uploads/2021/05/GROVES-REPORT.04-20-21.pdf>

⁸ Doctor DH, Doctor KZ. Spatial analysis of geologic and hydrologic features relating to sinkhole occurrence in Jefferson County, West Virginia. Carbonates and evaporites. 2012 Jun 1;27(2):143-52.

neighborhood or from the bike path is far too dangerous for it to be a plausible application of multi-modal transportation.

This large high density housing development would be in the middle of an area zoned Rural with no easy access to Route 9. To access Route 9, residents will have to travel through Kearneysville or into Ranson via Northport Avenue in front of Rockwool and down Route 115. They will share this route with 100 tractor trailer sized trucks a day from the Rockwool plant.⁹ This will increase congestion in Kearneysville and on Route 115, again decreasing convenience and quality of life and increasing carbon emissions. Without large infrastructural investments that may not even yield the desired effect due to the location of this land and the presence of Rockwool, this location simply does not provide for safe multi-modal transportation and will cause increased congestion.

This zoning change would place very disparate noncompatible uses in close proximity and thereby decrease the order and attractiveness of the area. This zone currently consists of large lot residential, agricultural, and wildlife corridors. The addition of a heavy industrial plant in the adjacent municipality has already created an unsightly juxtaposition. This would not improve that situation and only serve to make the situation worse.

When Jefferson Orchards sought a zoning change from Ranson, it claimed that there was no interest in a residential development in this area of the county. It therefore strains credulity that after the installation of a heavy industrial plant with intense heavy truck traffic and hazardous air emissions that now suddenly there will be more interest in such a development in the same area. It is far more likely that in a few years the same entity will be back before the Commission seeking to change the zoning in this location from residential to industrial because for this reason and the ones stated in the above several paragraphs, they are unable to interest residential developers.

Error or Under Scrutinized Property

The steering committee for the CP focused on municipalities, villages, and major intersections on Route 9 and 340 as the probable destination for residential and light industrial development because this is where this type of development makes sense in order to achieve the goals of the CP, the purpose of the county zoning ordinance, and the considerations required by the state zoning code. Focusing residential and light industrial development in municipalities, villages, and major intersections of highways preserves farm and agricultural land, reduces congestion, provides for multi-modal transportation, increases convenience, provides for orderly development, and adds to the order and attractive nature of the County. The extension of the utilities to the adjacent municipality does not address all of these considerations and does not cure the issues highlighted by these considerations. Therefore, the simple extension of utilities in the adjacent municipality does not represent an error or make this a previously under scrutinized property. Taken on balance with all of the consideration required or suggested in the authorities governing zoning, this change in the adjacent municipality does not warrant this zoning map amendment.

⁹ Based on materials presented at Rockwool Open House, August 2018.

Change in Neighborhood

While this is largely addressed in this here in above, we address it here in brief to directly rebut the claims of the applicant. The zoning change recently implemented in Ranson at the request of the same applicant was environmentally ill-advised. The County is under no obligation to accommodate this zoning change and the associated deed restrictions undertaken on land in the county with a zoning change of its own. In fact, as cited above it would be ill-advised from an environmental, economic, and planning standpoint. The installation of water, sewer, and natural gas does not change these facts.

Water, sewer, and natural gas utilities could be extended to Kearneysville without this zoning change. In fact, the natural gas line already passes through the village of Kearneysville on its way to Rockwool. The water and sewer lines could similarly travel down Route 115 to Kearneysville. It would make little sense for these utilities to travel north, circle through this development, before going back southwest to get to the village of Kearneysville. This route would necessitate an additional railroad crossing. Whereas, regardless of how this land is developed, the utilities could be extended to Kearneysville in a far more efficient approach along Route 115 or similar. Therefore, the extension of utilities in Ranson should have little bearing on this decision, and certainly do not constitute a change in the neighborhood.

