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***Evaluation of Risk to Brockway Borough Municipal
Authority Surface Water and Groundwater Sources
from
Flatirons Development, LLC Gas Drilling Operations
Jefferson and Elk County, Pennsylvania***

PREPARED BY:

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1.0 INTRODUCTION

1.1 Project Summary

This document provides the findings of Advantage Engineers, LLC (Advantage) evaluation of the potential for adverse impact from gas drilling operations to the water resources of Brockway Borough Municipal Authority (BBMA). The evaluation involved review of Flatirons Development, LLC (Flatirons) Well Pad 6 operations and their potential effects to Rattlesnake Reservoir and Rattlesnake Run. In addition to Pad 6, Flatirons has begun development, and/or proposed additional facilities, in the Rattlesnake Creek watershed and the contiguous Whetstone Branch watershed. The risk evaluation considered all of BBMA's land holdings where they have developed reservoirs and supply wells for potable water production. The attached Figures 1 and 2 show the approximate extent of BBMA's land holdings, and Flatirons existing and proposed facilities on USGS topographic mapping and recent aerial photography.

1.2 Documents Reviewed

The following documents were reviewed as part of this evaluation:

- *Draft*, Brockway Borough Municipal Authority, Well #5 Protection Plan, Flatirons Development, LLC, March 8, 2011, Rev. March 21, 2011.
- Responses to Advantage Engineers Review of Plan, August 2, 2011.
- Field Preparedness, Prevention, & Contingency Plan (PPC), Flatirons Development, LLC, 10-6-2011 (Revision Date).
- Erosion and Sedimentation General Permit (ESCGP-1) Application for the Flatirons Development, LLC, Dannie ESCGP-1 #4 Project, Horton Township, Elk County and Snyder Township, Jefferson County, Pennsylvania, October 2010, W.J. Young & Associates.
- Erosion, Sediment and Stormwater Control Plan for Oil and Gas Operations, Dannie ESCGP-1 #3A, Snyder and Horton Townships, Jefferson and Elk Counties, for Flatirons Development, LLC, prepared by Botsford Surveying, Inc. Marion Center, PA.
- Post Construction Stormwater and Site Restoration Plan for: Dannie ESCGP-1 #3A, Snyder, Horton Township, Jefferson, Elk County, Pennsylvania, July 2010, prepared by Botsford Surveying, Marion Center, PA.
- Material Safety Data Sheets for: CI-100 Acid Corrosion Inhibitor, CS 500 SI (scale inhibitor), FE-100L Iron Chelator, Shale Surf 1000, NE 100, ICI-3240 (biocide), Dupont Oust® XP Herbicide, Monsanto Roundup Pro® Herbicide, Genesis Xtra Drench (antiparasitic for sheep), CI 150 (acid corrosion inhibitor), B317 (scale inhibitor), HO15 (hydrochloric acid 15%), HO36 (hydrochloric acid 36%), J609 (friction reducer), L058 (iron stabilizer), and Diesel Fuel – High Sulfur.

1.3 Project Area Hydrologic Setting and Description

BBMA owns over 2,000 acres of environmentally-sensitive and unique land area in Elk and Jefferson Counties. Dating to the 1930's, these lands have been relied on to produce and store all potable water for the BBMA water system. The water supply sources found on BBMA lands include the following:

- Rattlesnake Reservoir
- Groundwater supply Well 5 located in the Rattlesnake Creek watershed
- Whetstone Branch Reservoirs Nos. 1 and 2
- Groundwater supply Wells 1 and 2 located in the Whetstone Branch watershed.

Given the heavily forested, undeveloped, and "pristine" condition of BBMA's lands, the water quality from the reservoirs and wells is exceedingly high, and requires minimal treatment prior to potable use.

The water sourced from these lands includes surface water from the streams that is stored in the reservoirs, spring water that discharges to the reservoirs and streams, and groundwater supply wells. The water from the streams and springs is sufficient to meet BBMA's average day demand of nearly 1,000,000 gallons per day (gpd) for most of the year. During the drier summer periods the artesian flow from wells 1, 2, and 5 are needed to supplement the supply.

