Update to the Reasonable Foreseeable Development (RFD) for the BLM Pecos District, SENM

FINAL REPORT

November 2014

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Executive Summary

Since the initial RFD report submitted in May of 2012, significant activity in development has occurred. As an example, in the Bone Spring/Avalon play alone, over 1,228 new completions have occurred from January 2011 through July of 2014. Due to the dramatic growth in development since 2010 (specifically the Bone Spring) the initial RFD quickly became outdated; missing areas of development that were not active or predicted. To capture this development activity and to better assess the impact, an update was required. This report provides the results of the update.

From January of 2011 through July of 2014, approximately 4,500 producing wells were completed in Chaves, Eddy, Lea and Roosevelt counties of Southeast New Mexico (SENM). The dominant play was the Yeso/Leonard which resulted in 2,053 completions or 45% of the total over the given time period. The second most active was the Bone Spring, with 1,228 completions or 27% of the total. However, the Bone Spring is the most productive and has the highest potential for continued activity. The third highest active play is the Delaware mountain group, with 325 well completed or 7% of the total. Subsequently, these three plays are responsible for 79% of the activity in SENM.

Activity in the Bone Spring play has been widespread, resulting in modifying the original potential regions. The Ochoa Mine area (Triple XXX pool), the southeast tip of the shelf trend, the western edge of the basin area (Hay Hollow, Pierce Crossing, Culebra Bluff pools), and the Jennings pools are all examples. In contrast, both the Yeso/Leonard and Delaware plays are well-defined and thus previous high, medium and low potential regions have been reasonably accurate. In addition, due to recent Wolfcamp activity south of the New Mexico –Texas stateline, the Wolfcamp play was modified by adding potential along the southern border.

Oil and gas resources in the Secretary's Potash Area will continue to be sought after for development. Both the Bone Spring and Delaware plays have potential in this area, and industry has indicated a desire to develop. A solution to co-develop both the oil /gas and Potash resources is to promote the use of "drill islands" within the designated area. They are especially well-suited for horizontal drilling, which can develop large tracts of land from a single island and simultaneously reduce the surface to near-surface footprint. As a result the drill island method is anticipated to expand.

According to a study by the NMOCD, average fresh water usage for stimulation in Eddy County is 25 Mbbls or 3.2 acre-feet per well and for Lea County 35 Mbbls or 4.5 acre-feet per well. Their study included all plays and all wells, vertical and horizontal. A detailed study of only Bone Spring completions in 2013 resulted in an average usage of 57 Mbbls or 7.3 acre-feet per well. This greater value for Bone Spring is due to the multistage hydraulic fracturing of a horizontal well which is the preferred completion method for this play. To reduce the usage of

fresh water, efforts by many operators are to use flowback and/or produced water. Technology has advanced such that creating an effective frac fluid is feasible from brackish/saline fluids. Furthermore, production performance results are encouraging, being as good if not better than previous. As a result, this trend is expected and encouraged to continue.

In summary, the Southeast New Mexico portion of the Permian Basin is extremely active and has some of the highest potential in the United States for development in the near future. Unconventional oil plays in the Bone Spring, Yeso and Delaware, utilizing technology advances in multistage fracing of a horizontal well are leading this effort. The continued activity is predicted to be very high. Furthermore, development of the Secretary's Potash area is possible with the use of drill islands, providing a means to co-develop oil and gas and Potash resources. And last, the increasing trend of using brackish/produced water for completion, specifically hydraulic fracturing, is anticipated and encouraged to continue and this resolve the problem of fresh water usage.

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Introduction

In the initial RFD report submitted in May of 2012, the ending date for all production data used in analyses was December 2010; i.e., the end of the 2010 calendar year. This date was chosen because all reporting was based on annual numbers and thus 2010 was the last full year of production available at the time.

As a result of this cutoff date, the major criticism of the RFD has been the lack of capturing the dramatic growth in development since 2010. As an example, in the Bone Spring/Avalon play alone, over 1376 new completions have occurred from January 2011 through July of 2014. Due to the dramatic growth in development since 2010 (specifically the Bone Spring) the initial RFD quickly became outdated; missing areas of development that were not active or predicted. To capture this development activity and to better assess the impact, the BLM contacted NMT to complete an update of the original RFD due in 2014.

The majority of this work was a continuation of the previously applied methods used in the 2012 RFD; that is, data collection and cleaning followed by statistical analysis. A comparison with the original RFD was accomplished to confirm if the predictions were valid and if not, to determine if the activity is a random event, e.g., wildcat, if it is an extension within a play, or if it is a new pool within a play.

In addition, industry was contacted to acquire their support in providing information and data, with the goal of adding value to the results from the above analysis.

The report is divided into a discussion of the significant plays, other plays and special issues. The emphasis is on the significant plays; e.g., Bone Spring, Yeso/Leonard, Delaware, and Wolfcamp, since these have the majority of activity.

Significant Plays

From January of 2011 through July of 2014, approximately 4,500 producing wells were completed in Chaves, Eddy, Lea and Roosevelt counties of Southeast New Mexico (SENM). The dominant play was the Yeso/Leonard* which resulted in 2,053 completions or 45% of the total over the given time period. The second most active was the Bone Spring, with 1,228 completions or 27% of the total. However, the Bone Spring is the most productive and has the highest potential and therefore will be discussed first. The third highest active play is the Delaware mountain group, with 325 well completed or 7% of the total. Subsequently, these three plays are responsible for 79% of the activity in SENM.

* Play names and descriptions are the same as in the original RFD report.

Bone Spring

Recent (2010 to July 2014) completions in the Bone Spring play were superimposed on the originally proposed high, moderate and low potential regions to confirm the previous predictions and to identify areas missed previously. From 2010 through July 2014, 1,228 completions in the Bone Spring occurred; of which 932 (75%) were within one of the potential regions. The high potential area includes 756 completions (61%), mostly capturing the shelf edge activity and to a lesser degree the basin-play near the Texas/New Mexico border.

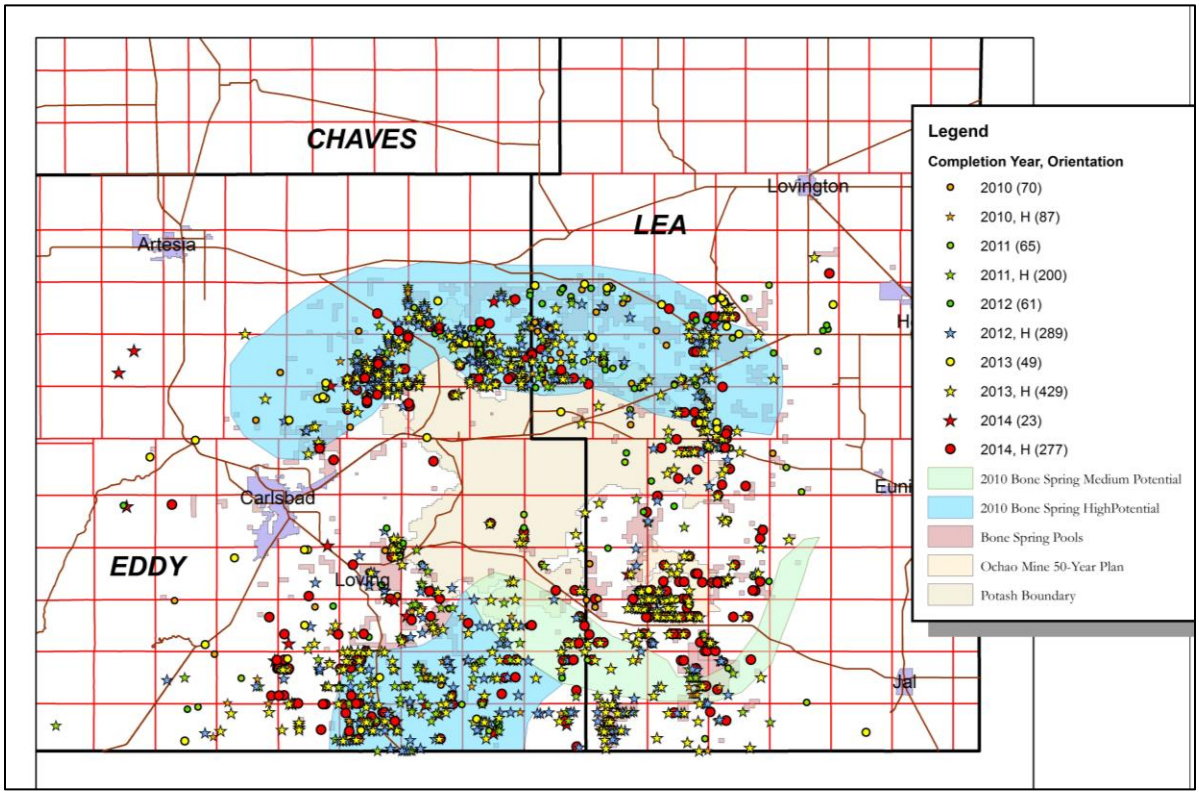


Figure 1. Map of completions in Bone Spring from 2010 through July 2014. Symbols indicate horizontal (star) or vertical (circle) completion. Also shown are Secretary's Potash Area, Ochoa mine proposal, and original estimate of High, Moderate, and Low potential areas.

The moderate region contained 80 completions (6%) and the low potential region 96 completions (7%), respectively. The near equality of the two regions indicates a revision is necessary to correctly categorize the regions.

An alternative presentation of the completion data was to calculate well density per township and then assign a value (color) for each township. This method provides a rapid indication of the various levels of activity. Figure 2 provides the well density by township superimposed on the 2010 estimated potential regions for comparison.

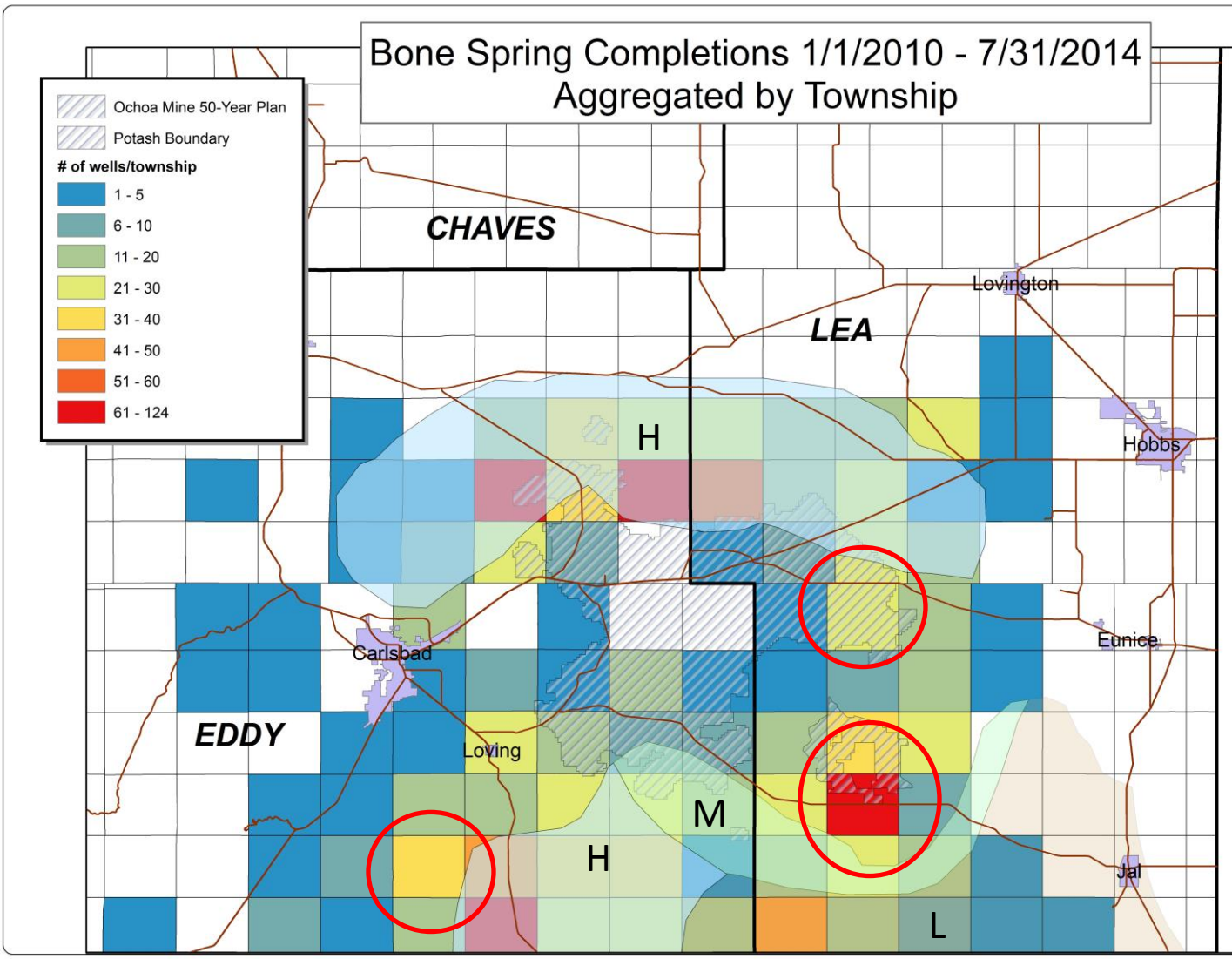


Figure 2 Cumulative Bone Spring completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions. Red circles indicate areas of activity not accounted for in the 2010 potential maps.