Likewise, the short extension of Northport Avenue to accommodate Rockwool does not constitute a change in neighborhood. The applicant implies that the WVDOH will install a road through its development. It also implies that the bike paths that may eventually be installed in its development will likely be extended to Shepherdstown. However, the applicant provides no evidence that this will be done in either case.

The bottom line here is that this neighborhood in the county has not changed. It continues to be Rural. This rezoning would create a spot where one property had a desperate use compared to the remainder of the zone to accommodate the development wishes of one landowner. This is spot zoning and is expressly not allowed by the state zoning code (§8A-7-3(d)).¹⁰

Does Not Align with the Balance of the Comprehensive Plan

The Comprehensive Plan clearly describes that preserving farmland is a priority and that when residential developments are made in rural areas, they should be required to have certain characteristics such as multi-modal accessibility and cluster development style. This encourages connectivity and reduces consumption of farmland into non-farmland uses. This development fails to achieve these goals.

Jefferson County is situated in the great valley and as such it enjoys excellent fertile farmland. It is critical that this natural resource be preserved and appropriately utilized. The three main

¹⁰ §8A-7-3(d) Each zone will be subject to the same rules, regulations, standards and designations throughout the zone, unless specific provisions are made by the governing body in the zoning ordinance.

drivers of our economy rely on the preservation of farmland and the bucolic nature of the County. As the population of our country grows and the need for resiliency in supply chains is realized this fertile land close to large population centers will exponentially increase in value, but only if it is appropriately preserved. The Comprehensive Plan states:

“One of the highest priorities of the Envision Jefferson 2035 Steering Committee and the public was the desire to preserve the rural landscapes, heritage, and lifestyle that attracted many residents to Jefferson County. Comments were received that indicated Jefferson County needs to balance the demands of growth with the protection of agricultural lands. Efforts of the agricultural and artisan communities can create desirable places for tourism to thrive. In these communities, visitors can visit working farms, shop at an artisan studio, and eat at restaurants that are either located on farms or that serve food derived from local enterprises. The form and types of development that takes place in the rural environment should be respectful of the rural culture and historic nature of the community”¹¹

and

“While limited development is possible based on the existing zoning regulations, the intention is not for urban scale development to take place in the Residential Areas and Rural/Agricultural Areas.”¹²

This zoning change would remove farmland in the Rural zone from the possibility of agricultural use and is therefore in direct contradiction with one of the highest priorities of the comprehensive plan.

The residential portion of this proposed Zoning Map Amendment also does not follow the recommendations in the comprehensive plan for residential development in rural zones.

“Between 1974 and 2007, nearly 14,000 acres of land were removed from agricultural production in the County. Approximately 78% of these acres were lands with prime soils or soils of statewide importance. It is important that viable existing farmlands are protected. By encouraging cluster residential development, a large portion of the property will be maintained for farming activities, which would allow Jefferson County’s agricultural and rural character to be maintained.”¹³

And

Rural Land Use Planning Recommendation (Goal2) point 4 “Protect the viability of agricultural lands and wildlife corridors by encouraging the utilization of cluster subdivisions as the preferred form of residential development within rural areas.”¹⁴

¹¹Envision Jefferson 2035 Comprehensive Plan, Page 35

¹² Envision Jefferson 2035 Comprehensive Plan, Page 17

¹³ Envision Jefferson 2035 Comprehensive Plan, Page 34

¹⁴ Envision Jefferson 2035 Comprehensive Plan, Page 39

The residential portion of the proposed Zoning Map Amendment also does not utilize the cluster subdivision model. Instead, it removes *en bloc* the entire parcel from agricultural use and filling the green space with parks and stormwater drainage.