The baseflow to the streams within the BBMA property is supplied from groundwater and spring flow which originates as infiltrating precipitation to the nearby lands. Some of this precipitation water infiltrates to shallow depths through only the soil mantle and discharges to springs and streams within hours to days. Water that drains further downward and into the bedrock aquifer will have a longer residence time in the subsurface prior to discharging to springs and the streams. Because of this interconnection between the springs and streams, and the nearby lands, both the Whetstone Branch and Rattlesnake Creek are susceptible to even small releases of contaminants from nearby areas, including sediment releases from construction. Some of the baseflow to the streams is also anticipated to originate from precipitation water that recharges the more distant uplands to the east at Boone Mountain.

Regarding Rattlesnake Creek and Whetstone Branch, Pennsylvania Department of Environmental Protection (PADEP) has classified the designated use for both streams as Cold Water Fishery (CWF). This classification refers to protected uses, and is the basis for development of water quality criteria for purposes such as determining appropriate land use in the watershed, and determining acceptable stream impact from proposed development. PA Code Title 25, Chapter 93 defines this classification as follows:

CWF - Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.

These streams are further protected by PADEP as High Quality, Cold Water Fishery (HQ-CWF,) from their headwaters to the Rattlesnake reservoir dam, and Whetstone Dam No. 1, respectively. This classification is special recognition of excellent water quality and habitat conditions that meet the following criteria (as excerpted from Chapter 93 regulations):

(a) Qualifying as a High Quality Water.

A surface water that meets one or more of the following conditions is a High Quality Water.

(1) Chemistry.

(i) The water has long-term water quality, based on at least 1 year of data which exceeds levels necessary to support the propagation of fish, shellfish and wildlife and recreation in and on the water by being better than the water quality criteria in § 93.7, Table 3 (relating to specific water quality criteria) or otherwise authorized by § 93.8a(b) (relating to toxic substances), at least 99% of the time for the following parameters:

<i>dissolved oxygen</i>	<i>aluminum</i>
<i>iron</i>	<i>dissolved nickel</i>
<i>dissolved copper</i>	<i>dissolved cadmium</i>
<i>temperature</i>	<i>pH</i>
<i>dissolved arsenic</i>	<i>ammonia nitrogen</i>
<i>dissolved lead</i>	<i>dissolved zinc</i>

(ii) The Department may consider additional chemical and toxicity information, which characterizes or indicates the quality of a water, in making its determination.

(2) Biology. One or more of the following shall exist:

(i) Biological assessment qualifier.

(A) The surface water supports a high quality aquatic community based upon information gathered using peer-reviewed biological assessment procedures that consider physical habitat, benthic macroinvertebrates or fishes based on Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish, Plafkin, et al., (EPA/444/4-89-001), as updated and amended. The surface water is compared to a reference stream or watershed, and an integrated benthic macroinvertebrate score of at least 83% shall be attained by the referenced stream or watershed.

(B) The surface water supports a high quality aquatic community based upon information gathered using other widely accepted and published peer-reviewed biological assessment procedures that the Department may approve to determine the condition of the aquatic community of a surface water.

(C) The Department may consider additional biological information which characterizes or indicates the quality of a water in making its determination.

It is also noteworthy that prior to Flatirons gas drilling operations, BBMA's lands were heavily forested land with no development except for BBMA's water system facilities. BBMA operates two (2) sand filtration plants to filter surface water from the reservoirs, but these operations do not involve the use of any large volumes of hazardous chemicals or ongoing land disturbance.

In summary, the streams located on BBMA lands are closely connected and vulnerable to the land uses of the nearby areas. These lands until recently were heavily forested with no development, except for BBMA's water sources and associated facilities. The streams provide all water used by BBMA, except for some groundwater from their wells that augment supplies during dry weather periods. These streams have been

classified as CWF and HQ-CWF in recognition of their excellent water quality and habitat conditions, which make these streams uniquely sensitive to disturbance and contaminants. Impacts to streams of this quality are normally irreparable.

2.0 EVALUATION OF FLATIRONS OPERATIONS

2.1 Pad 6

Flatirons constructed drilling Pad 6 in 2010 and has drilled one well to date. During drilling of the top hole for gas well DU-3-6-1H the artesian flow at BBMA's well 5 ceased and later returned. Based on these operations the gas well top hole is clearly in hydraulic communication with the fresh water bedrock aquifer, including well 5. The extent of this connection has not been determined by Flatirons. Following this event Flatirons prepared a Well 5 Protection Plan, but this plan did not adequately investigate the nature and extent of the fresh water bedrock aquifer in the area of Pad 6 and well 5. This condition is further discussed in Section 3.2 of this report.

