Lower Wisconsin State Riverway Viewshed Analysis

Submitted to:

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Executive Summary

The Wisconsin State Cartographer's Office (SCO) was selected to conduct a Viewshed analysis of the Lower Wisconsin State Wisconsin Riverway (LWSR) near the Town of Bridgeport in Crawford County, Wisconsin. This project was in response to the Pattison Sand Co. application to locate a 300 acre frac sand mining operation along the banks of the Wisconsin River. This analysis provides a graphical representation of the visible portion of the proposed mine site from various observation points along the Lower Wisconsin River. This project was authorized by the Lower Wisconsin State Riverway Board located in Muscoda, Wisconsin.

A viewshed analysis provides a graphical representation, in map form, of the line-of-sight visible portion of terrain and any above-ground natural cover or human structures, from observation points, and is useful to evaluate the visible impacts of proposed developments and structures. Because the SCO is part of the University of Wisconsin system, an educational component was incorporated into the project. A graduate student in the University of Wisconsin – Madison's Geographical Information Systems Certificate Program was employed to conduct this analysis under the supervision of the Wisconsin State Cartographer. Subsequent to the specification of project requirements, data required to perform this analysis was obtained from various sources as detailed in Appendix A.

Esri ArcGIS 10.1 software was used to prepare the data and perform the Viewshed and Observer Points analyses. Three different Viewshed analyses were performed which calculated visible terrain between various observation points located on the river and (1) the bare earth elevation, (2) 60' – 65' high forest cover elevation, and (3) 30' high material stockpiles on the proposed mine site. Additionally, two Observer Points analyses were

conducted to determine the visible points of the proposed mine site from a southern and eastern portion of the river. The results from the three Viewshed analyses were very similar, illustrating that the southern and eastern portions of the proposed mine site are visible from the river. The Observer Points analyses illustrated that both the southern and eastern channels of the river provided a visible line-one-sight view into the site (see Figures 4-9 for maps).

Despite advances in geospatial technology and the availability of highly accurate digital elevation terrain data, there are limitations in the analyses. First, average forest cover data of 60' and 65' heights did not account for line-of-sight variations in different forest species crown diameter and configuration in the vegetated model. Second, the seasonal leaf-off condition of deciduous trees was not represented in the vegetated model. Third, the stockpile model included a 30' high continuous elevation increase to represent potential mine-extracted material, which may not accurately represent differences in real world stockpiling conditions. Finally, all data used in these analyses are digital representations of the terrain and forest cover, and due to scale reduction and other data collection factors, include generalizations and potential errors that are inherent in all GIS data. Despite these limitations, these analyses provide the LWSR Board with a reasonable graphical expectation of line-of-sight from various observation points located along the river to the proposed mine site.

Methods

A Viewshed is defined as the visible area from a specific location, or a set of location, that is, the area of the Earth's surface that is viewable from an observation point in all directions (see Figure 1). Viewsheds are popular spatial analysis tools to determine line of sight from an observer point to the farthest point on the horizon.