The Comprehensive Plan Urban Level Development Recommendation “Require new urban level development to provide opportunities for multi-modal accessibility and to occur in a manner that enables connectivity to existing street and infrastructure networks or for future connectivity as development is extended to municipalities, UGBs, PGAs, or Villages.”¹⁵ This parcel has the train tracks and the new industrial development Rockwool and its 100 trucks per day between it and the Village of Kearneysville. This parcel has the train tracks, Rockwool and its 100 heavy trucks per day, and the village of Kearneysville between it and the Route 9 interchange. These pose significant barriers to safe travel even by car. This makes access to the bike path difficult and bike access to Kearneysville exceedingly dangerous for all but the most skilled cyclists. These barriers make travel by foot impractical in addition to being dangerous.

The land this proposed Zoning Map Amendment concerns is well outside of the Urban Growth Boundaries and Preferred Growth Areas, and therefore this proposed zoning map amendment does not conform to the Future Land Use Map. The evidence presented by the applicant taken together with the balance of the Comprehensive Plan demonstrates that the 5 criteria that would allow the County Commission to amend the zoning map despite its incongruity with the Future Land Use Map have not and would not be met in the reasonably foreseeable future. Of particular concern is the environmentally sensitive nature of this land. Therefore, this proposed Zoning Map Amendment should be denied.

This Zoning Map Amendment does not conform to the purpose of the Jefferson County Zoning and Land Development Ordinance.

The Jefferson County Zoning and Land Development Ordinance sets forth 11 purposes of the legislation. This Zoning Map Amendment is contrary to eight of these purposes. The purpose of the legislation is clearly to use the Comprehensive Plan to grow the economy while protecting the environment and historic preservation and increasing the livability, and attractiveness of the county and in doing so protect the health, safety and welfare of the people. This Zoning Map Amendment is contrary to the Comprehensive Plan and would adjoin vastly different land uses, decreasing agricultural and economic productivity of adjacent land, degrading historic sites, threatening widely used critical natural resources and the environment, and thereby threatening the health, safety, welfare and quality of life of a majority of residents in Jefferson County.

Article 1: Section: 1.1 of the Jefferson County Zoning and Land Development Ordinance gives the purpose of the ordinance. Purposes A through K are given. The eight applicable purposes are listed below:

¹⁵ Envision Jefferson 2035 Comprehensive Plan, Page 31

- A. Protect and encourage the health, safety, and general welfare of the present and future population of Jefferson County.
- B. Help guide the future growth and development of Jefferson County in accordance with the adopted Comprehensive Plan.
- D. Ensure that growth and development are both economically and environmentally sound.
- E. Encourage the maintenance of an agricultural base in the County at a level sufficient to insure the continued viability of farming.
- F. Encourage and support commercial, industrial, and agricultural activities while maintaining land use, order and compatibility.
- G. Encourage an improved appearance of Jefferson County with relationship to the use and development of land and structures.
- H. Encourage the conservation of natural resources.
- K. Encourage Historic Preservation.

Purpose F, G, and K would be unfulfilled or violated by this zoning Map Amendment. This Zoning Map Amendment would juxtapose industrial, residential and rural uses. This would lead reduced compatibility, order, and livability and more unsightly communities. This area has historic properties and such development would degrade these properties. This is precisely what the zoning is meant to prevent.

Purpose E would be violated by this Zoning Map Amendment. As described in detail above, this Zoning Map Amendment would remove a large continuous parcel that is contiguous with other large parcels of farmland from farmland use.

Purpose B would be violated by this Zoning Map Amendment. As described in detail above this Zoning Map Amendment is in conflict with the Comprehensive Plan.

Finally, Purpose A would be violated by this Zoning Map Amendment. This Zoning Map Amendment will threaten the natural resources of the county and thus will threaten the health, the safety and the welfare of the county residents.

This Zoning Map Amendment is antithetical to eight of the 11 purposes set forth in the zoning ordinance of Jefferson County and for this reason it should not be approved.

This Zoning Map Amendment does not conform to the West Virginia State Code on Zoning and Land Use.

The State Code sets forth seven issues that must be considered when enacting a zoning ordinance. We believe this Zoning Map Amendment contradicts all seven of the considerations.