The gas well was subsequently completed, and fracking was performed in November 2011. A pipeline is proposed to transfer gas from Pad 6 to an existing compressor station located about 3,000 feet to the east. Pad 6 lies directly north and within 1,000 feet of BBMA's Rattlesnake Reservoir. Surface water run-off from Pad 6 flows to a wetland area near BBMA's treatment building, and is subsequently conveyed to a location below the Rattlesnake Reservoir dam. The run-off from the proposed pipeline would intersect the reservoir and upstream areas of Rattlesnake Creek.

2.2 Possible Sources of Contamination at Pad 6 and Associated Operations

The following are recognized as sources/events that present a risk to the surface and subsurface/fresh water aquifer in the BBMA watershed.

Gas Well Drilling and Construction

Advancement of the borehole creates a potential connection (i.e., pathway) between the fresh water aquifer, and the lower intervals that contain saline/formation water and other objectionable water quality issues. **A clear hydrogeologic connection has already been established between Pad 6 and Well 5, and therefore any breach in the casing or grout seal places Well 5 and/or Rattlesnake Reservoir at risk.** In addition to a casing/grout seal breach, the presence of vertical fracturing intersected by the gas well may also serve as a possible pathway for saline water/fracking fluids to migrate into fresh water zones.

In addition to saline water, hydraulic fracturing (fracking) fluids, a.k.a. slickwater, include additional contaminants with various human health risks (ingestion, dermal contact, and inhalation) and ecological toxicity. Return water includes not only the slickwater chemicals added to facilitate stimulation of gas-producing zones, but also formation water which typically is very saline with very high dissolved solids (known to exceed 30% by weight), and elevated naturally occurring radioactive materials (NORM). A casing and/or grout breach could

enable fluids under pressure to leak directly into the fresh water bedrock aquifer, and/or the unconsolidated overburden. Such a breach might also result in leakage to the surface either directly or via subsurface. Given the interconnected nature of the groundwater system and surface water, both sources would be at risk of contamination. Depending on the volume of the release, the receiving surface and/or groundwater may be rendered unfit for potable use.

Drill cuttings are produced during drilling. When in contact with water these materials may produce run-off water with the same constituents as formation water, i.e., salinity and NORM.

There may be air born migration of unwanted chemicals from the pad site due to wind. These chemicals could be in the form of dust, vapors, or mists. Downwind transport and subsequent deposition directly into a water way, or onto the ground surface for later transport in run-off water, may adversely affect water quality and/or flora and fauna.

Hazardous/Toxic Fluids Handling

The large volume of aqueous-based fluids with hazardous/toxic chemical constituents represents a significant risk to surface waters and shallow groundwater. It can be expected that one (1) million gallons or more of brine water and fracking water will be stored, transferred, pumped, and transported during the course of operations. At these points of contact there is risk for spillage of relatively small volumes which is not of special concern; however, some operations involve risk of a large volume release, such as pressurized hose/pipe failure, sudden tank rupture, hidden leak that occurs over time, and transport tanker accident. Because fluid transfer to and from Pad 6 is performed with transport tankers, it is expected that there will be many hundreds, if not one (1) thousand or more individual trips. These trips generally occur over unpaved roadways constructed in mostly steep terrain, where a vehicle accident could result in rollover and sudden tank breach and subsequent release of 5,000 or more gallons of aqueous waste. Due to the steepness of the area, such a release could reach surface water as run-off, and with infiltration to shallow groundwater interflow water. Such a release could potentially result in a chronic source of contamination to surface and groundwater, since even very low concentrations of some of the known constituents in the fluids are known to be a risk to human health and the environment.

Liquid transport tanker routes are assumed to proceed further west of Pad 6 to the compressor station. Areas west of Pad 6 lie upgradient of the Rattlesnake Reservoir dam, and thus within the HQ-CWF designated use section of Rattlesnake Creek. As such, this area is considered especially sensitive to a large release of aqueous waste.

