Stewardship of West Virginia NHD, 2011-2012

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Introduction

This report presents results for West Virginia's current NHD project, "A Policy for Maintaining the NHD in West Virginia's Areas of High Change." As the name suggests, the over-arching goal of the project is to develop a policy and methodology for maintaining West Virginia's high resolution NHD dataset in areas of high change related to urban development, resource extraction, road construction or other factors. The specific goals of the project, as outlined in the statement of work, are as follows:

- Compile existing datasets of surface mining features and extant stream networks.
- Continue the development of datasets of surface mining features over those areas of the southern coalfields where data is incomplete or unavailable.
- Utilize surface mining datasets to catalog high resolution NHD features that have been impacted by surface mining.
- Begin editing those features (geometry, primarily) to more accurately reflect their current state, post-mining.
- Develop a phased work plan to pre-stage data relevant to editing the high resolution NHD in areas where surface change is most likely to occur in the future, such as known mining permit areas or planned highways.

Additionally, we have found the following four goals are important enough to be added to that list:

- Review datasets of surface mine features and determine which are useful for identifying effected streams
- Review data capture methods in mined areas
- Compile best practices and recommendations for editing the NHD – ie, case #1 – remove stream, case #2 – replace stream with digitized valley fill drainage structure, etc.
- Review the issue of man-made feature "permanence" on surface mines with experts

Results

In this section, we review goals presented in the introductory section and describe progress so far and plans to complete.

<u>Identification of Surface Mining Features</u>

In this section, we review:

- Compile existing datasets of surface mining features and extant stream networks.

- Review datasets of surface mine features and determine which are useful for identifying effected streams

To date, we have received and reviewed five datasets that depict surface mining areas in West Virginia. These datasets were created for various purposes and exhibit varying degrees of accuracy. In order to quickly gauge the usefulness (or lack thereof) of each dataset for our purposes, we conducted a simple test. First we performed a select by location and found all of the HR NHD streams that intersected each dataset. We then took a random selection of 10% of these features and reviewed them one at a time to determine whether or not the feature required editing. This exercise provided us with a quick look at the relative quality of datasets. The results of that effort can be seen below, in Table 1.

Intersecting Feature	Intersected Features	Test Features	Features Requiring Edits	Percentage
Valley Fills (2009)	1626	163	115	70.73%
Refuse Structures (2009)	439	44	35	79.73%
Permit Boundaries (released or phase rel only)	3704	370	131	35.37%
Skytruth MTR Areas	3194	319	213	66.69%
Fill Analysis Data (WVDEP, Shank 2009)	1787	179	165	92.33%

Table 1. Results of random selection review of intersecting features.

This exercise was important as it shattered some preconceived notions about the relative qualities of datasets. Unfortunately, there is still a great deal of work to be done on this subject. These datasets solely address surface mining which is, of course, a major contributor to change to surface water features in West Virginia, but hardly the sole contributor. We continue to actively seek out datasets to refine the tracking and identification portion of this project.

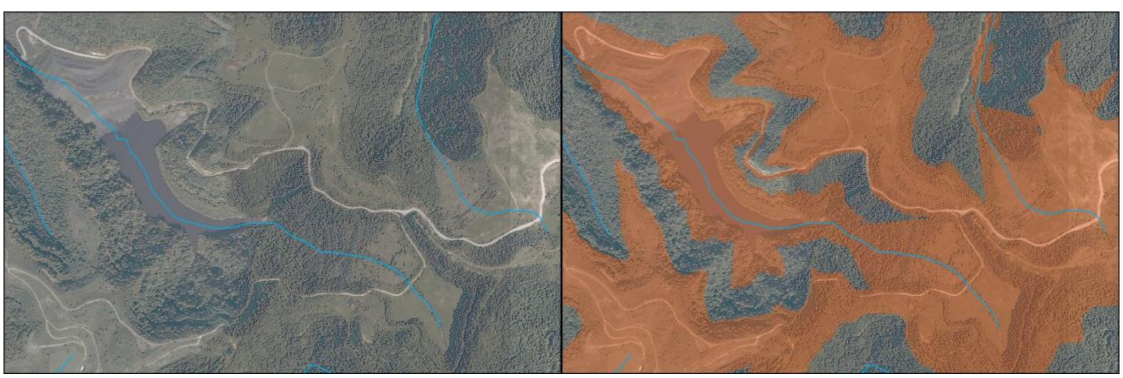

Figure 1. Stream reach affected by mining; in this case, the permit boundary data (orange, right) effectively identifies the damaged reach. The WVDEP fill analysis data (not pictured) also identifies the reach.