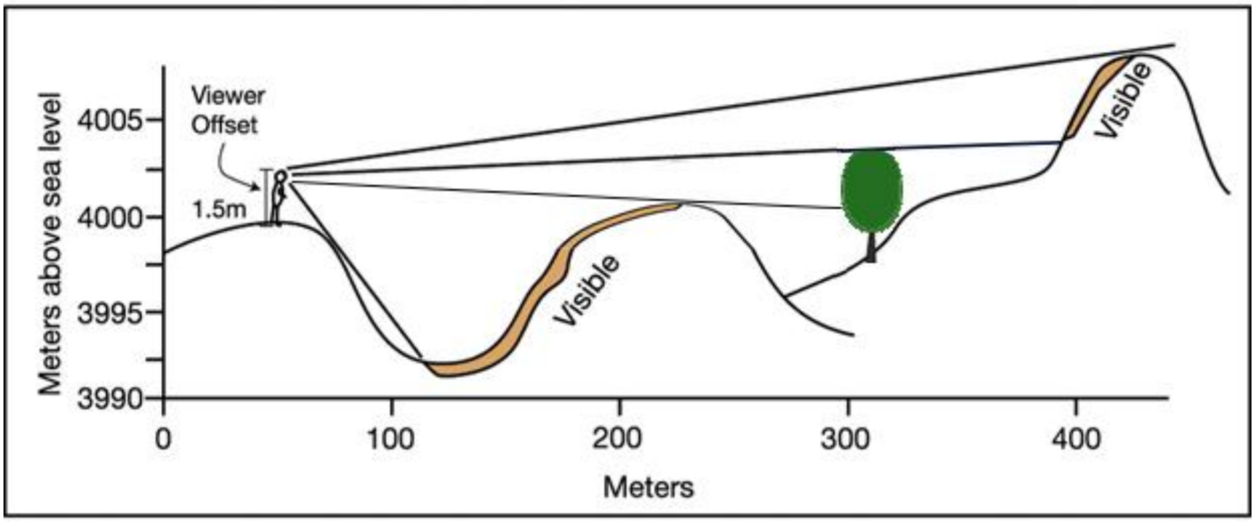

Figure 1. Viewshed conceptual diagram (modified from: http://mapaspects.org/colca/research/viewshed/what_is.html).

Figure 2 illustrates the process used to prepare data and conduct the Viewshed analysis. Step one involved acquiring digital terrain data to represent the Earth's surface. This project used five-foot resolution (i.e., each cell represented an individual terrain elevation as a 5' x 5' square), hydro-flattened, bare-earth Digital Elevation Model raster data derived from county LiDAR (Light Detection and Ranging) data. These data were acquired from the Wisconsin View website (www.wisconsinview.org). LiDAR data was originally acquired through funding from the Wisconsin Department of Commerce through the Community Development Grant Emergency Assistance Program (CDBG-EAP). Crawford

County and Grant County five-foot DEM's were clipped and stitched together into a single mosaic to represent the entire study area. Next, DEM's were resampled to a 50 foot grid size to decrease computing analysis time to generate an initial glimpse into the general spatial trends in the study area. Subsequently, a hillshade relief map was generated to visualize the bare earth terrain, absent of any land cover. It was immediately evident that the riverbed is very straight and wide in the study area. Additionally, this initial glimpse into the visible terrain suggested a further resampling of DEM data to a 150 foot grid cell size to reduce computer processing time during this initial study area prescription step.