Note in Figure 2, that the original estimation of potential captured the majority of activity on the shelf edge and along the NM-TX state line. However, other areas (particularly the Ochoa Mine area) were missed. These areas are highlighted in Figure 2 with red circles. Also, what was considered a region with low potential for development in the southeast portion of this trend, has proven to be an area that has development falling within the moderate level of potential.

Based on the updated completion and intention data and discussions with operators in the area, previously defined potential regions should be redrawn to better represent the recent activity. A significant example is the Ochoa Mine area (Triple XXX pool) discussed in the December 2013 review and update. Other examples include: the southeast tip of the shelf trend, the western edge of the basin area (Examples are: Hay Hollow, Pierce Crossing, Culebra Bluff pools), and the Jennings pools. Figure 3 is an updated Bone Spring potential map including the revisions described.

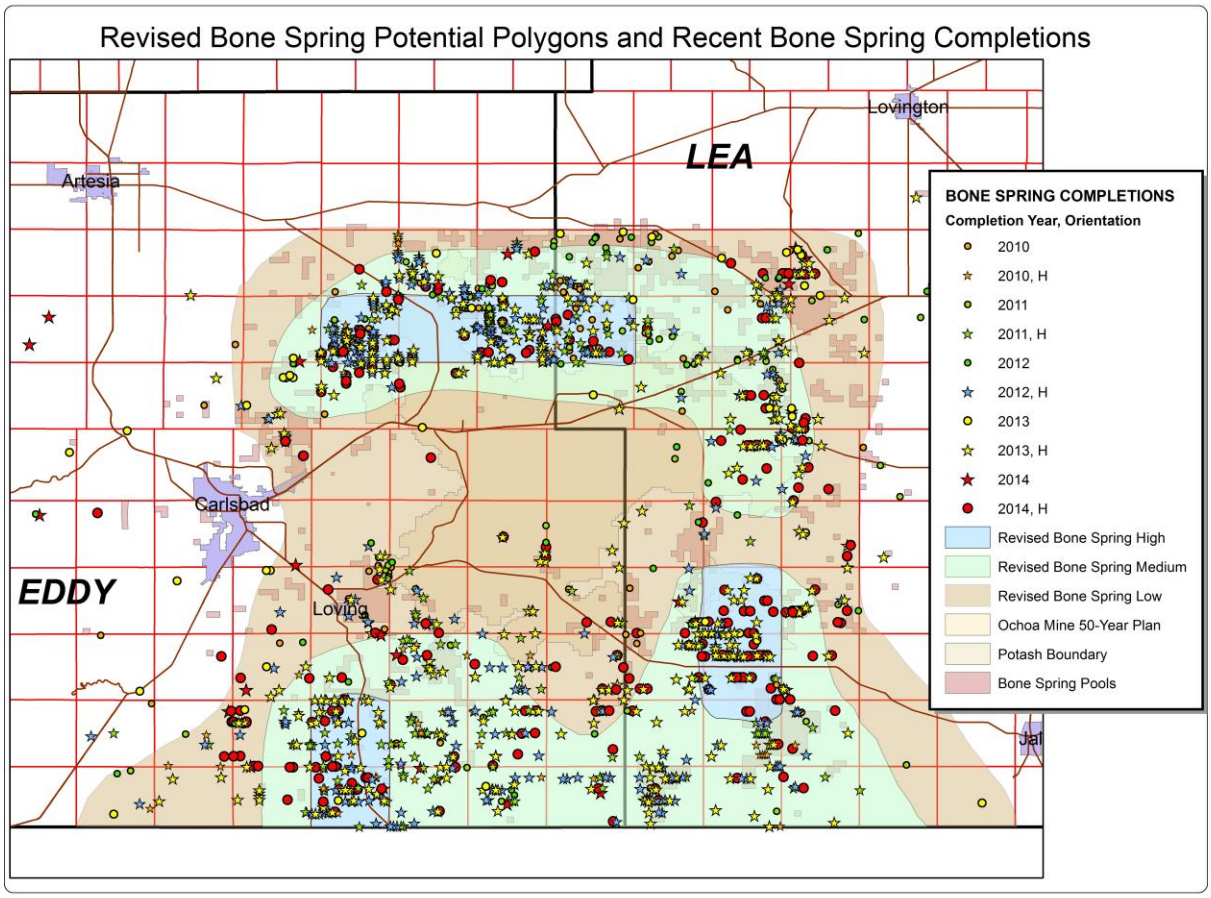


Figure 3. Updated Bone Spring potential map

The new high potential region accounts for 37% of all Bone Spring well completions since 2010. Similarly, the moderate region contains 41% and the low potential region 21 % of the completions. Only 24 wells are outside the new potential boundaries. Of these, half are listed as

wildcats, and the remaining half are new pools; e.g. Arkansas Junction (Bone Spring). Production performance for all of these wells is poor, with the best producing 31 MBO to date, and averaging slightly less than 5 MBO/well.

Horizontal drilling coupled with hydraulic fracturing has been a game changer in proving economic production from previously believed unproductive rock. As mentioned, the majority (82%) of all new completions in the Bone Spring/Avalon are horizontal. It was also suggested in the reviews that the majority of the RFD was based on vertical well data only. However, the benefit of horizontal wells was recognized and discussed in the RFD in general (Sec 4.5, pg 30) and specifically with regards to the Bone Spring/Avalon (Appendix). Figure 4 is an update to Figure 10 in the Bone Spring appendix of the RFD.

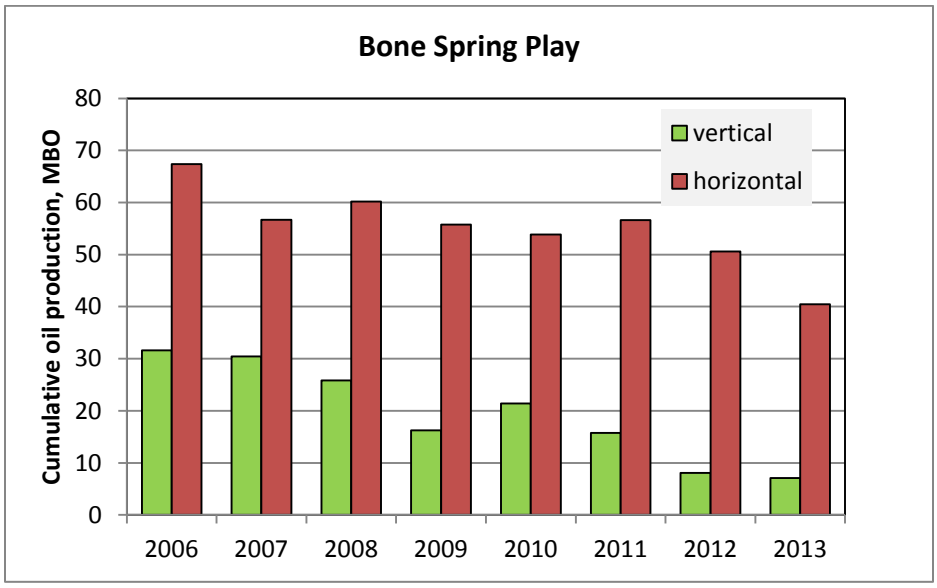


Figure 4. Comparison of average horizontal and vertical cumulative oil production per well based on year of beginning of production. (Data source: I.H. S. Energy+GOTECH)

From 2006 through 2013, performance in horizontal wells has averaged 3.5 times better than vertical wells. And in the last full year of data (2013), the ratio was approximately 6:1, the best to date. The trend indicates an increase in success of horizontal wells in the Bone Spring/Avalon play and confirms the likelihood of future activity with horizontal wells.

Leonard/Yeso Trend

Recent development for the Leonard Restricted Platform play is shown in Figures 5 and 6. This play includes the extremely active Glorieta- Yeso shelf development as well as the Paddock - Blinebry-Tubb-Drinkard development on the central basin platform. Observe, the activity is very well defined and thus allows for a fairly accurate estimate of the potential region. The only revision is to extend the shelf play to the southwest (Penasco Draw, Seven Rivers, Cemetary

Pools). This also happens to be the area with the highest concentration of horizontal wells in this play.

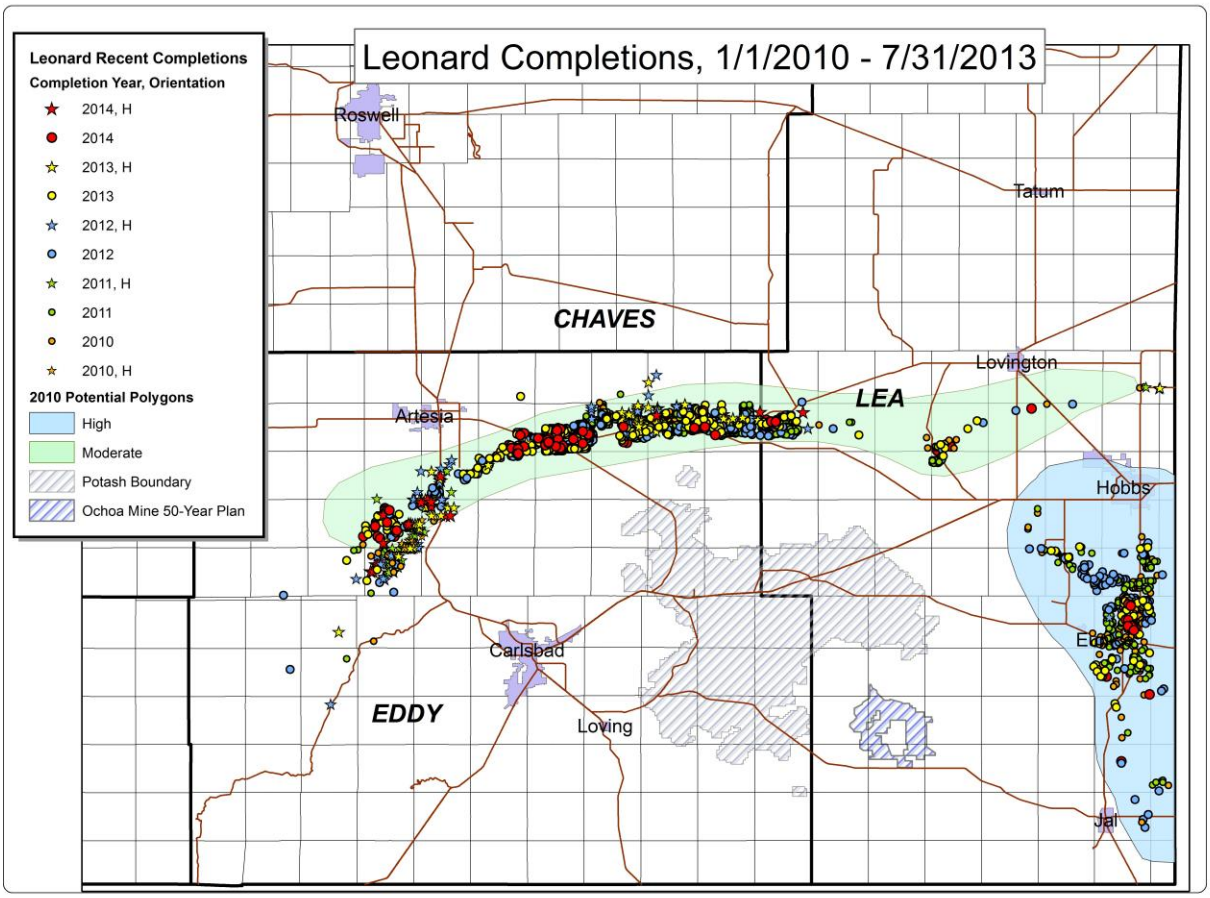


Figure 5. Map of completions in Leonard play (aka Glorieta-Yeso along the shelf edge) from 2010 through July 2014. Symbols indicate horizontal (star) or vertical (circle) completion. Also shown are the Secretary's potash area, Ochoa mine proposal, and original (based on data through 2010) estimates of High, Moderate, and Low potential areas.