“Chapter §8A-7-2. Contents of zoning ordinance states:

(a) The following *must* be considered when enacting a zoning ordinance:

- (1) Promoting general public welfare, health, safety, comfort and morals;
- (2) A plan so that adequate light, air, convenience of access and safety from fire, flood and other danger is secured;
- (3) Ensuring attractiveness and convenience is promoted;
- (4) Lessening congestion;
- (5) Preserving historic landmarks, sites, districts and buildings;
- (6) Preserving agricultural land; and
- (7) Promoting the orderly development of land.” (emphasis added)

This Zoning Map Amendment will remove land from agricultural use. It will juxtapose widely divergent uses including industrial, residential, rural, and historically significant lands, thereby reducing attractiveness, the orderly development of land and degrading historic sites and buildings. It will increase congestion in Kearneysville and on Route 480. Finally, and likely most important, this Zoning Map Amendment will endanger natural resources thus threatening the health, safety, and welfare of the residents. This land use in this location is therefore in contradiction to the required considerations of the State Zoning Code and must not be approved.

The §8A-7-3(d) of the West Virginia State Code states that “[e]ach zone will be subject to the same rules, regulations, standards and designations throughout the zone, unless specific provisions are made by the governing body in the zoning ordinance.” This eliminates “spot zoning” in which the use of one parcel of land differs from the surrounding properties in that zone. This is exactly what is occurring here where one parcel is being allowed to have a different use than all the surrounding land which is rural.

Final Arguments of the Applicant

The applicant argues that the Comprehensive Plan is nearly out of date. This on its face is preposterous. The Comprehensive Plan was only adopted by the County Commission in 2015 and is therefore only just over halfway through its tenure as an authoritative document.

The applicant also argues that if the county is unwilling to rezone the land that it could be easily annexed into the municipality of Ranson. Again, the County is sovereign from Ranson and

cannot allow the government of Ranson—elected by less than one five hundredth of the county population—control county zoning decisions.

Conclusion

This owner requested Zoning Map Amendment does not conform to the Comprehensive Plan, and the evidence provided by the applicant when taken together with the balance of the Comprehensive Plan fails to fulfill the five criteria that would allow the County Commission to amend the Zoning Map despite this incongruity. Of particular concern is the potential or negative impacts on natural resources due to the environmental sensitivity of this parcel and this part of the County. Furthermore, this proposed Zoning Map Amendment does conform to the purpose of the Jefferson County Zoning and Land Development Ordinance or the West Virginia State Code on Zoning and Land Use. Therefore, we respectfully ask that you deny this Zoning Map Amendment request.

Best regards,



Dr. Christine Wimer
President
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cc:

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Exhibit A: Environmental Sensitivity of the Subject Land

This parcel, and much of the surrounding land is highly environmentally sensitive. The hydrogeologic characteristics of this portion of Jefferson County make the groundwater aquifer exquisitely sensitive to surface pollutants and therefore ill-suited to industry. If the groundwater is contaminated in this location, tens of thousands of people stand to be affected from Jefferson County to the Chesapeake Bay. This is an unacceptable risk to ask the people and economy of Jefferson County and the region to bear for the profitability of the few. This information is readily available and must be taken into consideration in the rezoning decision.

It has been well defined in the scientific literature that this portion of Jefferson County has karst hydrogeology.¹ A karst landscape is characterized by the presence of sinkholes, springs, caves, ridges and sharp projections in the underlying bedrock, and highly irregular soil-rock interface. The karst landscape is a consequence of the presence of soluble bedrock, which consists of limestone in the case of Jefferson County. The maps in Figure 1 show that the entire area in question is underlain by Conococheague or Stonehenge limestone commonly found in areas of advanced karst. In such landscapes water percolates through the ground and dissolves the underlying rock creating a porous network of caverns and throughways.