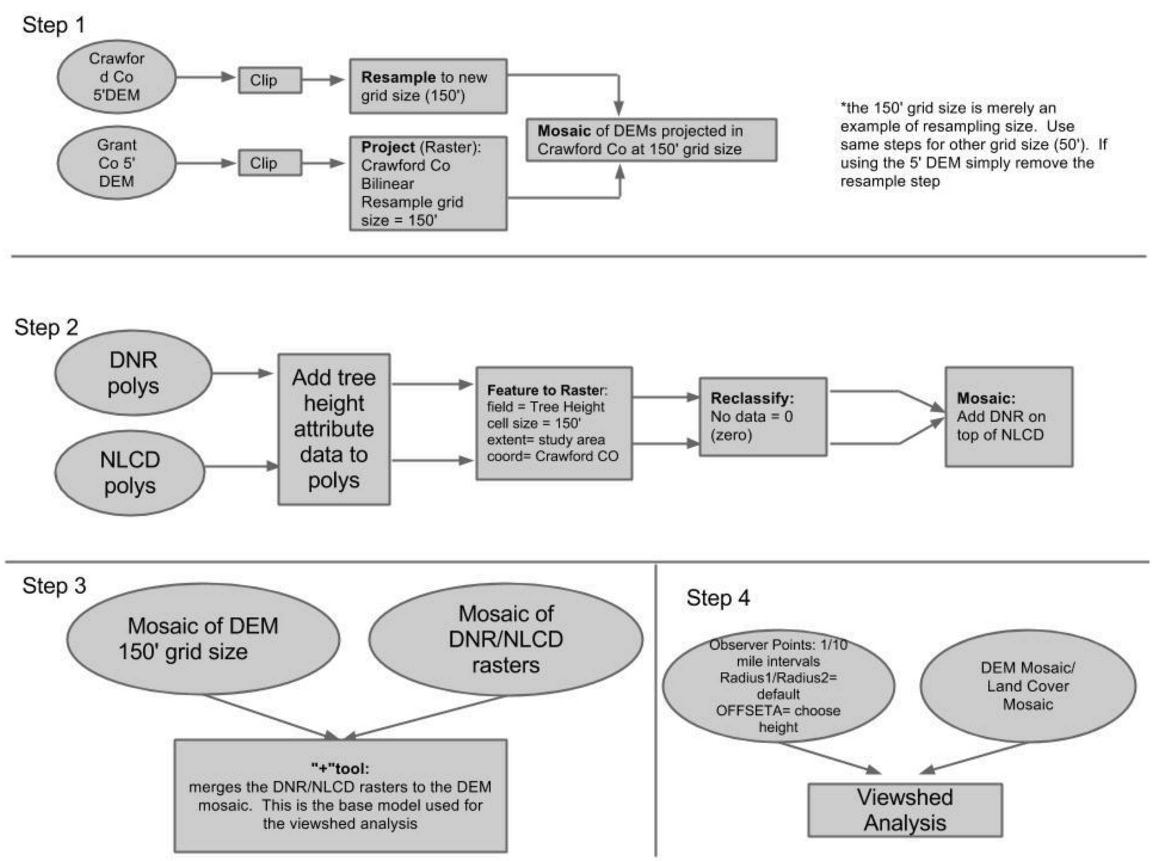

Figure 2. Lower Wisconsin State Riverway Viewshed analysis implementation model.

Prior to conducting the Viewshed analysis, the Observer Point Tool in ArcMap 10.1 was implemented to verify the spatial extent of the mine site viewshed. First, points were selected at 2.5 mile intervals along the centerline of the main channel for a 40 mile extent of the Wisconsin River to verify the absence of key points up or downstream of the study area that could be viewed from the proposed mine site. This process was repeated at regular decreasing intervals until a final 13 mile x 9 mile study area was determined that extended 10 miles upstream, and 3.5 miles downstream of the proposed mine site. This analysis provided assurance to narrow the project study area to the final extent as shown in Figure 3. Based on this final study area extent, original 5' x 5' resolution DEM's were clipped to the final study area and stitched together into a single mosaic to form the primary bare earth base data.

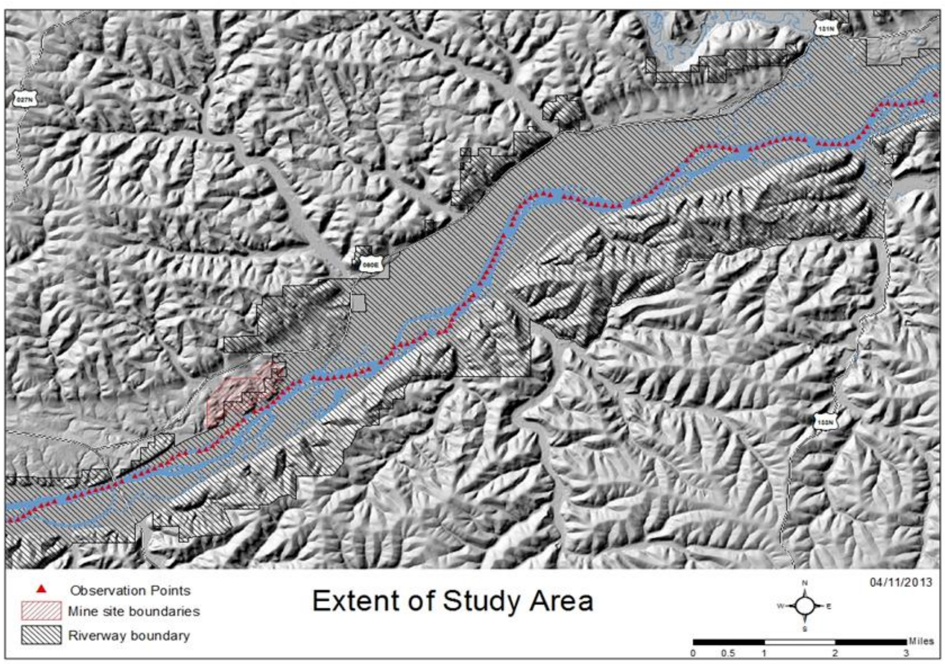

Figure 3. Extent of project study area.