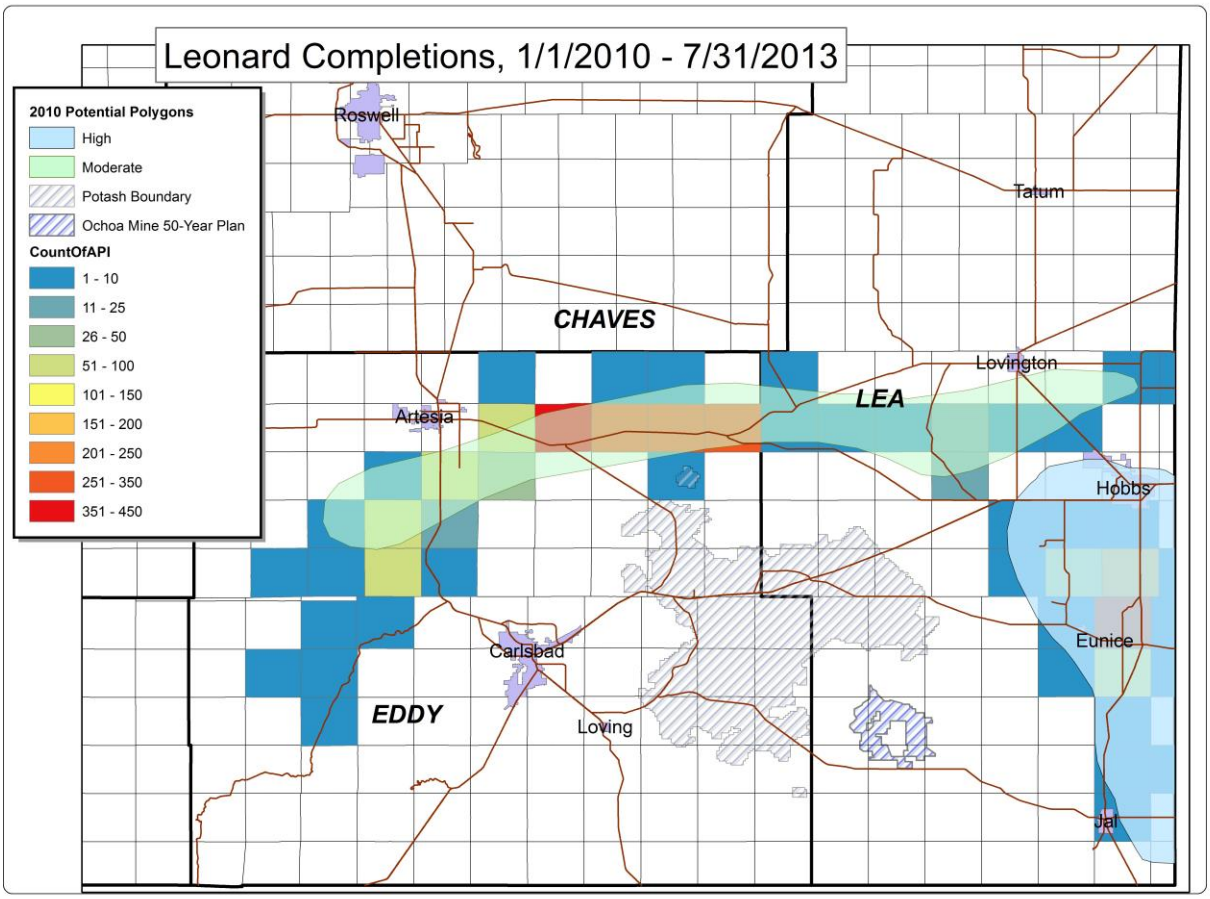


Figure 6 Cumulative Yeso/Leonard completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.

An update potential map for the Yeso/Leonard play is shown in Figure 7.

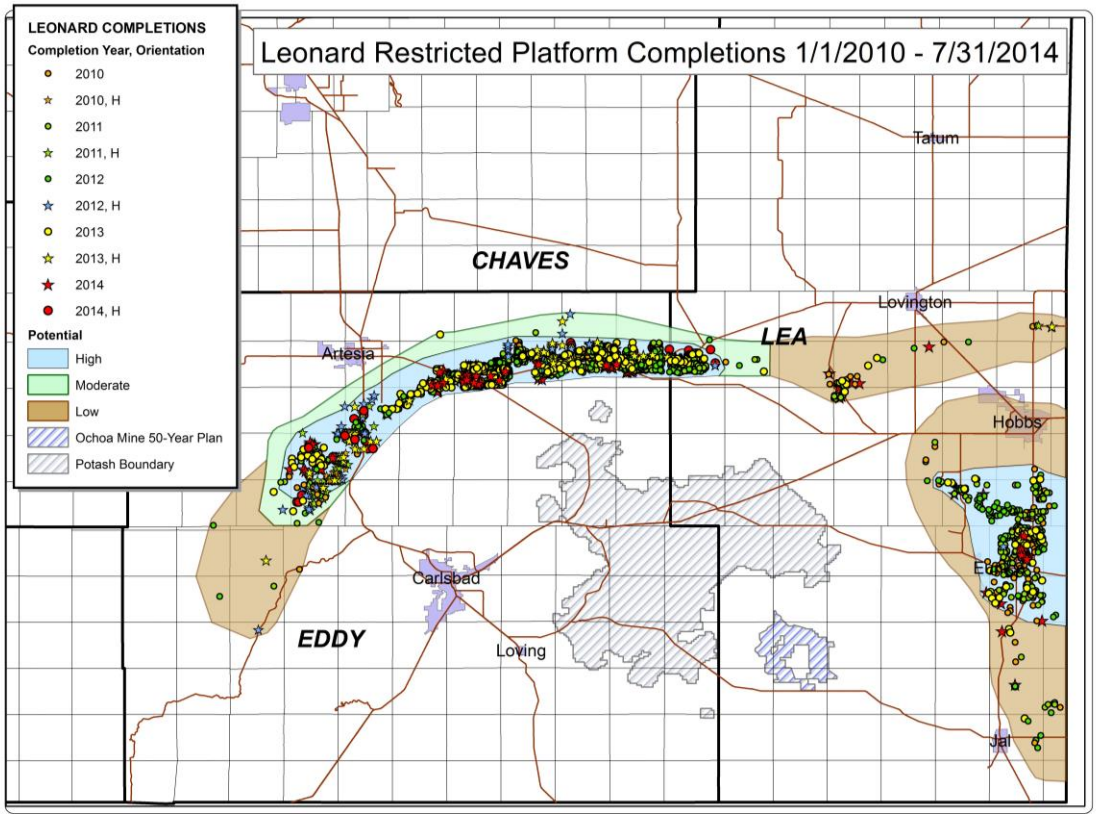


Figure 7. Updated potential map for the Yeso/Leonard play.

Horizontal well development has not been as active in the Yeso/Leonard as the Bone Spring.

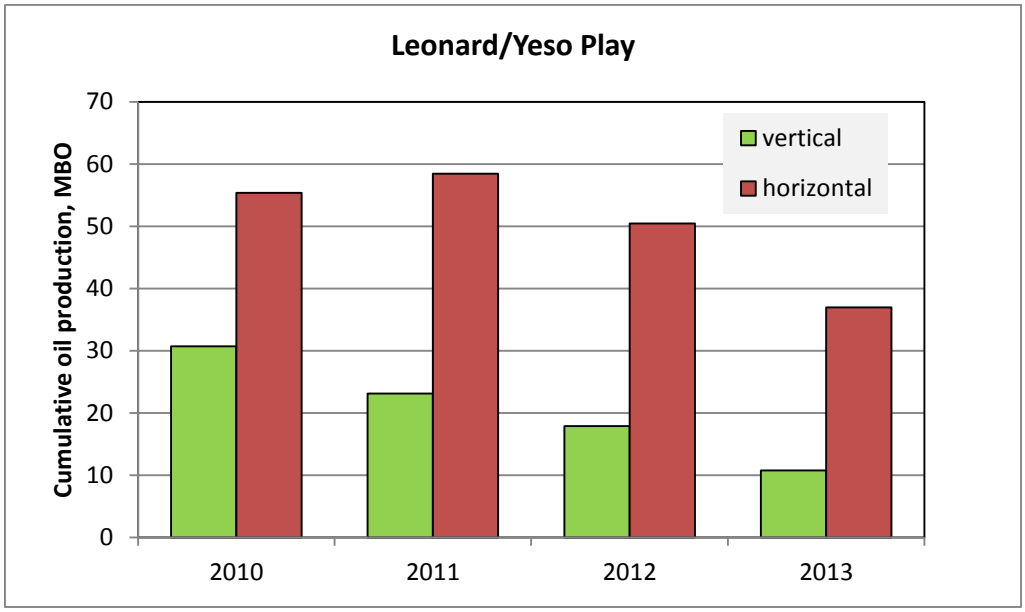


Figure 8. Comparison of average horizontal and vertical cumulative oil production per well based on year of beginning of production. (Data source: GOTECH)

Figure 8 illustrates the comparison between horizontal and vertical completions in the Yeso/Leonard play over the last four years. The horizontal:vertical production ratio has increased each year to a maximum of 3.4 in 2013. At the same time the percent of horizontal wells completed has increased from a low of 4% in 2010 to a high of 14% in 2013. The good performance indicates a likely trend of increasing horizontal well development in the Yeso shelf trend.

Delaware Mountain Group

Shown in Figures 9 and 10, is the Delaware Mountain Group activity for the same time period. Again, the development is well-defined within the center of the basin and thus the high potential region accurately captures this activity. No changes were made to the previous potential map. However, as mentioned in the meeting (7/15/2014) the Secretary's Potash Area has significant potential that has not been developed. A separate discussion on the potash area is later in this report.

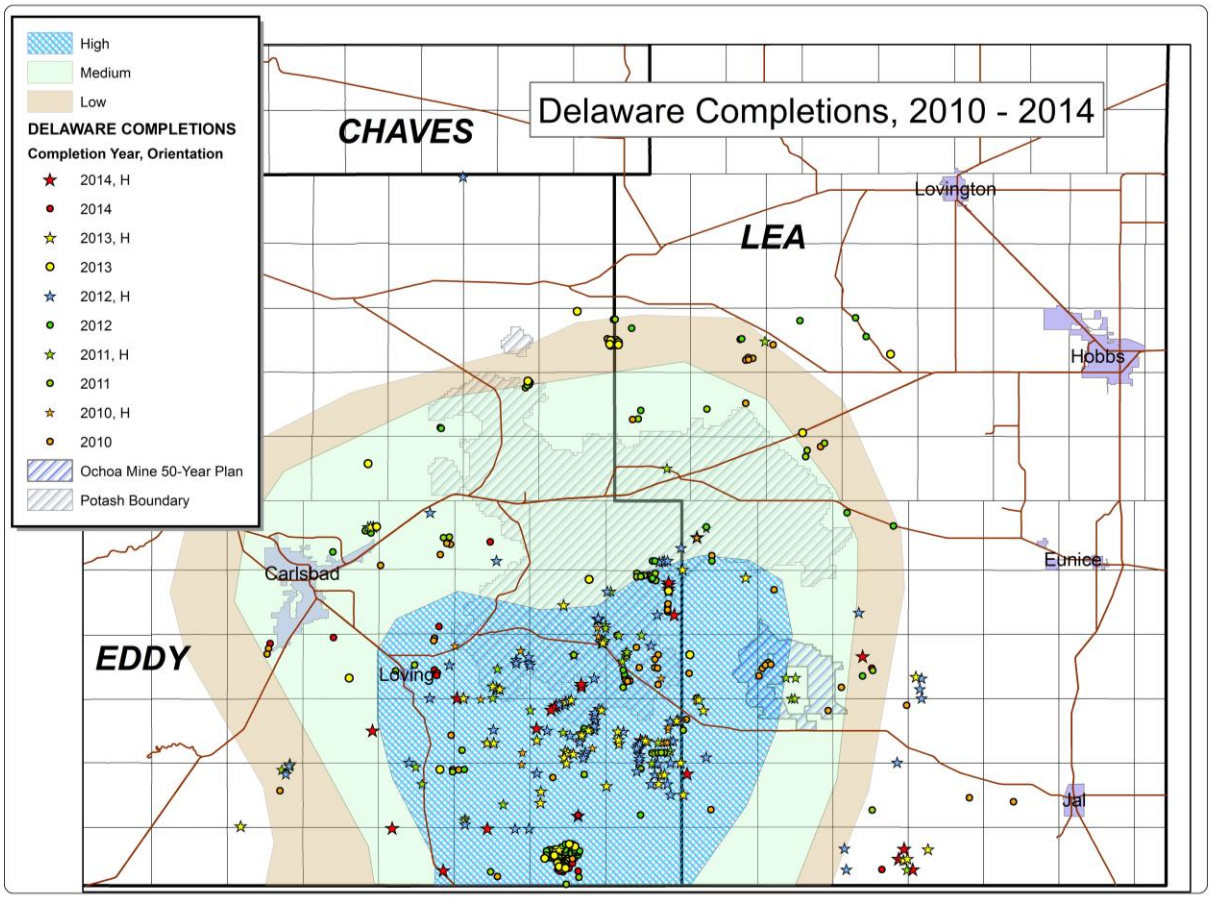


Figure 9. Map of completions in Delaware Formation from 2010 through July 2014. Symbols indicate horizontal (star) or vertical (circle) completion. Also shown are Secretary's Potash Area, Ochoa Mine Proposal, and original estimate of High, Moderate, and Low potential areas.