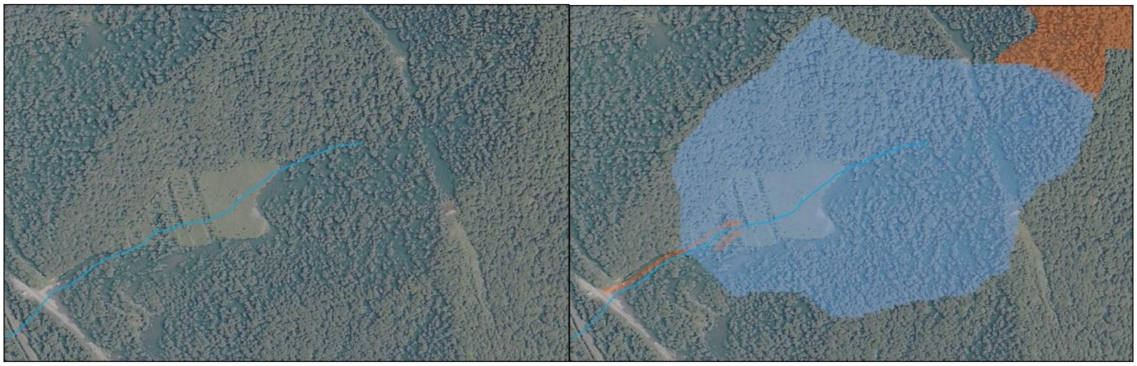

Figure 2. Stream reach affected by mining; in this case, the WVDEP fill analysis data (blue) captures the damaged reach, but the permit boundary data (orange) does not.

Figures 1 and 2 illustrate reaches that needed to be identified and edited due to impacts from surface mining. The main take-away point from these figures is to note that the WVDEP fill analysis data captures impacts that permit boundary data does not. While an exhaustive analysis (and verification data) would be required to account for both errors of commission as well as omission, it appears to be generally true that the WVDEP fill analysis data exhibits a very low degree of errors of commission. Errors of omission when utilizing that dataset appear to be related to the temporal limits of the analysis and to the fact that not all mining includes fills. The same cannot be said for the WVDEP permit data, which exhibits high degrees of errors of both types.

"Trends in Mining Fills and Associated Stream Loss in West Virginia 1984-2009 (Shank 2010)" found that 844 miles of streams have been directly impacted by mining fills in West Virginia. This work dealt with a large amount of space, time and impacts, but was still limited enough in scope that we fully expect that number to exceed 1,000 by the time our analysis and cataloging effort is complete.

There are datasets now included in this analysis that are highly accurate and will be very useful for our project. Those datasets, however, are limited to a very short time period (2003-2009) and cover a relatively small area (Three southern West Virginia HUCs).

<u>Identification of Stream Networks In Mined Areas</u>

In this section, we review:

- Review data capture methods in mined areas
- Compile best practices and recommendations for editing the NHD – ie, case #1 – remove stream, case #2 – replace stream with digitized valley fill drainage structure, etc.
- Review the issue of man-made feature "permanence" on surface mines with experts
- Utilize surface mining datasets to catalog high resolution NHD features that have been impacted by surface mining.

At the heart of this work is the goal of editing the NHD and provide corrected geometry in areas where surface change has rendered the HR-NHD obsolete. Once areas in need of editing are positively identified, we are faced with a dilemma: do we simply remove the stream line and move on, or do we endeavor to replace that line with data representing new, man-made drainage structures? This depended somewhat on data availability, so we'll discuss that first.

We engaged in a review of data capture methods in areas that require editing. The goal was to determine, with available photography and elevation data, how feasible it is to capture data in coal mine areas of man-made drainage features. Additionally, we hoped to answer some simple questions: what features are visible post-mining? How long after mining are these features visible? Other than digitizing, what data capture methods are available to us; is automated feature extraction from elevation data reasonable? How time consuming will these processes be?

Automated feature extraction is a hot topic these days, so we gave a cursory look at the possibilities of using hot-off-the-presses LiDAR data (collected under contract by WVU for the WVDEP) to retrieve new surface drainage features. This particular LiDAR data acquisition did not include simultaneous collection of detailed aerial photography. Raw LiDAR datasets were subsequently processed to create 1m cell size Digital Elevation Models for the region. Standard hydrological analyses were conducted within ArcGIS (sinks filled, flow accumulation, flow direction, etc.) to determine if LiDAR-produced DEMs would provide additional insight into altered stream drainage patterns in mining affected watersheds. After systematic examination of several test quadrangles, it was determined that the amount of drainage detail produced using these methods was actually far too high to accurately map streams and stream alterations without comparison with detailed aerial photography or actual site visits. This left us with photo interpretation.