The second step involved adding land cover information to the bare earth data to more accurately represent the above ground terrain that would obstruct observations in the study area. Land cover data was acquired from the Wisconsin Department of Natural Resources (WIDNR) and the National Land Cover Dataset (NLCD). Visual inspection of land cover data in the study area illustrated specific vegetation types that would exist above the earth's surface as represented by the DEM. Forest cover selected for modeling included Oak, Bottom Hardwoods, Central Hardwoods, and Red/White Pine from the WIDNR dataset, along with Deciduous Forest, Evergreens, Mixed Forest, and Woody Wetlands from the NLCD. All WIDNR derived polygons were assigned a height of 65', while NLCD data was assigned a height of 60'. Polygon vector data was then converted to a raster, pixel-based format, to match the DEM data model required for the Viewshed analysis. Next, the DEM and the forest cover data were combined to produce a raster data layer with each pixel containing a single elevation value representing the maximum obstruction height equaling the bare earth plus any forest cover.

NLCD forest stands are classified from satellite imagery at a 30m x 30m resolution leading to slight variations from the actual ground cover spatial location and extent. Therefore, the polygon forest stands were manually edited to match actual conditions based on the heads-up digitizing of forest stands from a NAIP 2010 orthorectified aerial imagery. This work completed data preparation through step three as illustrated in Figure 2. Next, the proposed mine polygon boundary, the Wisconsin River polygon boundary, and observation points supplied by the WIDNR at 1/10th mile intervals, were added to the overall model to complete data preparation.

For this project, the Observer Point Tool in Esri ArcGIS 10.1 was used to calculate the viewshed from several observation points along the LWSR. The Observer Point Tool identifies which observation points are visible from each surface location while the Viewshed Tool determines the raster surface locations visible to a set of observer features

(Esri 2011). Both tools require an observation height to be specified prior to tool execution. After discussions with the LWSR board a 12' elevation was designated to represent a 6' tall person standing on a pontoon boat that is 6' higher than the Ordinary High Water Mark (OHWM). To achieve this height, 1' was added to the observed height on the DEM, as it was determined that the DEM elevations were on average 1' below the OHWM as provided by Mohn Surveying from a physical shoreline analysis. Three different models were then analyzed: (1) vegetated model, which includes forest cover heights added to the bare earth elevations, (2) harvested model, a bare earth model representing the removal of all forest cover simulating a total clear cut scenario within the mine site boundary, and (3) a stockpile model, which added 30' of elevation to the bare earth elevations within the mine area to simulate potential stockpiles of mine extracted materials.

Results

Viewshed analysis

Vegetated Viewshed Model: Figure 4 illustrates the results from the vegetated model Viewshed analysis. Areas visible from the river are shown by the yellow-red overlay; yellow areas are visible from a few locations along the river, while red areas are visible from many locations. As evident, the viewshed intrusion is along the eastern edge of the mine site.