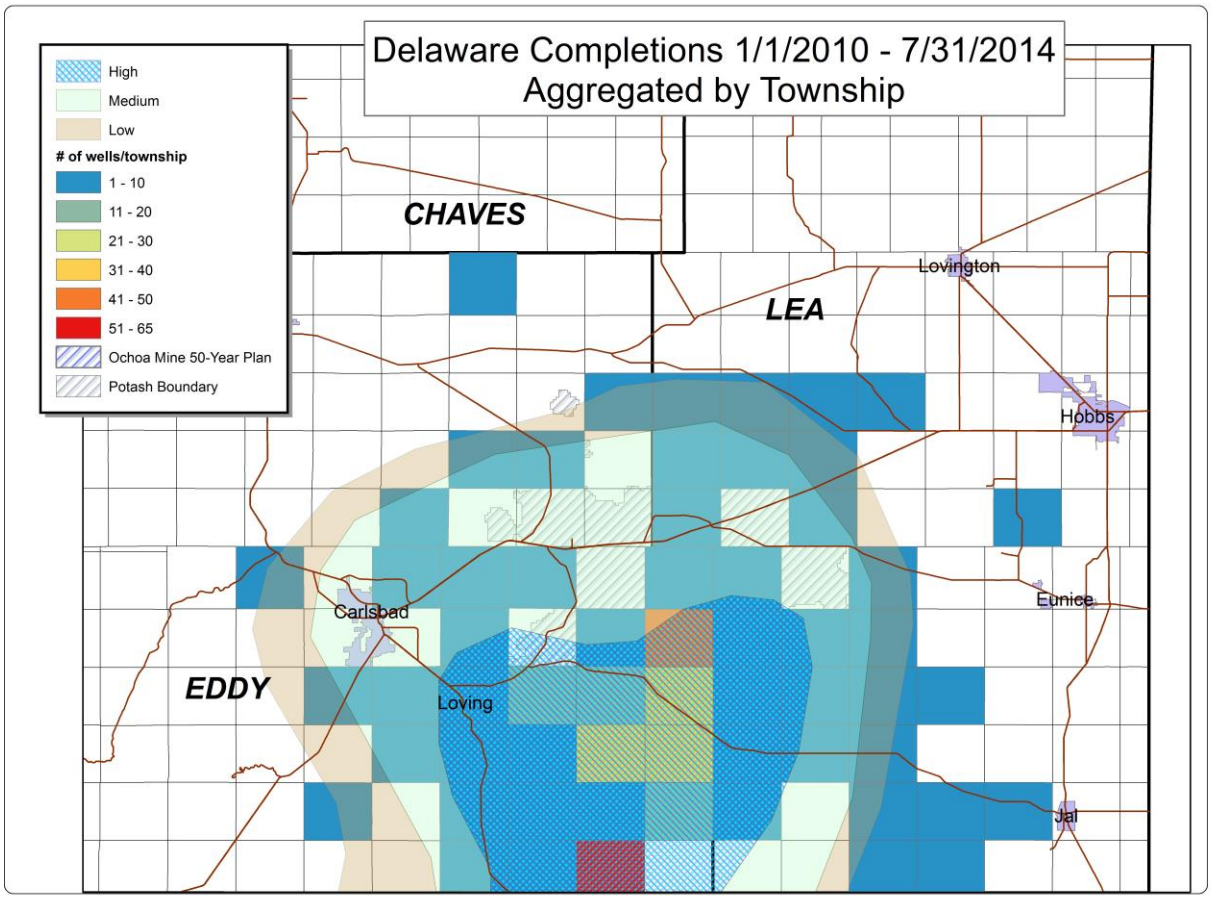


Figure 10 Cumulative Delaware completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.

Wolfcamp Play

Development since 2010 in the Wolfcamp is shown in Figure 11, superimposed on the original potential regions proposed in the previous report. The Wolfcamp (aka Lower Basal Abo) activity in the north part of the map area was captured reasonable well by the moderate potential region. However, recent successful activity south of the New Mexico – Texas stateline has been encouraging and as a result industry has indicated a high interest in the Wolfcamp along the stateline.

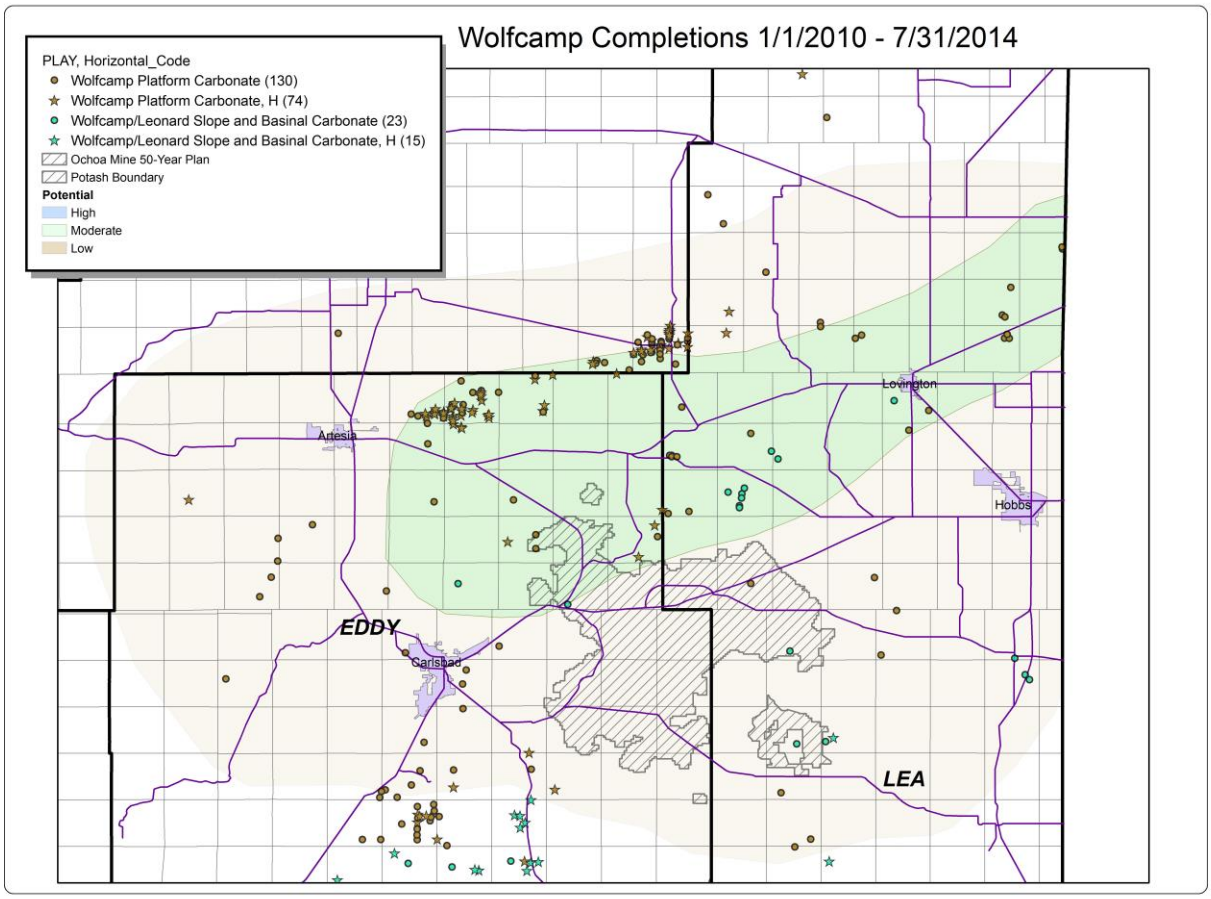


Figure 11. Map of completions in the Wolfcamp Formation from 2010 through July 2014. Symbols indicate horizontal (star) or vertical (circle) completion. Also shown are Secretary's Potash Area, Ochoa Mine Proposal, and original estimate of High, Moderate, and Low potential areas.

A density map of cumulative Wolfcamp completions over the last 4 ½ years is shown in Figure 12. Both areas of activity, along the northern shelf edge and the stateline are shown on this map. To date, the activity level is rather low, with 242 total wells completed (36% horizontal) over the 4 ½ years and well density of < 5 per township.

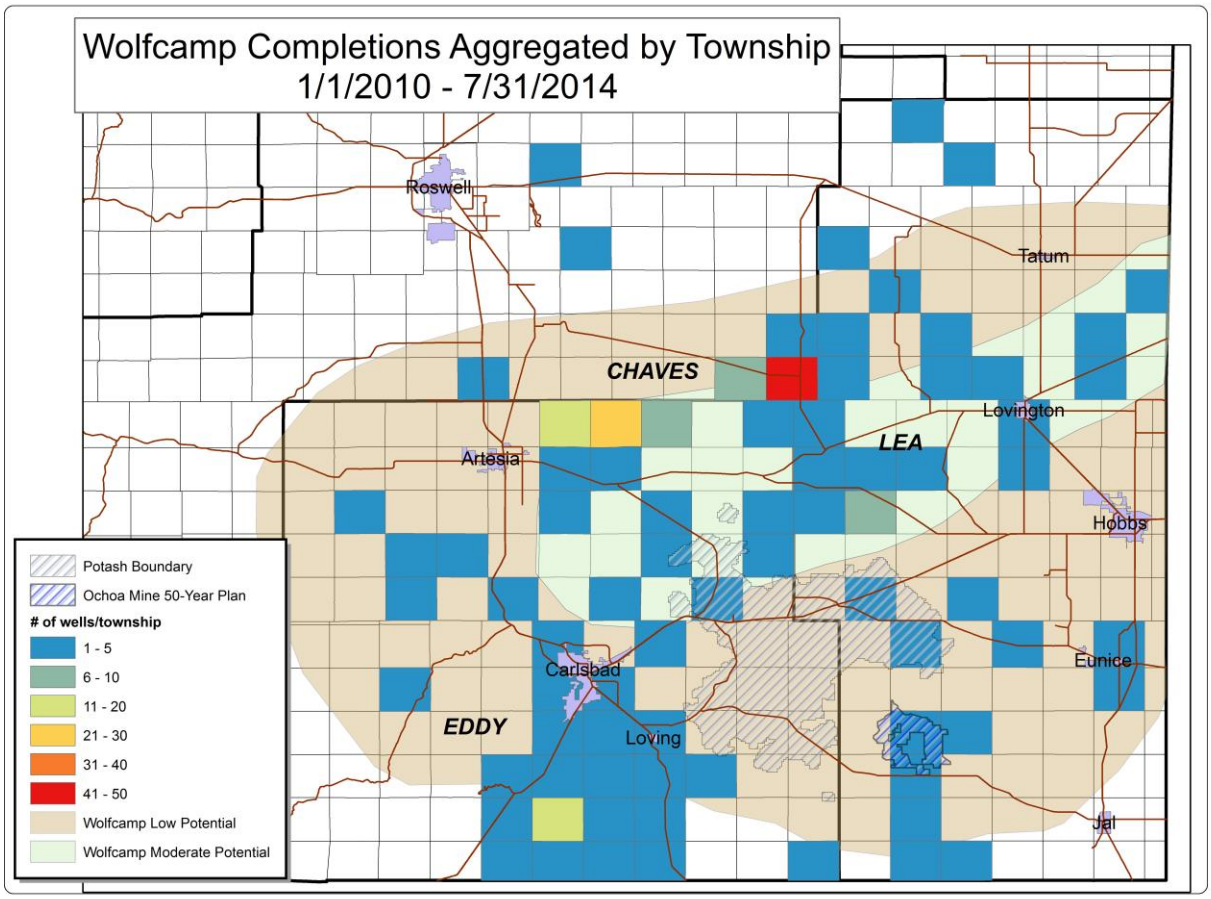


Figure 12 Cumulative Wolfcamp completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.

An updated Wolfcamp potential map has been generated to account for the possible future development along the stateline. Figure 13 includes two additional shaded regions indicating current activity and future potential.