Rather than stage an additional layer of work dedicated to determining what drainage features were visible on a mine in aerial photography, we conducted an informal census while undertaking visual analysis to tag stream features as "changed." We discovered that, broadly speaking, post-mining drainage patterns are random, confusing and temporary (with one exception, see below). The following figures will walk through a typical example.

Figure 3. Mined area with effected streams marked (red)

The effected streams in Figure 3 (marked in red; identified in the process described later in this document) all require editing due to mining activity. The question at hand is simple: how, if at all, have these features been "replaced?"

Figure 4. Disappearing 2-d feature

Identifying 2-d features on surface mines is relatively simple. Drainage ponds tend to be fairly sizeable and numerous. Drainage ponds, however, pose a problem: permanence. As you can see in Figure 4, over the course of 8 years, the drainage pond in this example disappears. This example exemplifies a fairly standard problem in mapping drainage patterns in coal mining areas. To some extent, all surface drainage demonstrates a high level of impermanence, but these areas are especially unpredictable. Experience has taught us that these landscapes are subject to accelerated natural reclamation and, in some cases, frequent follow-on disturbance as the land is allocated into some other use by a mining company or new owner.

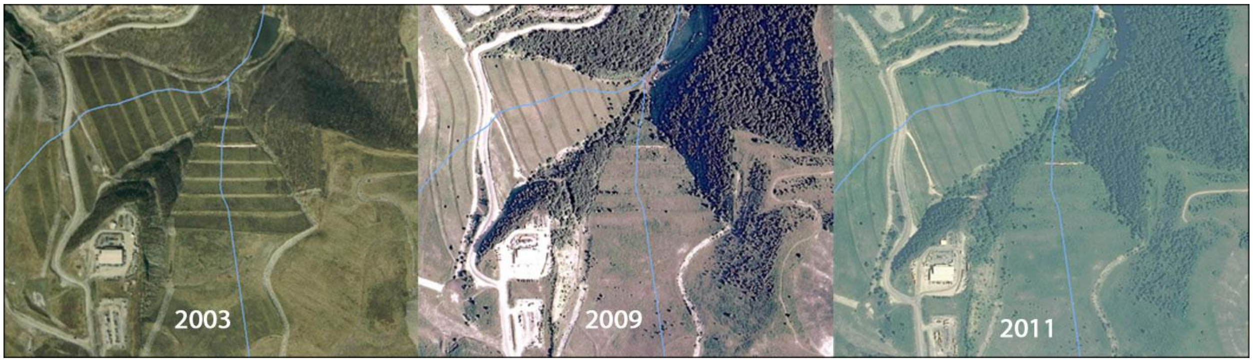

Figure 5. Gravel rip-raps on valley fills.

Some features, however, have a more permanent fixture on the landscape post-mining. The most apparent (and, because of high visibility, the most easily collectible) features on reclaimed surface mines are large gravel ditches. These ditches are always present to some degree on and/or around a valley fill. At the base of the valley fill(s), and at the terminus of the ditches, one can almost always find a drainage pond which then feeds into the remaining portion of the original stream. Figure 5 depicts two valley fills. The gravel rip raps lie on the outer edges of the fills and extend a short distance into the reclaimed surface mine. These features clearly serve a drainage function and because of that, we will endeavor to collect these features and replace HR NHD in those areas with these features. Figure 6 represents a crude representation of these features (red).

Figure 6. Gravel rip-rap and drainage pond detail.

The one concern with this plan is that the lion's share of imagery available to us in this effort is leaf on. Figure 5 shows the same area over 3 timestamps. The rip raps are only clearly visible in the 2003 image – which happens to be very recently after the fills were constructed. It remains to be seen how viable it is to collect these features in a uniform manner, especially given the lack of availability of leaf-off photography pre-2003.

Through this work, we compiled a dataset of altered and destroyed NHD streams in WV. We utilized two datasets for the work – the database of fills compiled by Michael Shank of the WVDEP (Shank 2010), and a dataset of visible mining collected by the Natural Resource Analysis Center for three areas in Southern West Virginia – the Coal and Upper Guyandotte hydrologic units and Mingo County. We first utilized basic geoprocessing to identify potentially effected features (select by location). We then cycled through and checked each feature against all available aerial photography to determine if the feature had been affected by mining and, if so, to what extent. We also added adjacent features not originally included in the select by location operation in cases where they were visible. A total of 1,979 High Resolution NHD features with a length of 805 miles were identified as part of this process (Figure 7).