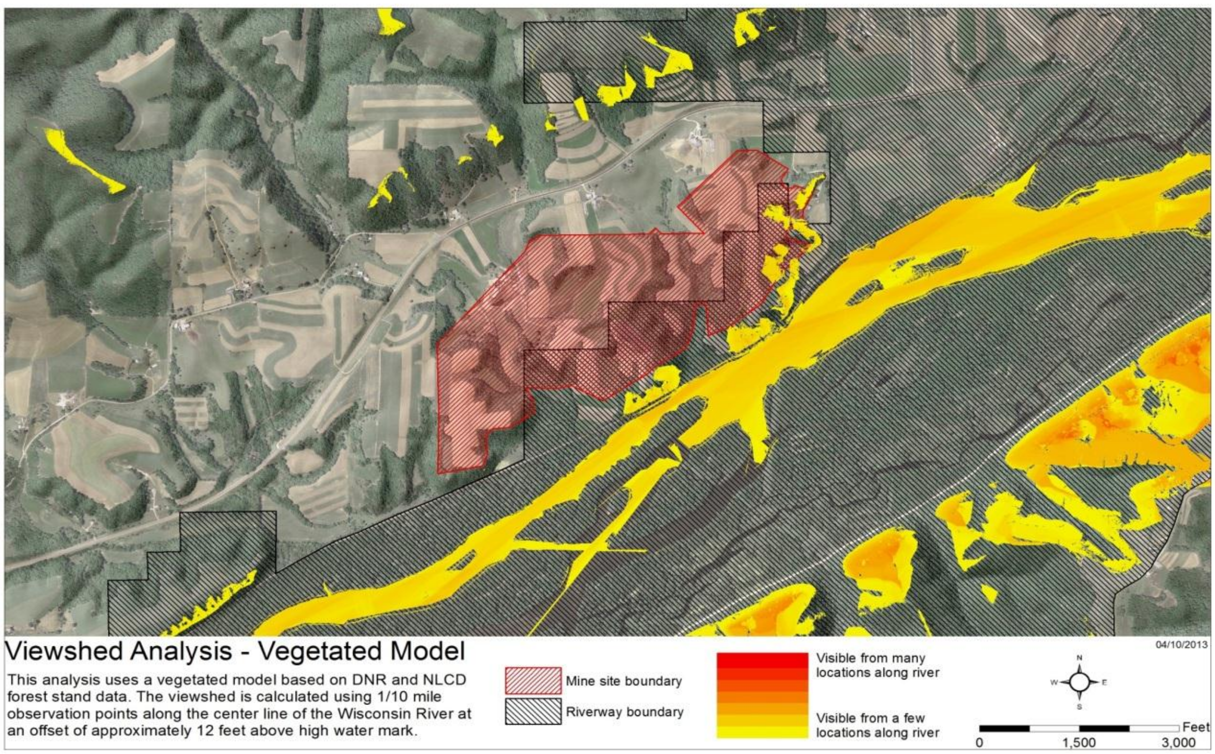

Figure 4. Vegetated Viewshed Model results.

Harvested Viewshed Model: Figure 5 illustrates the results from the harvested model Viewshed analysis. Results are quite similar to the vegetated model, but the viewable area has actually decreased somewhat. This result may seem counter-intuitive, but simply indicates that parts of the viewable area within the mine site in the vegetated model are actually the tops of trees.

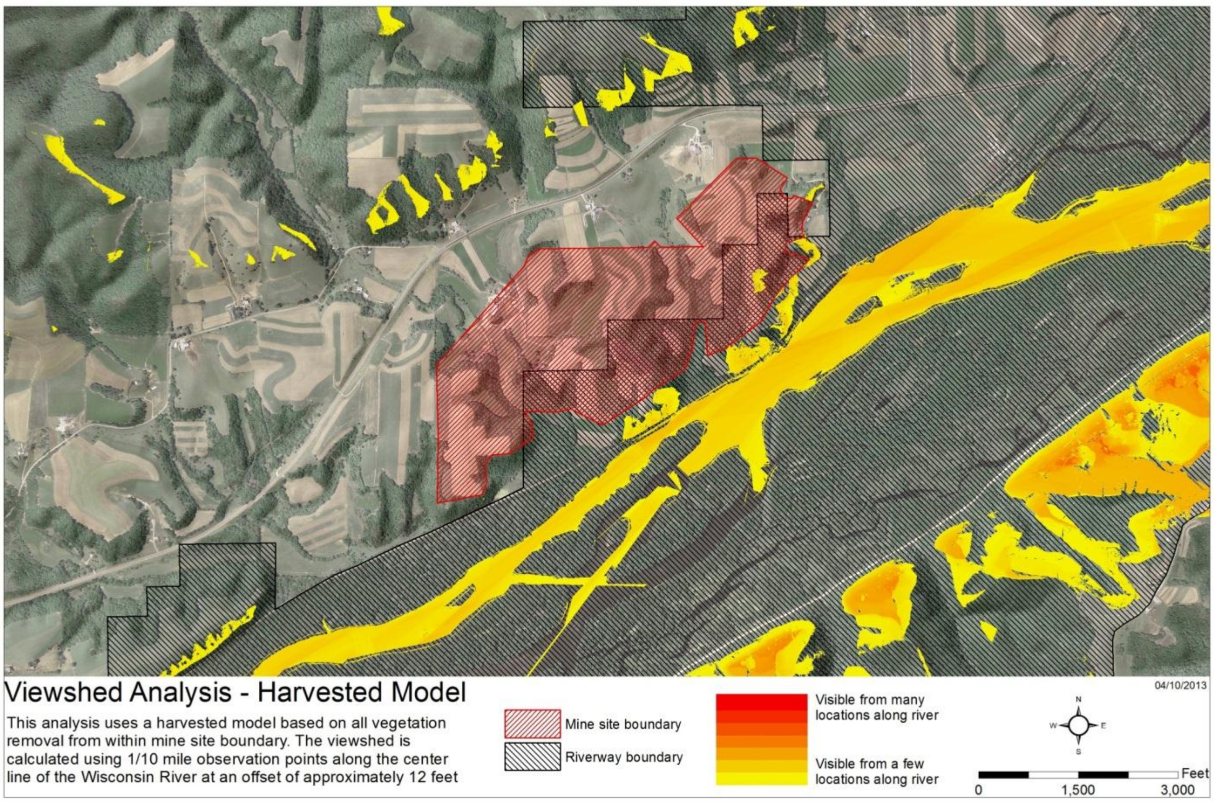

Figure 5. Harvested Viewshed Model results.