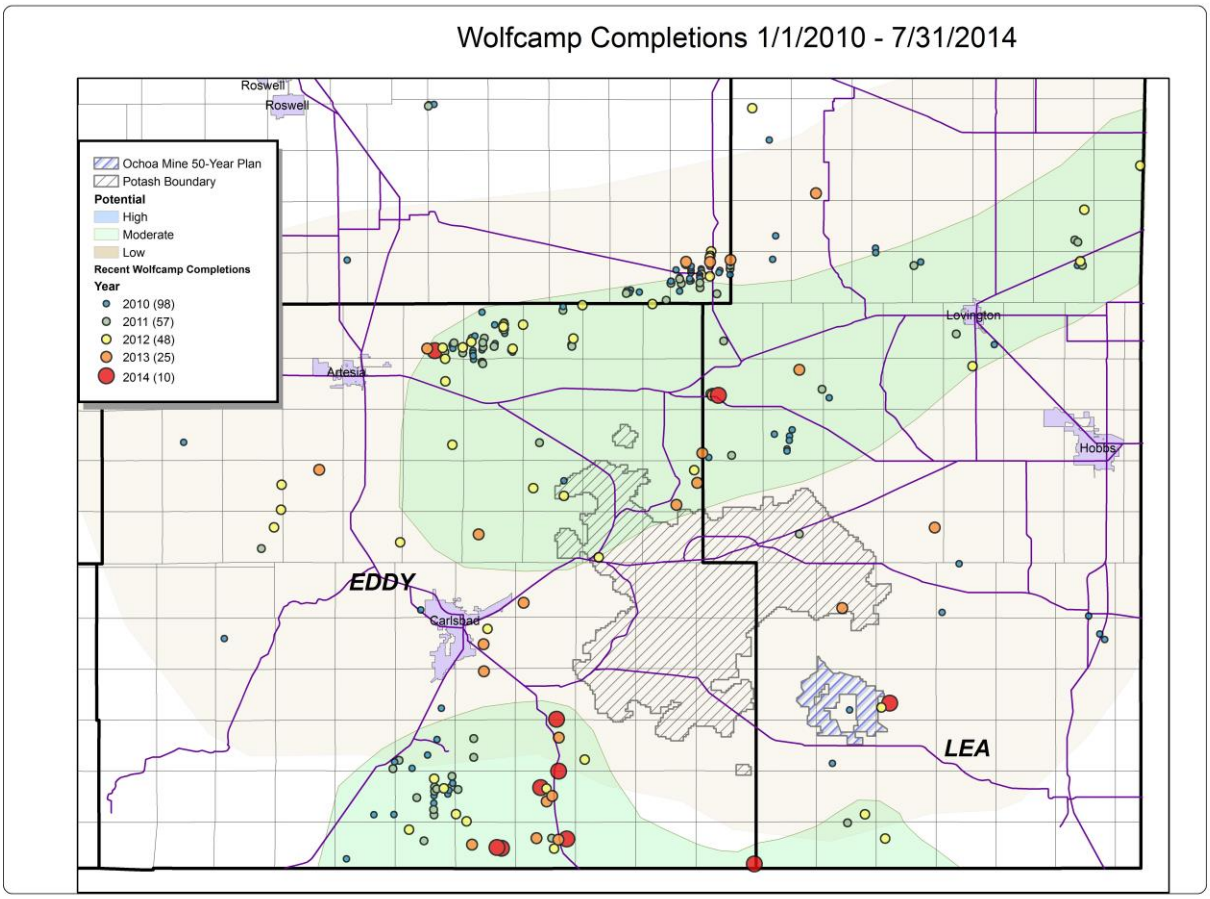


Figure 13. Updated potential map for the Wolfcamp play.

Remaining Plays

Activity in all other plays was combined together and is shown in Figures 14 and 15, respectively. The majority of wells in this group are completed in one of the Grayburg – San Andres trends: Upper San Andres and Grayburg Platform Mixed—Artesia Vacuum Trend, Upper San Andres and Grayburg Platform Mixed—Central Basin Platform Trend, and the Northwest Shelf San Andres Platform Carbonate trend. Since the San Andres/Grayburg development is well-defined and since most if not all wells are infill development, the activity coincides with the predicted potential areas (see Figure 14).

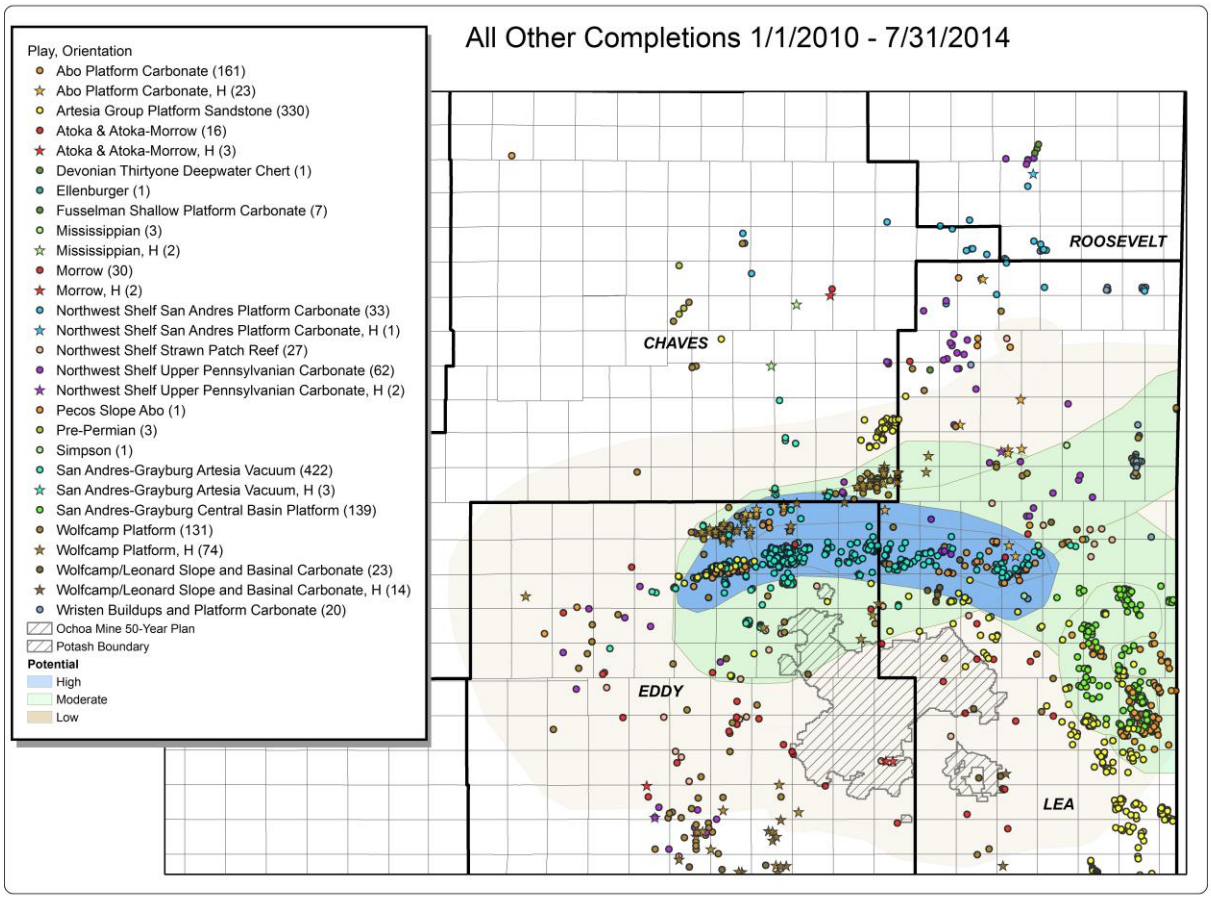


Figure 14. Map of completions in other plays from 2010 through July 2014. Symbols indicate horizontal (star) or vertical (circle) completion. Also shown are Secretary's Potash Area, Ochoa Mine Proposal, and original estimate of High, Moderate, and Low potential areas

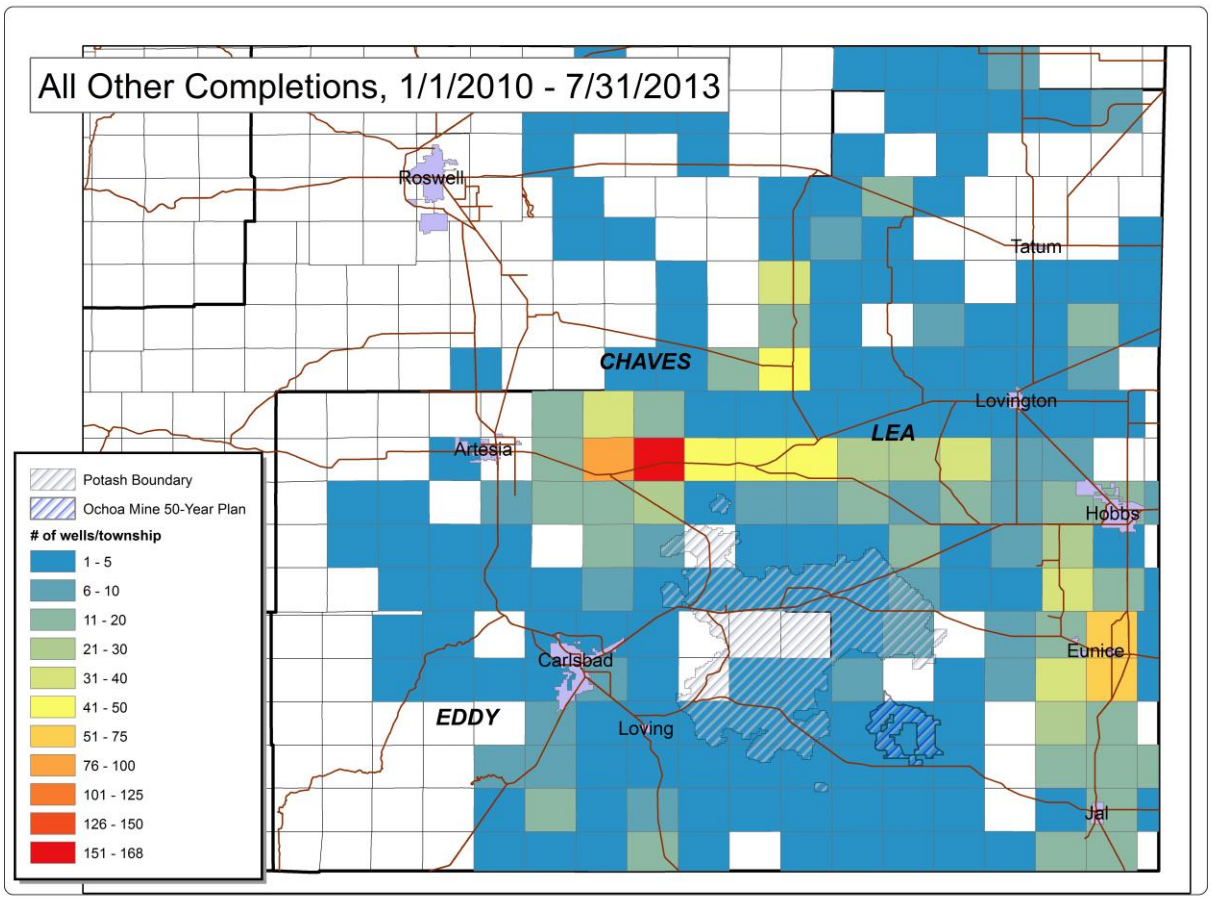


Figure 15 Cumulative other completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.

Special Issues

Secretary's Potash Area

A report by Balch, et al, 2009 applied geologic understanding of the area with historic production data to estimate the potential in the Secretary's Potash Area. Major existing plays that would likely see an immediate increase in development include the Brushy Canyon Formation in the Delaware Mountain Group play and the Bone Spring play. In addition, mature plays such as the Artesia Group would likely have renewed interest within the currently restricted areas of the reserve and with increased natural gas prices, the Morrow as well.

An example is highlighted in Figure 16. It is easily seen that there are gaps in development of the Bone Spring in the potash area. The areas indicated with red circles are surrounded by significant and productive Bone Spring development.