3.0 RISK EVALUATION AT PAD 6

3.1 Water Quality Impacts

It is our opinion that the identified exposure pathways described above require 1) increased safeguards by Flatirons, and 2) further effort to characterize the potential for a completed pathway to determine whether additional safeguards are needed. The following should be addressed:

- Tanker transport represents a significant risk for a large hazardous materials spill given the anticipated large number of tanker trips that will occur. There does not appear to be sufficient attention to planning for such an event, especially with regards to prevention. There must be plans in place to address operations (or cessation thereof) during inclement weather, as well as regular road inspections to ensure that road surfaces are stable. Some locations may require a barrier or fencing to preclude a tanker from leaving the road or rolling. Overall, there must be a specific response plan in place to address the potential release scenarios, which includes personnel-specific training.
- A subsurface release of fluids from the gas well, or possibly directly from the lower borehole interval via existing vertical fracturing, has the potential to serve as a long-term but possibly undiscovered contaminant source. The water resources of BBMA remain at risk until sufficient information is provided to document that these pathways are not complete, that such migration would not reasonably occur, or that a system is in place that would quickly detect such a release to allow time to prevent significant impact. A monitoring program is necessary to enable early detection of this condition.

The Field Preparedness, Prevention, & Contingency Plan (PPCP) prepared by Flatirons should be modified and expanded to address the issues described above.

3.2 Groundwater Impacts

As previously stated, the hydrogeologic conditions that resulted in the loss of artesian flow at well 5 during top hole drilling at Pad 6 were not fully characterized. Supplemental information to the Well 5 Protection Plan was provided by Flatirons as requested; however, no conclusions or assessment of the interconnectivity between the Flatiron and #5 wells were provided. There are also questions regarding the volume of groundwater removed during top hole drilling, grouting of the top hole, and the pre- and post drilling Well 5 water quality analyses based on review of the Protection Plan.

It is understood that an aquifer test and analysis will be conducted for Well #5. This test will provide additional data, provided that groundwater is monitored at the Flatiron pad site. The aquifer testing plan should be submitted to BBMA prior to testing for their review.

The following are specific items that should be addressed as part of the aquifer testing and as follow-up investigation to the Protection Plan:

1. Clearly define the interconnectivity between the Flatirons gas well top hole and Well #5, including but not limited to:
 - a. Horizontal hydraulic gradient between Well # 5 and Flatiron top-hole well
 - b. Specific dip angle and attitude in top hole well
 - c. Vertical hydraulic gradient between Well #5 and Flatiron top-hole well
 - d. Groundwater contour map based on site specific and area static water levels
2. Either the rate of discharge or total volume removed from top-hole during drilling activities should be provided. The information provided is in inches of water stream, which does not allow calculation of the total water volume or flow rates.
3. A distance drawdown analysis between Well #5 and the Flatiron top-hole well is recommended in order to define the magnitude of interconnectivity. It is understood that the proposed aquifer pumping test would provide this information. This data would also aid in determining the potential zone of influence for similar activity in other nearby areas.
4. The pre- and post-drilling Well 5 water quality parameters were not consistent and therefore a direct comparison could not be made for all parameters. Of concern was the turbidity increase from 0.27 nephelometric turbidity units (NTU) before the top hole was drilled, to 1.39 NTU afterwards.
5. It was noted that a 50% excess cement volume was used when the 11 3/4 inch surface casing was grouted, and that no return flow was observed. The impact of injecting grout within the formation should be reviewed, especially within the fresh water aquifer, to ensure that potential water bearing zones are not grouted shut and that area groundwater flow is not adversely impacted. Additionally, an alternative method should be employed during grouting of the top-hole to minimize the introduction of grout into the formation.
6. Cross sections were provided for review; however, no cross section from the Flatiron pad site to Well 5 was included. This cross section, with groundwater gradients and structural features, would help conceptualize the subsurface model being developed.

The information from the above work should be evaluated prior to expansion of gas drilling activities that are in proximity to BBMA supply wells.

4.0 RISK EVALUATION AT OTHER FLATIRON OPERATIONS

Flatirons has proposed other drilling pads, roads, a freshwater impoundment, and pipelines within the Rattlesnake Creek and Whetstone Branch watersheds. As previously stated, the additional facilities proposed for Rattlesnake Creek watershed are within the drainage area designated as HQ-CWF, which requires an additional level of evaluation for risk to water quality, and may require some additional level of permitting beyond a general permit. For the most part, all of the possible contaminants and exposure pathways described for Pad 6 are also applicable to the other operations and should be addressed.