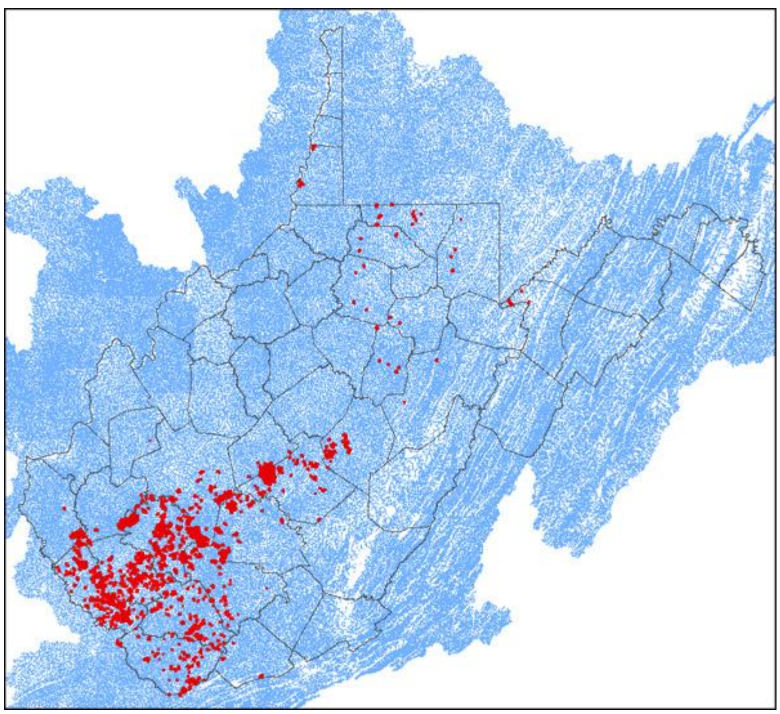

Figure 7. General view of streams identified as effected by or missing due to mining.

The last major hurdle pre-edit is to determine the best course of action for what to do with data for streams (and ponds) that no longer exist. The most basic inquiry is whether to replace deleted features. Based on work to date and conversations with various experts, the most likely scenario in most cases is that the effected stream will be dropped from the HR-NHD and not be replaced with any new feature. The difficulty of collecting new hydrographic features en masse, across multiple years of photography, is simply too much to overcome within the confines of available resources. We will endeavor to collect rock rip-rap features and associated drainage ponds wherever possible in order to preserve some semblance of the manufactured drainage pattern, but ponds and ditches that lie on other portions of surface mines will be ignored.

As previously noted, initial collection of data has resulted in a dataset of 1,979 High Resolution NHD features that require editing. It is highly likely that we will be removing up to 805 miles of streams from the high resolution NHD. It is unclear at this time to what extent those features will be replaced by digitized representation so post-mining features.

Editing the NHD

In this section, we review:

- Begin editing those features to more accurately reflect their current state, post-mining.

In order to prepare to edit the NHD, we collected replacement features for streams that have been destroyed by mining in a single HUC. We started this work in the Gauley River Watershed (05050005, pictured in context in Figure 8) due to the fact that we have previously edited the watershed and corrected a number of other problems. A total of 143 features (~74 miles) were identified as in need of edits in this area.

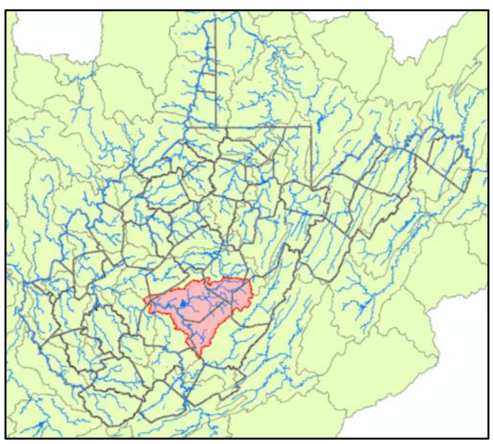

Figure 8. The Gauley River watershed (in red).