Karst aquifers are known to be “extremely vulnerable to pollution,” due to direct connection between the surface and underlying high permeability aquifers.² This particular site is on an upland area with relatively few surface streams, seasonal variability in the water table that results in numerous estavelles, and large amounts of water in the epikarst. This water is easily contaminated because of rapid diffuse infiltration of surface water into the ground water through the porous bedrock and point infiltration through sinkholes. This site has severe ground instability and a high rate of sinkhole formation. The springs at the margins of this upland area are directly affected by the water quality at this site (Exhibit B). In this way pollutants could be carried from the surface at the site into the groundwater affecting water wells and to surface water affecting several surface water streams and the Potomac River.

There are dozens if not hundreds of private wells within a mile of the site. In a dye test, the USGS found that the water from just adjacent to this site emerged in the headwaters of Shaw

¹ Kozar MD, Hobba WA, Macy JA, Geohydrology, water availability, and water quality of Jefferson County, West Virginia with emphasis on the carbonate area, US GEOLOGICAL SURVEY, 1991
Doctor DH, Doctor KZ. Spatial analysis of geologic and hydrologic features relating to sinkhole occurrence in Jefferson County, West Virginia. Carbonates and evaporites. 2012 Jun 1;27(2):143-52.
Doctor DH, Weary DJ, Brezinski DK, Orndorff RC, Spangler LE. Karst of the Mid-Atlantic region in Maryland, West Virginia, and Virginia. Field Guides. 2015 Sep 1;40:425-84.
Doctor DH, Weary DJ, Orndorff RC, Harlow, Jr GE, Kozar MD, Nelms DL. Bedrock structural controls on the occurrence of sinkholes and springs in the northern Great Valley karst, Virginia and West Virginia. In Sinkholes and the engineering and environmental impacts of karst 2008 (pp. 12-22).

² . Gutiérrez F, Parise M, De Waele J, Jourde H. A review on natural and human-induced geohazards and impacts in karst. Earth-Science Reviews. 2014 Nov 1;138:61-88.
Ford D, Williams PD. Karst hydrogeology and geomorphology. John Wiley & Sons; 2013 May 3.
Machiwal D, Jha MK, Singh VP, Mohan C. Assessment and mapping of groundwater vulnerability to pollution: Current status and challenges. Earth-Science Reviews. 2018 Oct 1;185:901-27.

Run, Rocky Marsh Run, Town Run, Elk's Run and Rattlesnake Run (Exhibit B).³ Rocky Marsh Run and Elk's Run are important for municipal water sources, and all of these waters eventually enter the Potomac River which provides water to 6 million people east of Jefferson County.

A study demonstrated that in this area, several factors increased the rate of sinkhole development, including presence of surface water and development. Therefore, the construction, large weighty buildings, drastic changes in ground contour, and centralized stormwater management that is typically required by industry will actually make the karst situation worse, causing karst features to develop and progress more quickly. This was exemplified by the Rockwool construction project, where 22 sinkholes developed thus far during construction. In fact, the Rockwool site has a sinkhole density of more than 140 sinkholes per square mile. The same or worse would be expected in this location as it has a higher sinkhole vulnerability (Exhibit C).

³ Doctor DH, Doctor KZ. Spatial analysis of geologic and hydrologic features relating to sinkhole occurrence in Jefferson County, West Virginia. Carbonates and evaporites. 2012 Jun 1;27(2):143-52.

Exhibit B:

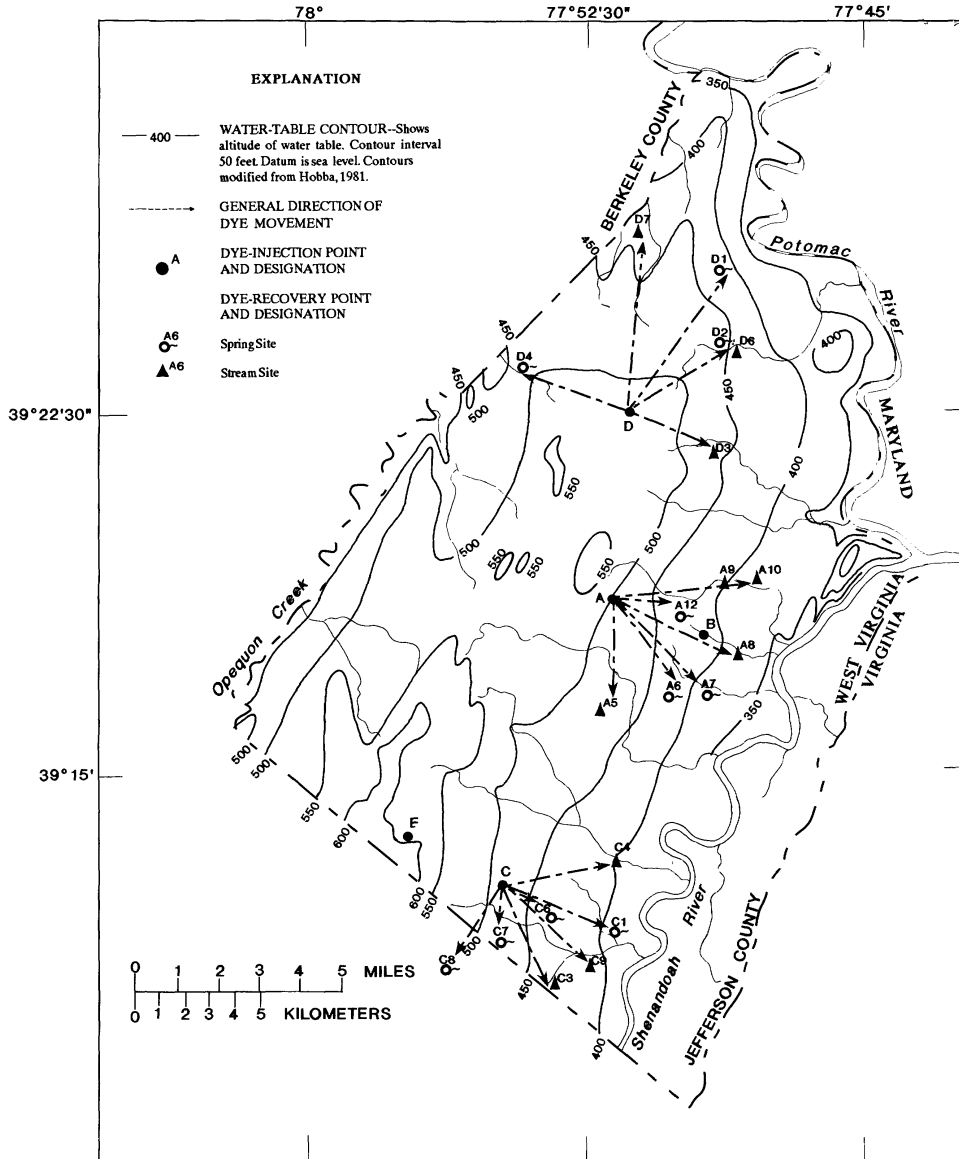


Figure 9.-- Water-table contours, dye-injection points, and generalized direction of dye movement in the ground water in Jefferson County, West Virginia.

Source: Kozar MD, Hobba WA, Macy JA, Geohydrology, water availability, and water quality of Jefferson County, West Virginia with emphasis on the carbonate area, US GEOLOGICAL SURVEY, 1991