Stockpile Viewshed Model: Figure 6 illustrates the results from the stockpile model Viewshed analysis. The result is again very similar to the vegetated model. Hence, stockpiles of mine extracted materials 30' high along the eastern edge of the mine site would be visible from the river.

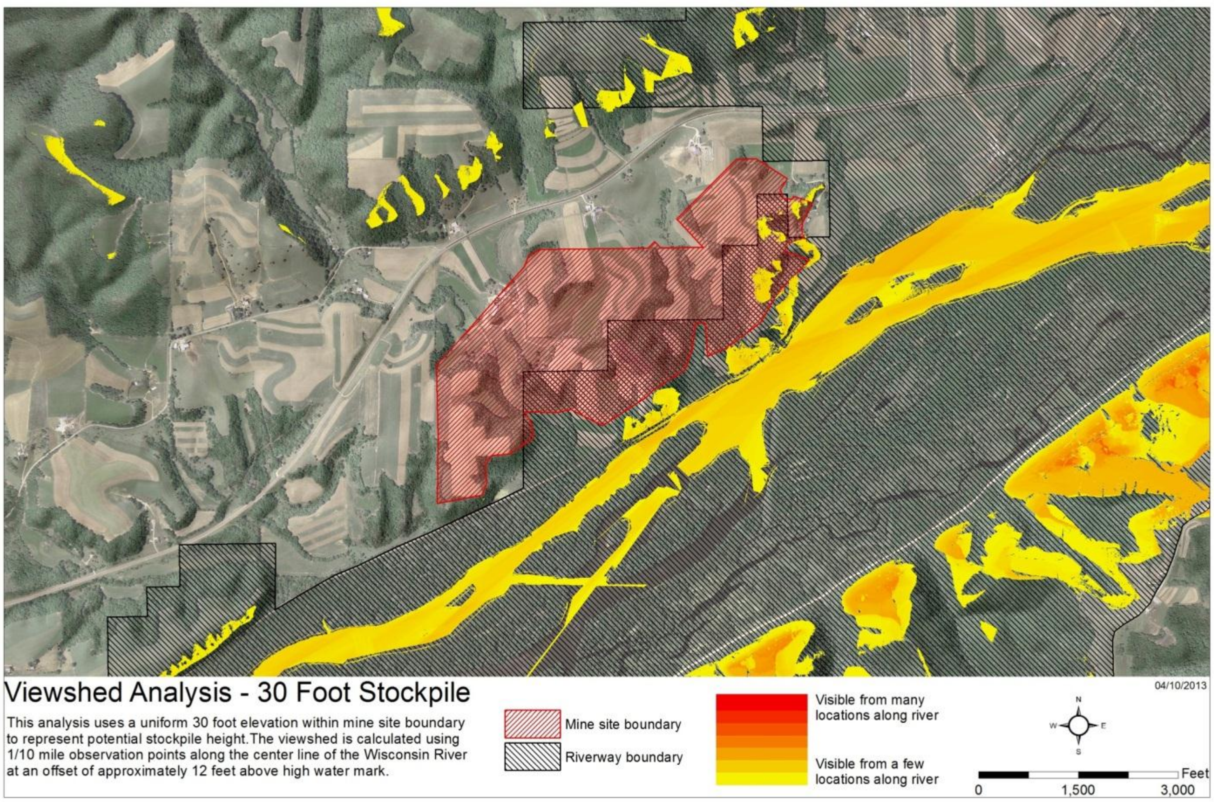

Figure 6. Stockpile Viewshed Model results.

Observer Point analysis

South channel Observer Point analysis: LWSR board members indicated there may be key points of observation into the mine site from the river channel directly south of the proposed site. Therefore, an Observer Points analysis was conducted based on four observation points as illustrated in Figure 7 by the red triangles. These points were not included in the main channel locations for the Viewshed analysis reported above. The analysis indicates that areas in the center portion of the mine site are visible from the south channel, despite the steep riverbank and tree cover. Since the vegetated model was used, it is possible that at least some of the visible area represents tree cover. If tree cover was removed, visibility may be increased to the mine site from the observer points.