The proposed operations at other locations may also pose additional risk to BBMA wells 1 and 2, depending on proximity. Insufficient investigation has been performed to adequately understand the bedrock aquifer hydraulics.

5.0 COMMENTS REGARDING FLATIRONS PLANS AND PERMIT APPLICATIONS

Comments regarding the erosion and sedimentation control, stormwater control, and post construction stormwater and site restoration plans and general permit applications are provided below:

Pad 6 Erosion, Sediment & Stormwater Control Plan

1. There should be additional plans with details of all the proposed E&S controls.
2. There are cross culverts shown on the construction entrance but no information provided for riprap at the discharges (stone size, pad dimensions, etc.).
3. There should be silt fence/ silt soxx on the down slope side of the topsoil stockpiles.
4. The Erosion, Sediment and Stormwater Control Plan for Oil and Gas Operations in section 5.c. and d. states there is no increase in runoff, but there is a change in cover condition. There is no discussion/demonstration in defense of the statement that the pre- and post-development runoff volume is equal.
5. The E&S Report does not contain any site specific information regarding the BMP's that are proposed. These should be completed by the plan designer and should not be left for a contractor to select and design at the time of construction.
6. Minimal information is provided for the infiltration trench, e.g., whether it is to be lined with geotextile fabric, how much cover, etc.
7. Overall limits of disturbance should be shown to delineate areas of disturbance.
8. Further information should be provided regarding how sediment is prevented from entering the infiltration trenches.
9. Further information should be provided regarding the permanency of infiltration trenches, and these should be shown on the restoration plan.
10. No construction sequence is provided.
11. The application states 14.8 acres of disturbance. The amount of disturbance required on the plans shown appears significantly less. The proposed areas to be disturbed should be clearly shown.

These questions and comments should be addressed in order to adequately describe the proposed development(s), and ensure that impacts from erosion and sedimentation are minimized, and appropriately managed for this CWF and HQ-CWF setting.

Other Locations

- Rattlesnake Creek upstream from the dam is designated HQ-CWF, so this includes the entire reservoir area. This water body is also classified by PFBC as a naturally reproducing trout stream. These classifications must be accounted for in any plan/permit application for facilities within this portion of the watershed. This may necessitate in some instances the requirement to obtain individual instead of general permits, and also meet antidegradation standards.

6.0 SUMMARY OF FINDINGS

Based on the excellent water quality and habitat conditions, and location(s) of recharge area, the Rattlesnake Creek and Whetstone Branch watersheds are especially vulnerable to degradation from development activities that have potential to introduce contaminants to the ground surface and fresh water bedrock aquifer. The drilling at Pads 5 and 6, and associated activities at other locations within these watersheds **clearly** have the potential to adversely impact the sensitive surface water and groundwater supplies relied on by BBMA to serve their water system. Prior to further gas well drilling and development activities it is recommended that the following be completed:

1. The Preparedness, Prevention, & Contingency Plan prepared by Flatirons should be modified to address all aspects of hazardous fluid storage, and tanker transport of fluids, inclement weather operations, road inspections, and the need for roadside barriers to prevent a tanker roll and/or sudden tanker breach.
2. Flatirons should provide sufficient information to document that a subsurface release of fluids from a gas well will not affect the fresh water aquifer and/or surface water in the area. A monitoring program is necessary to enable early detection of this condition.
3. Aquifer testing should be completed at Pad 6 in order to adequately characterize the interconnection between the gas well top hole and BBMA well 5. The use of excess grout and the groundwater turbidity increase should be investigated
4. All plans and permits should be modified to address the operations proposed for the HQ-CWF designated areas of Rattlesnake Creek and Whetstone Branch.
5. The Pad 6 E&S and Stormwater plans require clarification and/or additional information in order to adequately describe the proposed development(s), and ensure that impacts from erosion and sedimentation are minimized, and appropriately managed for this CWF and HQ-CWF setting.