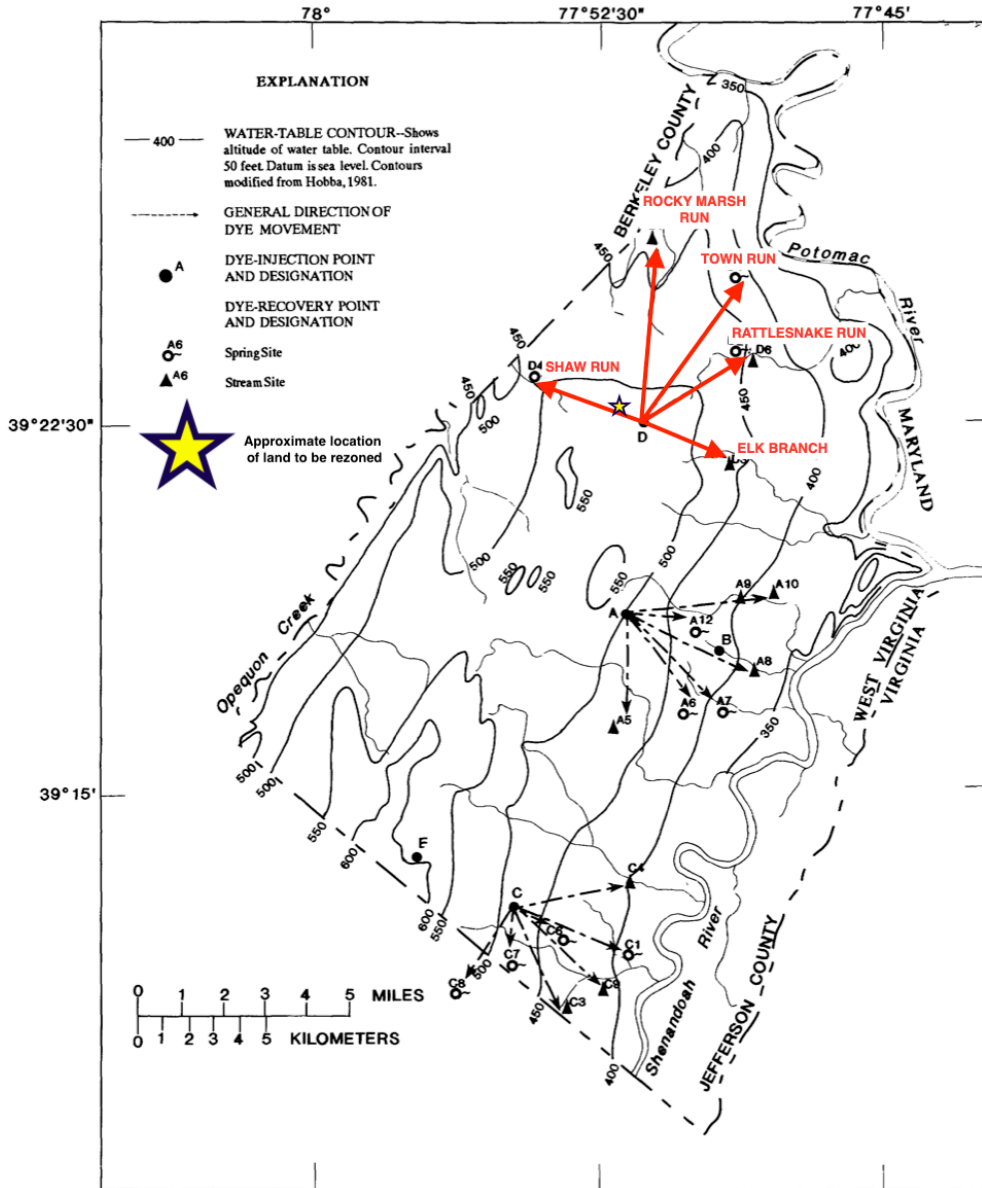
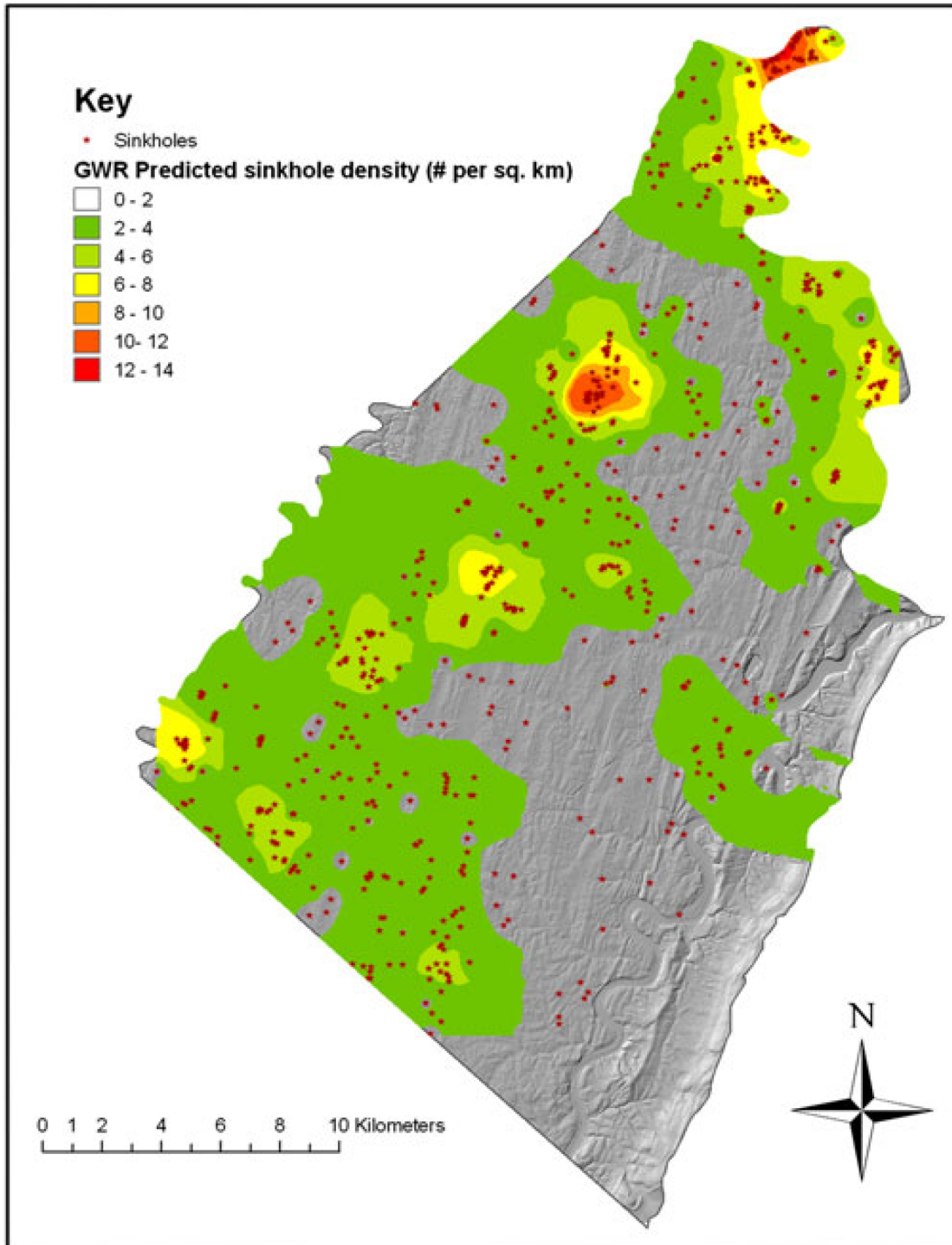


Figure 9.-- Water-table contours, dye-injection points, and generalized direction of dye movement in the ground water in Jefferson County, West Virginia.

Augmented by JCF on May 27, 2021

Kozar MD, Hobba WA, Macy JA, Geohydrology, water availability, and water quality of Jefferson County, West Virginia with emphasis on the carbonate area, US GEOLOGICAL SURVEY, 1991

Exhibit C: Sinkhole Density



Source: Doctor, D.H., Doctor, K.Z. Spatial analysis of geologic and hydrologic features relating to sinkhole occurrence in Jefferson County, West Virginia. Carbonates Evaporites 27, 143–152 (2012).