We were able to collect replacement features in 48% of cases in the Gauley River watershed (~43 acres of ponds and ~20 miles of lines). Those replacement features are entirely of 3 types: rock rip-rap/ditches (line), culvert drain pipes from ponds (line) and sediment settling ponds (polygon). Figure 8 contains examples of these features. Our collection was greatly aided by the fact that a new, high resolution, leaf-off (mostly) imagery dataset became available as we entered this phase of the work. See Appendix 1 for a full list of imagery datasets utilized in this work. Photography from multiple time stamps was useful in determining the extent and nature of alterations to existing stream networks. The red lines in Figure 9 depict the old HR NHD features. It is difficult to say if this pattern (replacing half the modified features with new geometry) will hold across other watersheds due to variations in photography, time since mining, etc.

Figure 9. Typical replacement features in post-surface mining areas;
linear feature (left), lake/pond feature (right).

Prior to editing, we consulted with the USGS in order to determine the appropriate feature type values for each of these feature. At USGS' recommendation, we utilized the Canal/Ditch FTYPE for all features similar to those depicted in Figure 9 (left) and Lake/Pond for now ponds (Figure 9, right). Using photo interpretation, we were able to subjectively determine the extent to which a stream was replaced by a ditch.

Once features were assembled and verified, we began editing with the most recent version of the USGS NHD GeoEdit toolset. All edits were completed in Arc GIS 9.3, installed on a Windows XP virtual machine. Installation, documentation and use of the NHD GeoEdit tool kit has improved substantially and, over all, the editing process is smooth. Geometric editing was completed over the course of approximately one week. During the course of geometry edits, we utilized the full scope of available imagery to again check the extent of changes and ensure that the changes made were correct.

At the time of the completion of this report, editing of the Gauley River watershed is nearing completion. Following the close of edits on that watershed, we will continue work in other subbasins.

<u>Stewardship Coordination</u>

In this section, we review:

- Develop a phased work plan to pre-stage data relevant to editing the high resolution NHD in areas where surface change is most likely to occur in the future, such as known mining permit areas or planned highways.

Completion of the last task – development of a pre-phased work plan that anticipates future change – will largely rely on coordination between the NHD Stewardship team and several other state agencies. We will be meeting with the parties in question – various divisions of the WVDEP and WVDEP, in particular – in the coming months in order to begin the process of data sharing and coordination. Coordination is an ongoing effort.

Conclusions

Our findings reveal that nearly 2,000 High Resolution NHD features with an estimated length of 800 miles have been impacted by surface mining and require editing. As part of this project, we corrected approximately 74 miles across 143 HR NHD features within the Gauley River watershed.

The biggest positive to come out of this project is apparent low errors of commission we were able to achieve by utilizing Shank's fill analysis work as our primary dataset of potential problem areas. The high incidence of intersection with actual problems (92%, see Table 1) allowed us to, relatively speaking, quickly and efficiently target specific areas for edits. Ideally, work of this nature will continue outside of the NHD Stewardship team. Work that should ultimately support our NHD efforts is currently in progress, such as Michael Strager's (WVU Dept. of Forestry) remote sensing of mine sites and Ross Geredien's similar work for the US EPA.

That being said, these are still datasets of indirect importance and due to the continued lack of authoritative geographic information for major stream modifications related to surface mining in West Virginia, it continues to be difficult to measure exactly how many errors of omission remain. The projects mentioned in the previous paragraph do hold some promise in this regard. Coordination with the WVDEP is an ongoing process and it is our hope that this coordination will eventually result in increased adoption of the dataset as well as more efficient utilization of regulatory data to better target areas for editing.

One of the unstated goals of this project is to further integrate NHD stewardship into the workflow of the WV GIS Technical Center. We believe this is more possible now than ever before, due in large part to the stability and stream-lined nature of the latest NHD tools. We **conservatively** estimate that completion of all edits to the NHD, including edits in mined areas utilizing the methodology elucidated in this report, would require 1 year of work by a single full time employee (~1,950 hours). We encourage USGS, WVDEP and other partners to continue providing NHD maintenance support for NHD Stewardship in West Virginia.

References

Shank, Michael, "Trends in Mining Fills and Associated Stream Loss in West Virginia 1984-2009" (Report, West Virginia Department of Environmental Protection, 2010).

APPENDIX 1

Dataset Title	Year	Source Agency	Resolution	Leaf Off
SAMB	2003	WV State Addressing and Mapping Board	2 ft/0.6 meter	yes
NAIP 2009	2009	USDA-NRCS	3.3 ft/1 meter	no
NAIP 2011	2011	USDA-NRCS	3.3 ft/1 meter	no
Pictometry	2011	WV Sheriff's Association	1 ft/0.3 meter	partial

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