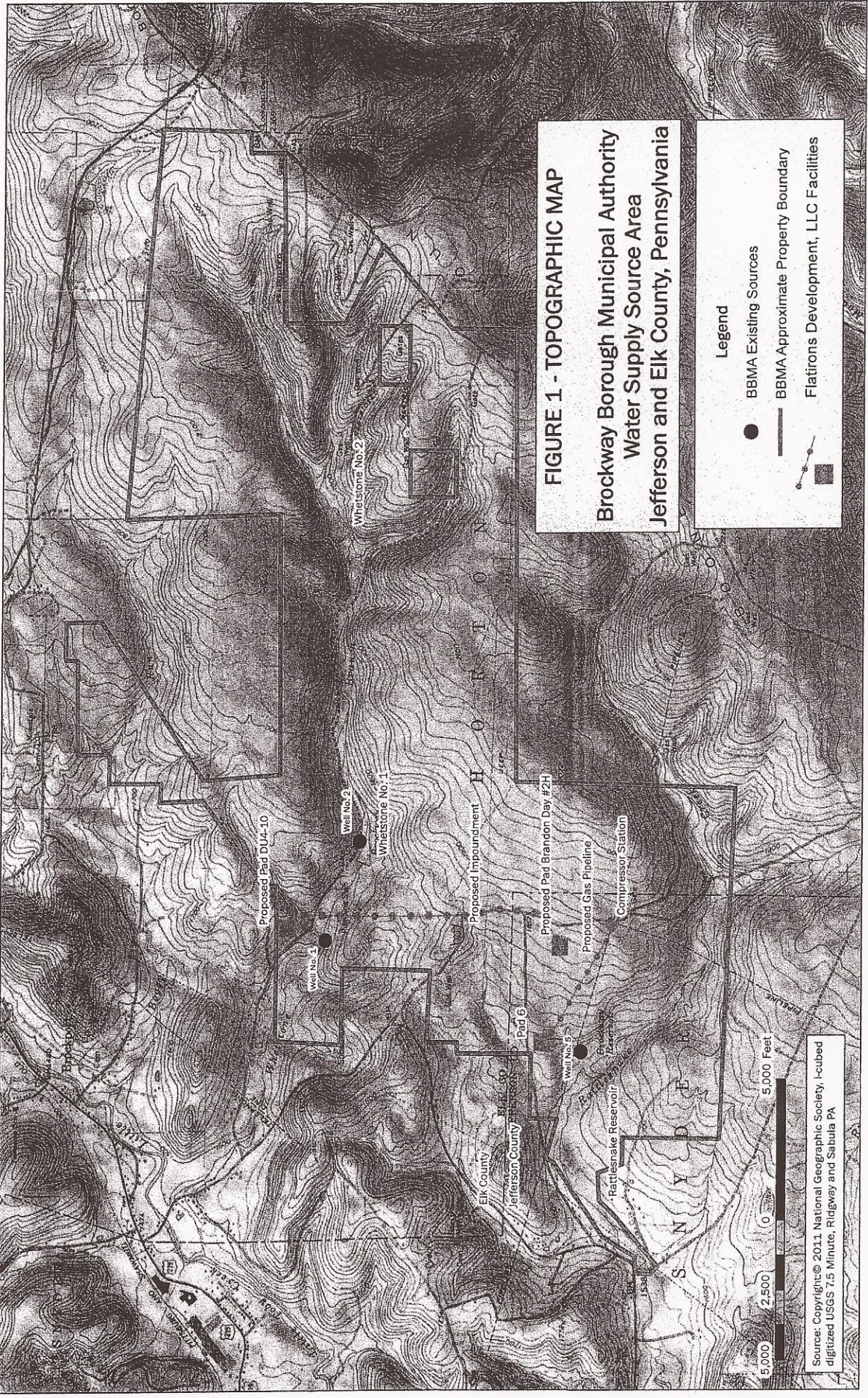


FIGURE 1 - TOPOGRAPHIC MAP
Brockway Borough Municipal Authority
Water Supply Source Area
Jefferson and Elk County, Pennsylvania

Legend

- BBMA Existing Sources
- BBMA Approximate Property Boundary
- ▭ Flatirons Development, LLC Facilities