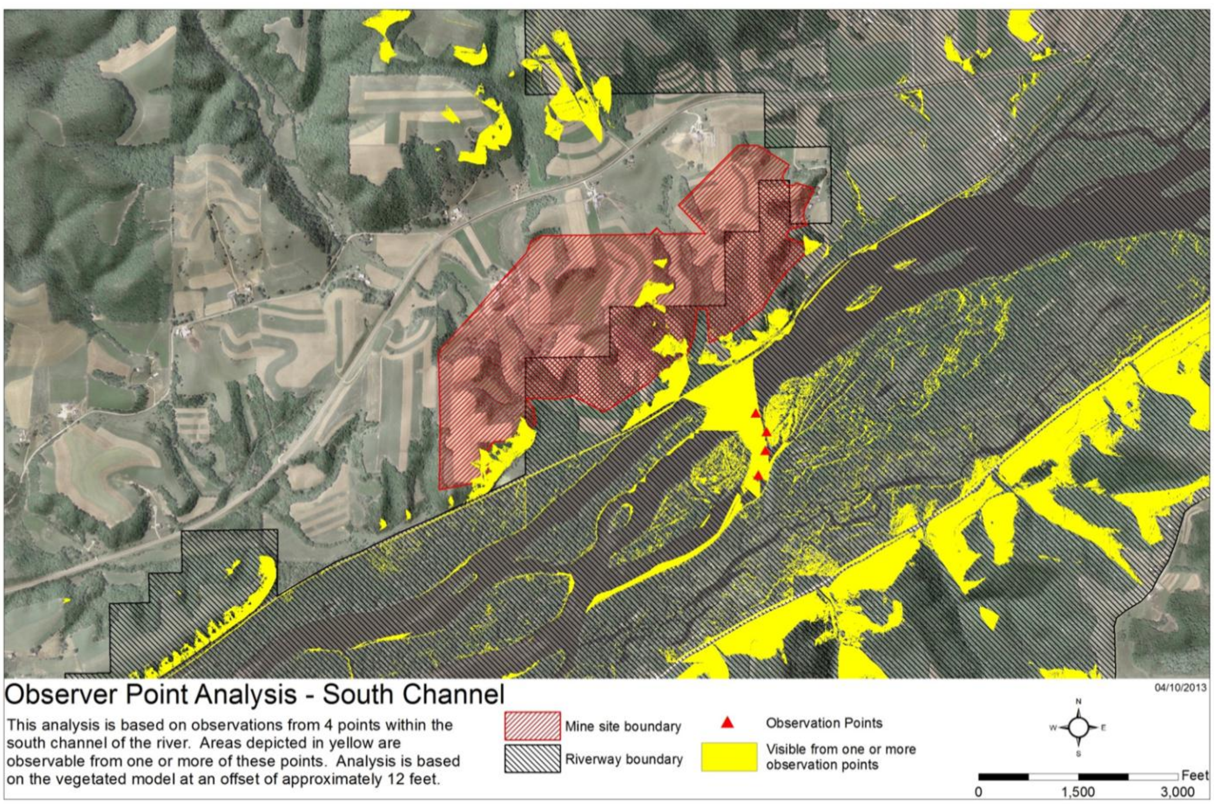

Figure 7. Observer Point analysis – channel south of the river.

East main channel Observer Point analysis: An Observer Points analysis was also conducted on the main river channel east of the mine site based on four observation points as illustrated in Figure 8 by the red triangles. Again, the vegetated model was used. The results indicate a similar pattern to the Viewshed analysis, indicating a direct line of sight for anyone coming down the main channel of the river in this area.