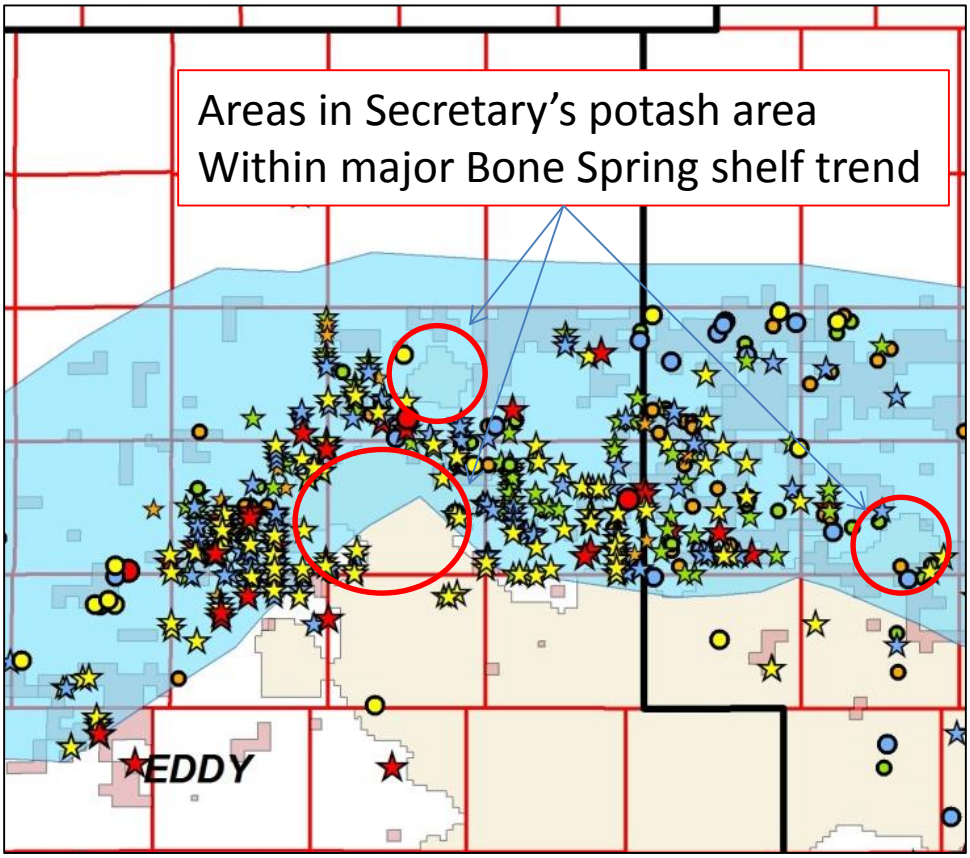


Figure 16. Expanded view from Fig 1 of Bone Spring shelf trend illustrating areas of lack of Bone Spring development within the Potash area.

A solution to co-develop both the oil /gas and Potash resources is to promote the use of "drill islands" within the designated area. Drill islands are multiwall pads that minimize the surface and near-surface disturbance while simultaneously allowing development of deeper oil and gas

resources. They are especially well-suited for horizontal drilling, which can develop large tracts of land from a single island.

A detailed study of the Potash area is beyond the scope of this work; however, evidence supports potential in both the Bone Spring and Delaware plays. A moderate potential exists along the fringe of the Potash area for the Bone Spring, and reduces to a low potential towards the center. The moderate potential is based on current development around the perimeter. The center with less development and higher geologic risk has a lower potential. The Delaware (particularly the Brushy Canyon), has higher potential along the southern portion of the Potash area and then decreases northward. The extent of the higher potential regions can move northward if future development; i.e., drill islands, are successful.

Water usage for fracing

Frac fluid volumes were compiled by the NMOCD by county for all wells and all plays for 2013. Table 1 is the results of this effort. [Martin, 2014]

County	Wells	Fluid, bbls	Acre Ft	bbls/well
Eddy	883	22,897,026	2,951	25,931
Lea	460	15,956,755	2,057	34,689
Rio Arriba	93	870,719	112	9,363
San Juan	92	692,740	89	7,530
Sandoval	38	655,439	84	17,248
Other*	17	243,756	31	7,466
TOTAL		**41,316,434**	**5,325**	

* Other includes Chaves, McKinley, and Roosevelt Counties

Source: OCD

Table 1. 2013 Frac Fluid Volumes (Source NMOCD)

For this report a detailed study was made for the Bone Spring completions in 2013. To estimate water usage for stimulation, data must be manually collected from the NMOCD Frac Disclosure forms for each well. Figures 17-19 were constructed from new well completions in the Bone Spring Formation for 2013 only. Information for 434 wells was available; resulting in an average use of 57 Mbbls of water per well. This average is significantly greater than the OCD study of 26 Mbbls/well and 35 Mbbls/well from Eddy and Lea counties, respectively. The difference is due to the OCD study including all wells; i.e., all producing horizons and both vertical and horizontal completions; while this report focused only on the Bone Spring play. The Bone Spring was selected because of its dominance in current activity, its likelihood to be in the future as well, and due to the majority of completions being horizontal.The distribution is shown in Figure 17 below.

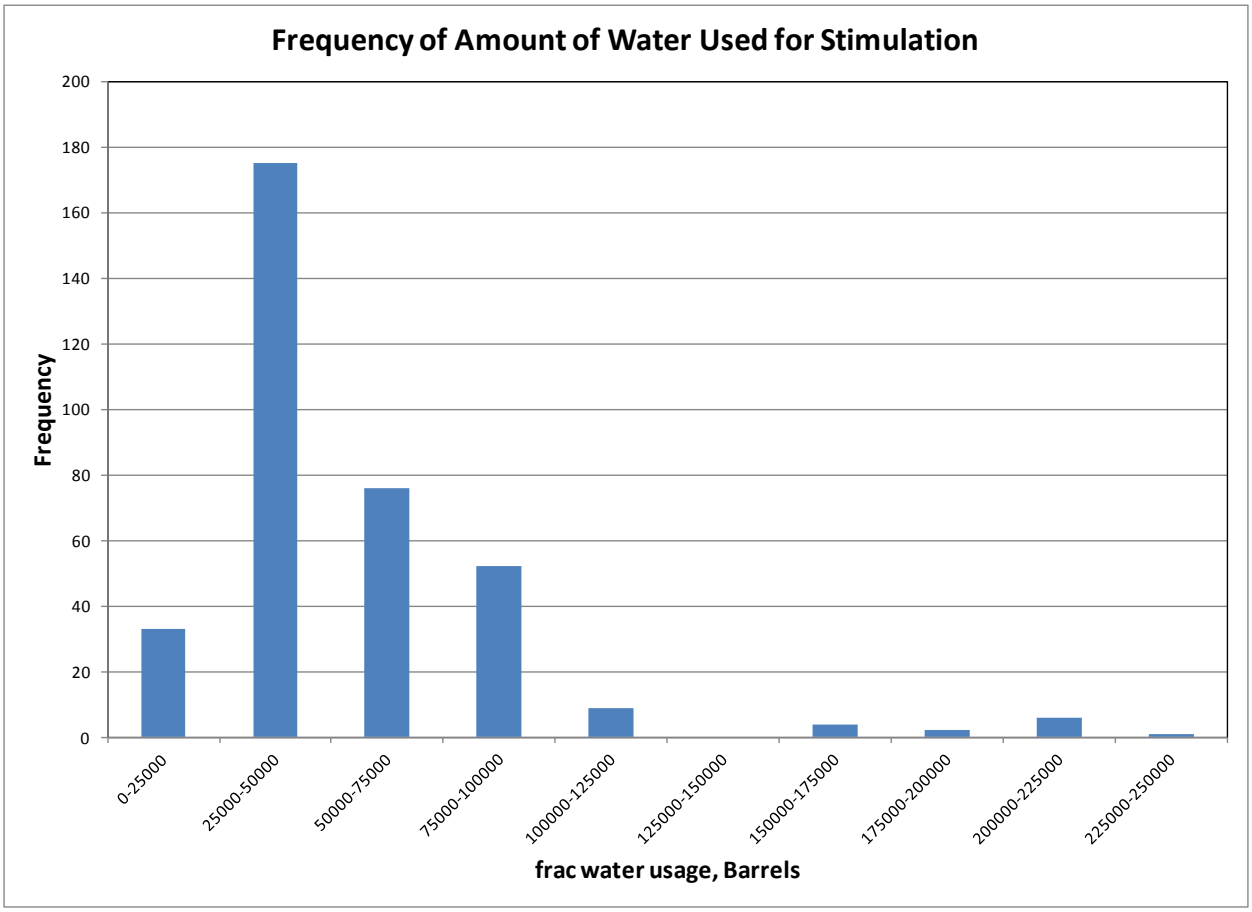


Figure 17. Histogram of frac water usage in barrels vs frequency for a bin range of 25,000. (Source: Frac Disclosure forms from NMOCD)

The same data set is shown as a function of operator (Fig. 18) and pool (Fig. 19). The pronounced volume of EOG Resources stimulation in the Red Hills (Upper Bone Spring Shale) pool is evident from the graphs.

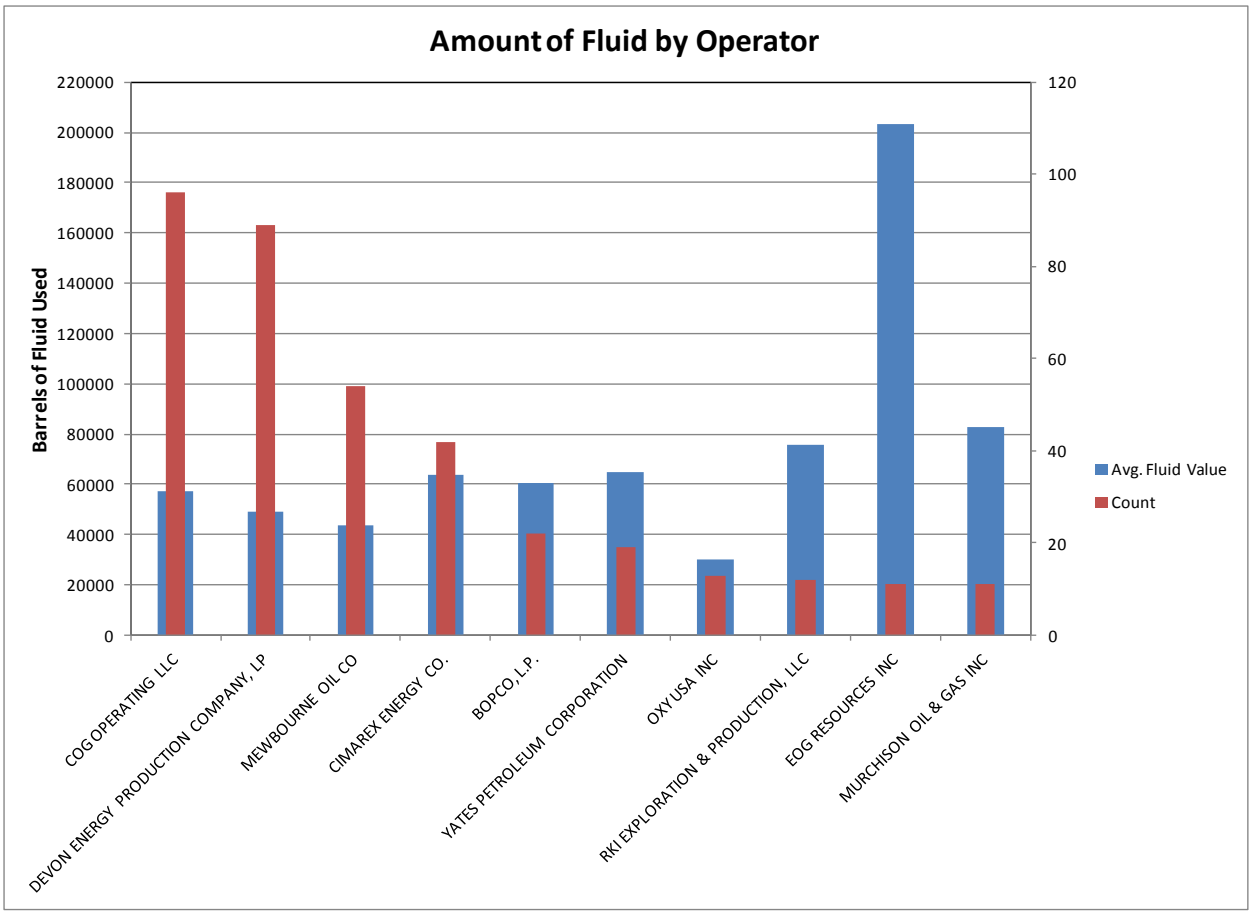


Figure 18. Histogram of frac water usage in barrels as a function of operator , minimum count of 10 wells (Source: Frac Disclosure forms from NMOCD)