Source: Copyright © 2011 National Geographic Society, Inc.ubed
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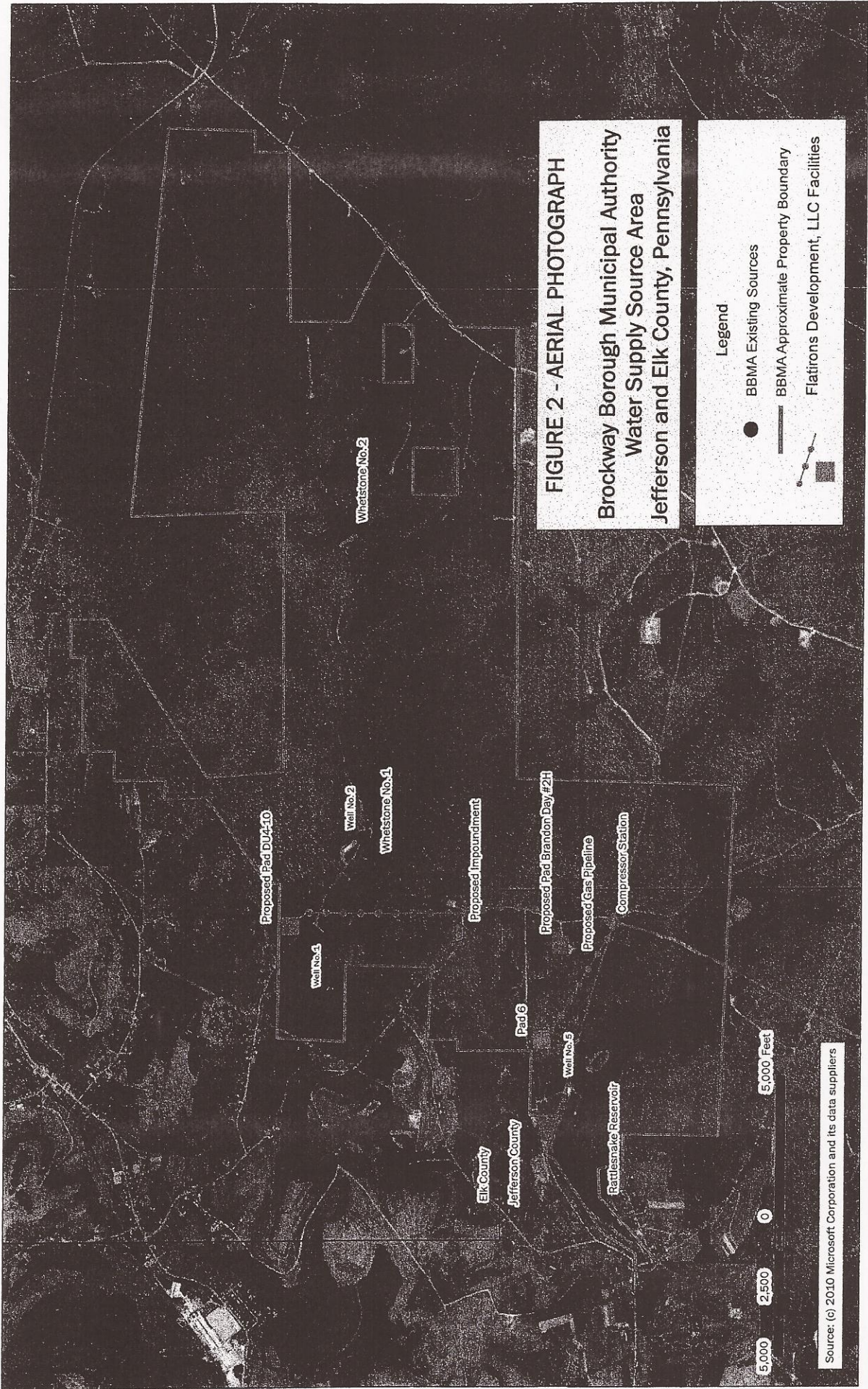


FIGURE 2 - AERIAL PHOTOGRAPH
Brockway Borough Municipal Authority
Water Supply Source Area
Jefferson and Elk County, Pennsylvania

Legend

- BBMA Existing Sources
- ▭ BBMA Approximate Property Boundary
- ▬ Flairons Development, LLC Facilities

5,000 2,500 0 5,000 Feet

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