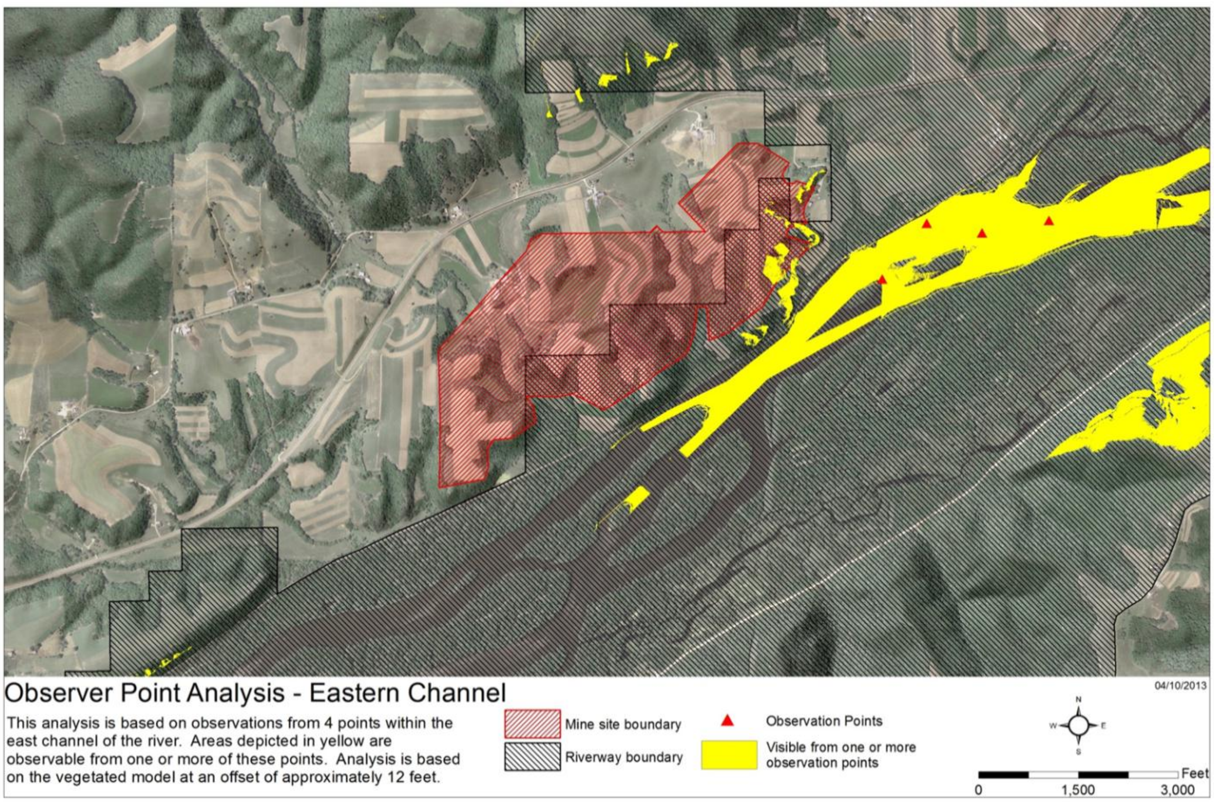

Figure 8. Observer Point analysis – channel east of the river.

Conclusions

Results indicate that some of the southern and eastern portions of the mine site are visible from the main channel and a selected south channel of the Wisconsin River. However, this analysis, similar to any geospatial analysis, is a simplified model of real world objects and cannot take into account the complexity of the real world. For this study, direct line of sight visibility is calculated from an observation point to every raster cell in the study area. Raster cells that have a direct line of sight to the observation point are given a positive value, while those cells that do not are given a negative value. Real-world phenomena such as the annual shedding of leaves on deciduous trees, and gaps in tree crowns, were not incorporated into this analysis. Additionally, all data used in the analysis are digital representations of the terrain and forest cover; they cannot be completely accurate due to temporal differences, scale reduction, generalization and potential errors that are inherent in all GIS data, and other data collection factors. Future analysis might focus on additional observer points in other locations along the main and secondary river channels for a more comprehensive viewshed picture. Despite these limitations, the analysis provides the LWSR board with maps of specific areas of potential concern, for which additional ground-based observations should be made to make a final determination of visibility.

Literature cited

Esri. 2013. *Using Viewshed and Observer Points for visibility analysis*. Esri 2011 [cited July 25, 2013 2013].

Appendix A. Data Sources

Crawford County Lidar derived DEM (5'x5' pixel resolution, grid size). (2013)
http://www.wisconsinview.org/

Grant County Lidar derived DEM (5'x5' pixel resolution, grid size). (2013)
http://www.wisconsinview.org/

NLCD Description of Land Class: Http://www.mrlc.gov/nlcd2001.php

WI DNR Forestry Data Sets: http://dnr.wi.gov/topic/forestmanagement/data.html

24k Hydro Layer (WI River layer): ftp://dnrftp01.wi.gov/geodata/

NAIP Aerial Imagery: Aerial and Satellite Imagery (2010):
http://www.wisconsinview.org/