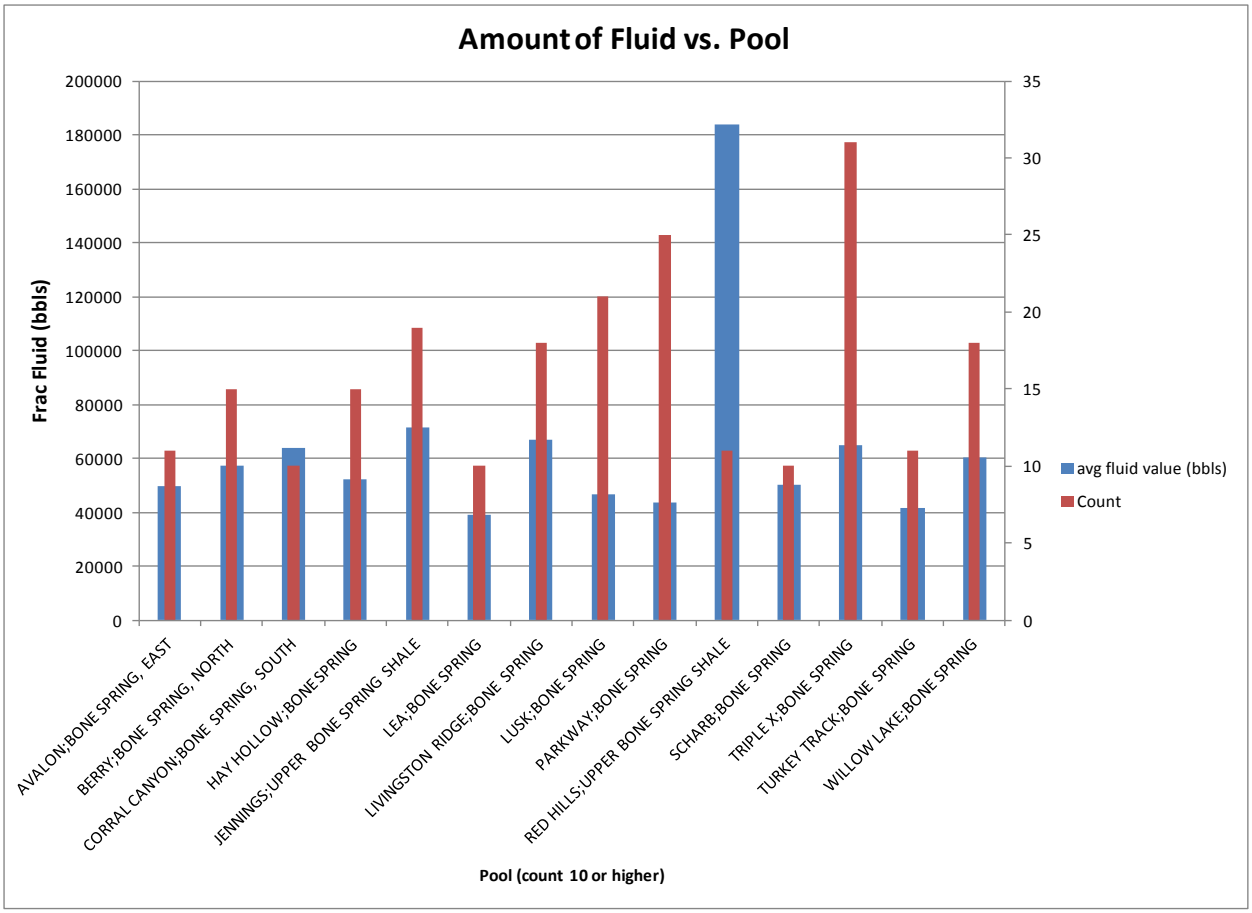


Figure 19. Histogram of frac water usage in barrels as a function of pools , minimum count of 10 wells (Source: Frac Disclosure forms from NMOCD)

Conclusions

This update report has used more recent data to reevaluate the potential development regions in southeast New Mexico plays defined in the 2012 report. The 2012 report was based on data through the end of 2010. Most trends noted in the earlier report have held up fairly well; however there were a few exceptions. The most notable differences between the initially estimated activity and current drilling appears to be in the Bone Spring play. Although an increase in the importance of horizontal drilling was noted in the original report, horizontal activity has been much more active in a broader areal expanse than originally anticipated. The Leonard Restricted platform play has shown a limited increase in activity in the south westernmost part of the region that was not captured in the original report. Likewise, the anticipated increase in Wolfcamp development along the New Mexico – Texas stateline has been included in this study. Polygons of predicted potential development have been redefined for all of these plays.

Oil and gas resources in the Secretary's Potash Area will continue to be sought after for development. Both the Bone Spring and Delaware plays have potential in this area, and industry has indicated a desire to develop. A solution to co-develop both the oil /gas and Potash resources is to promote the use of "drill islands" within the designated area. They are especially well-suited for horizontal drilling, which can develop large tracts of land from a single island and simultaneously reduce the surface to near-surface footprint.

According to a study by the NMOCD, average fresh water usage for stimulation in Eddy County is 25 Mbbls or 3.2 acre-feet per well and for Lea county 35 Mbbls or 4.5 acre-feet per well. Their study included all plays and all wells, vertical and horizontal. A detailed study of only Bone Spring completions in 2013 resulted in an average usage of 57 Mbbls or 7.3 acre-feet per well. This greater value for Bone Spring is due to the multistage hydraulic fracturing of a horizontal well which is the preferred completion method for this play. To reduce the usage of fresh water, efforts by many operators are to use flowback and/or produced water. Technology has advanced such that creating an effective frac fluid is feasible from brackish/saline fluids. Furthermore, production performance results are encouraging, being as good if not better than previous. As a result, this trend is expected to continue.

References

Robert S. Balch, Martha Cather, and Vidya Bammidi: “Oil and Gas Potential Analysis of the Secretary of the Interior’s Potash Area, Southeastern New Mexico”, PRRC Report 09-07, nov 2009

David Martin, Secretary of the Energy, Minerals & Natural Resources Department: “Priority Issues in the Energy, Minerals and Natural Resources Department Related to Energy and Extractive Industries”, presented at the Association of Commerce and Industry Energy & Extractive Industry Policy Committee (May 2, 2014)

Appendix A – Development by Operator

In addition to the statistical analysis, industry input was solicited on where and to what degree they consider future activity to occur. For reference, Bone Spring activity listed by operator is shown in Figure A-1.

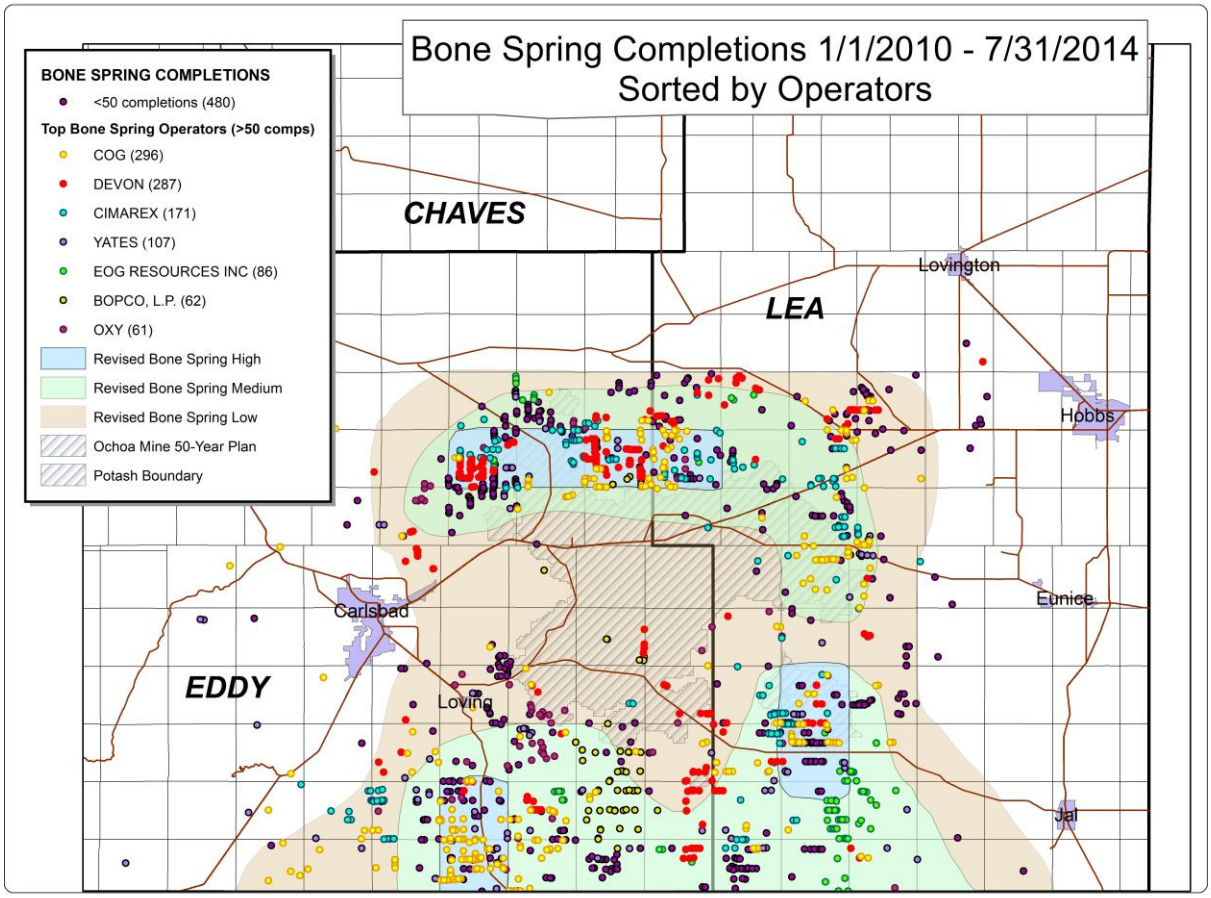


Figure A-1. Map of completions in Bone Spring from 2010 through July 2014 by operator. Also shown are Secretary's Potash Area, Ochoa mine proposal, and updated estimate of High, Moderate, and Low potential areas.

A review of the investor presentations for the most active producers in the Bone Spring revealed an estimated potential of over 15,000 locations for horizontal wells in this play. Overestimations are due to the positive nature of investor documents and the duplication of locations due to gross versus net acreage. However, evidence to support this high potential is the stacked pay of the Bone Spring providing numerous targets, and aligns with opinions from experts in area.

Several operators expressed potential in relatively undeveloped acreage. These areas have been added to the maps as low or moderate potential; however specifics will not be given to protect the confidentiality of the information.

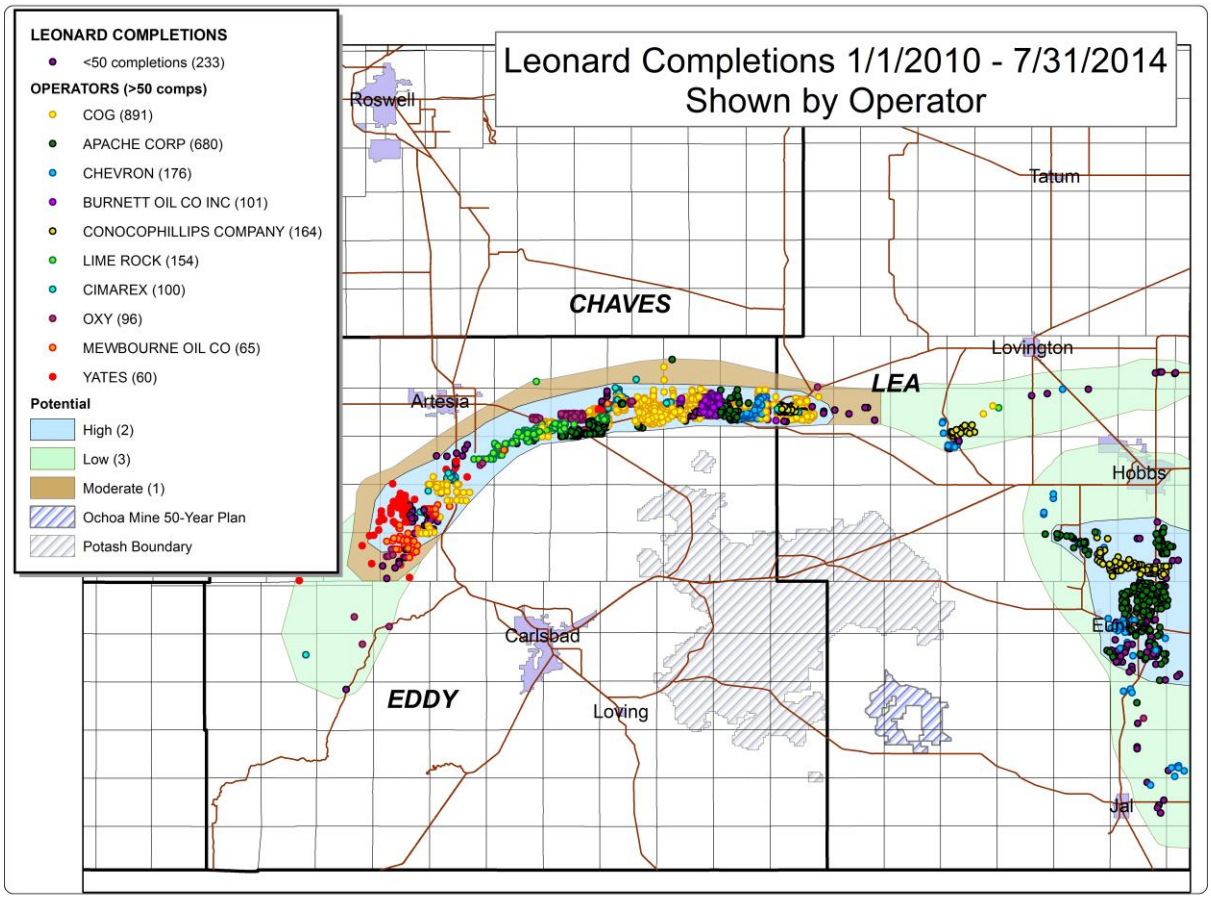


Figure A-2. Map of completions in the Leonard play (aka Glorieta-Yeso along the shelf edge) from 2010 through July 2014 by operator. Also shown are Secretary's Potash Area, Ochoa mine proposal, and updated estimate of High, Moderate, and Low potential areas.

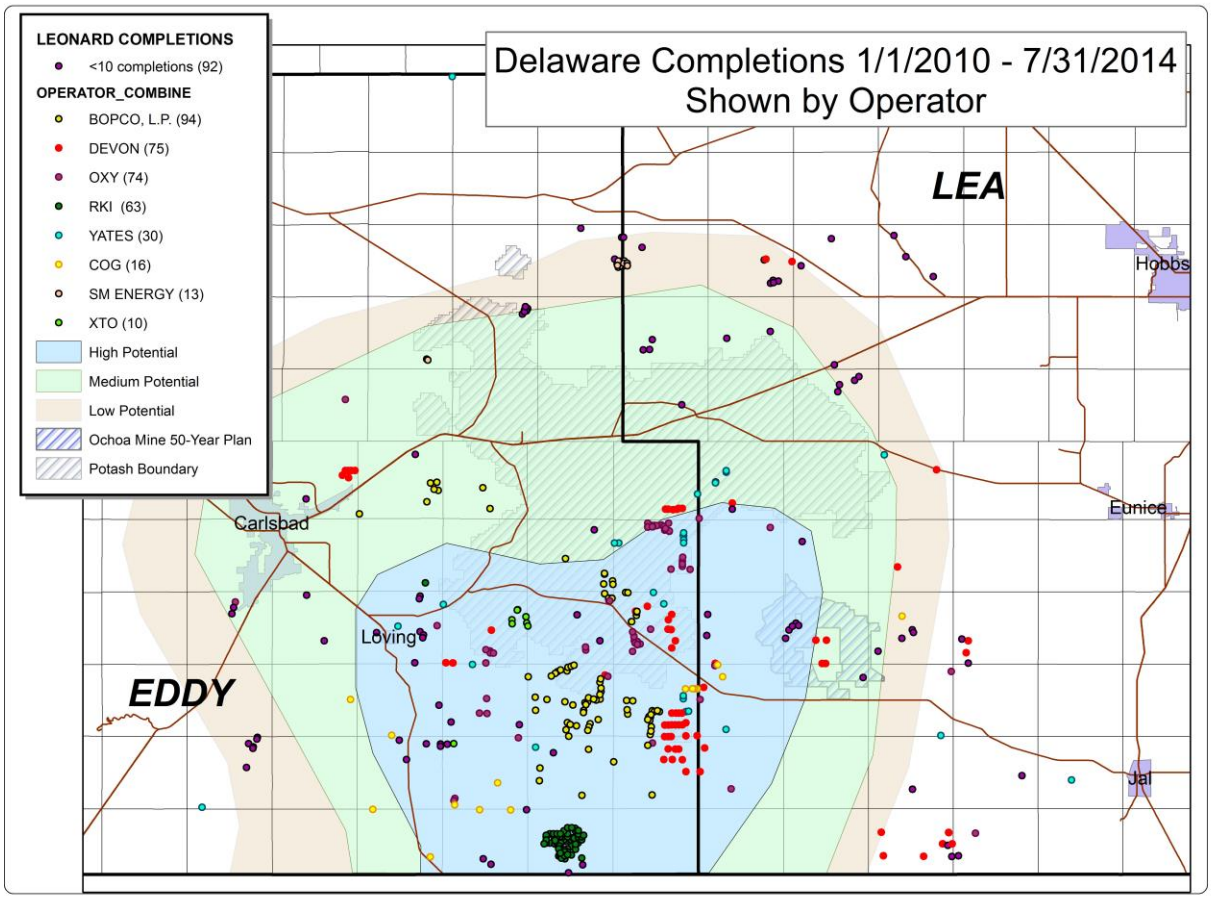
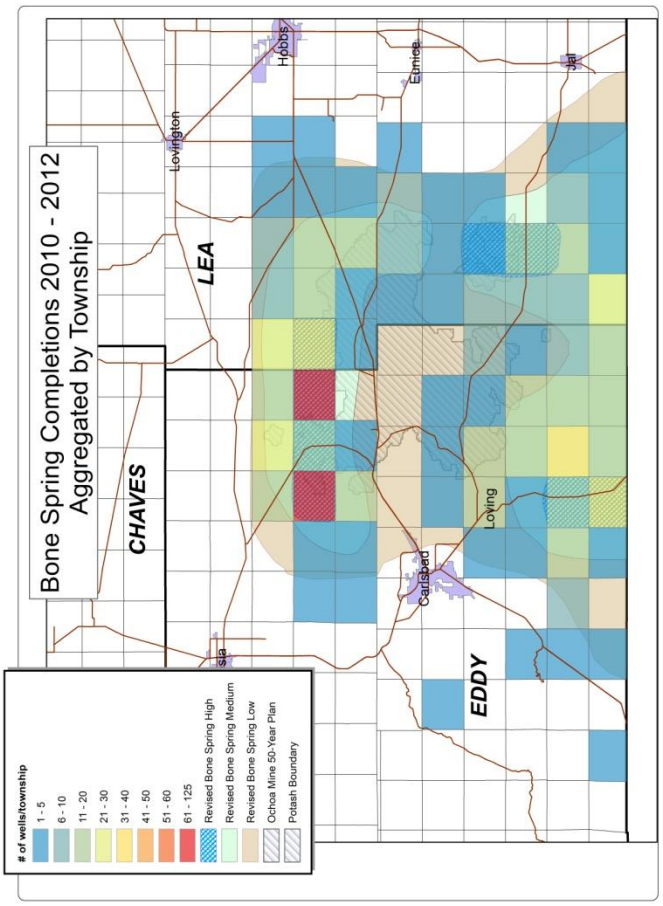
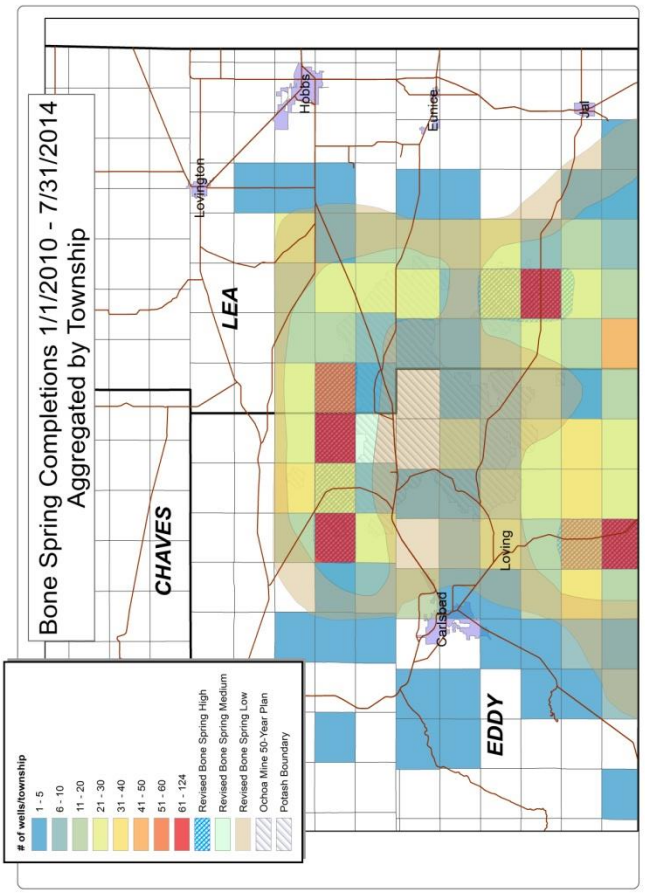
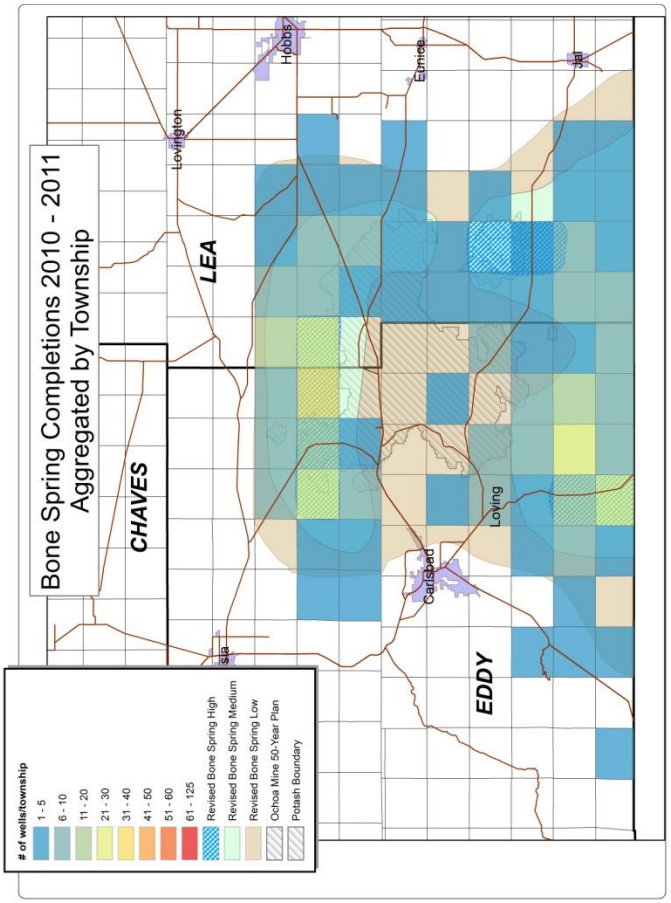


Figure A-3. Map of completions in the Delaware Mountain play from 2010 through July 2014 by operator. Also shown are Secretary's Potash Area, Ochoa mine proposal, and original estimate of High, Moderate, and Low potential areas.

B-1. Progression of cumulative Bone Spring completions from 2010







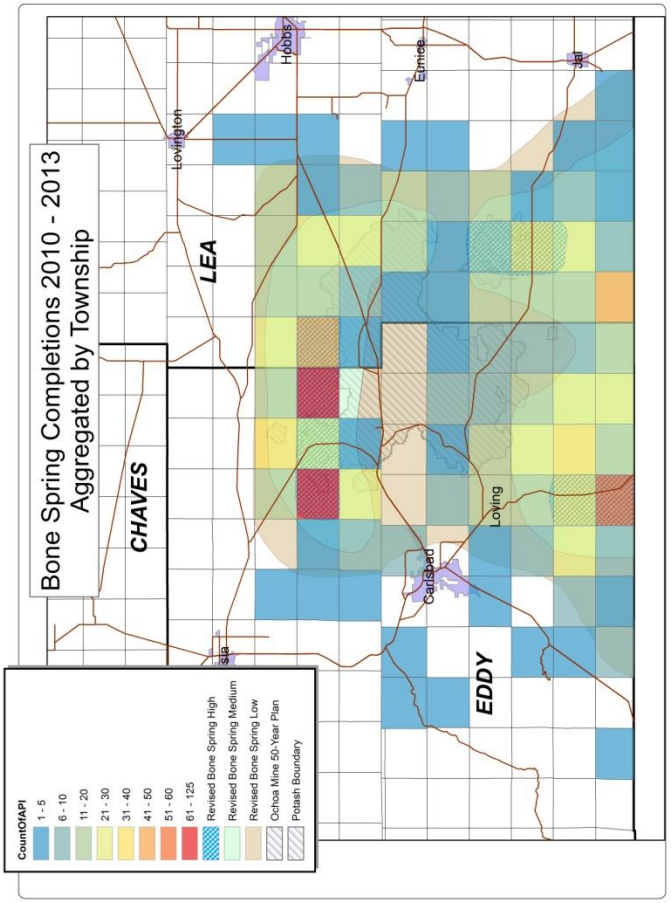
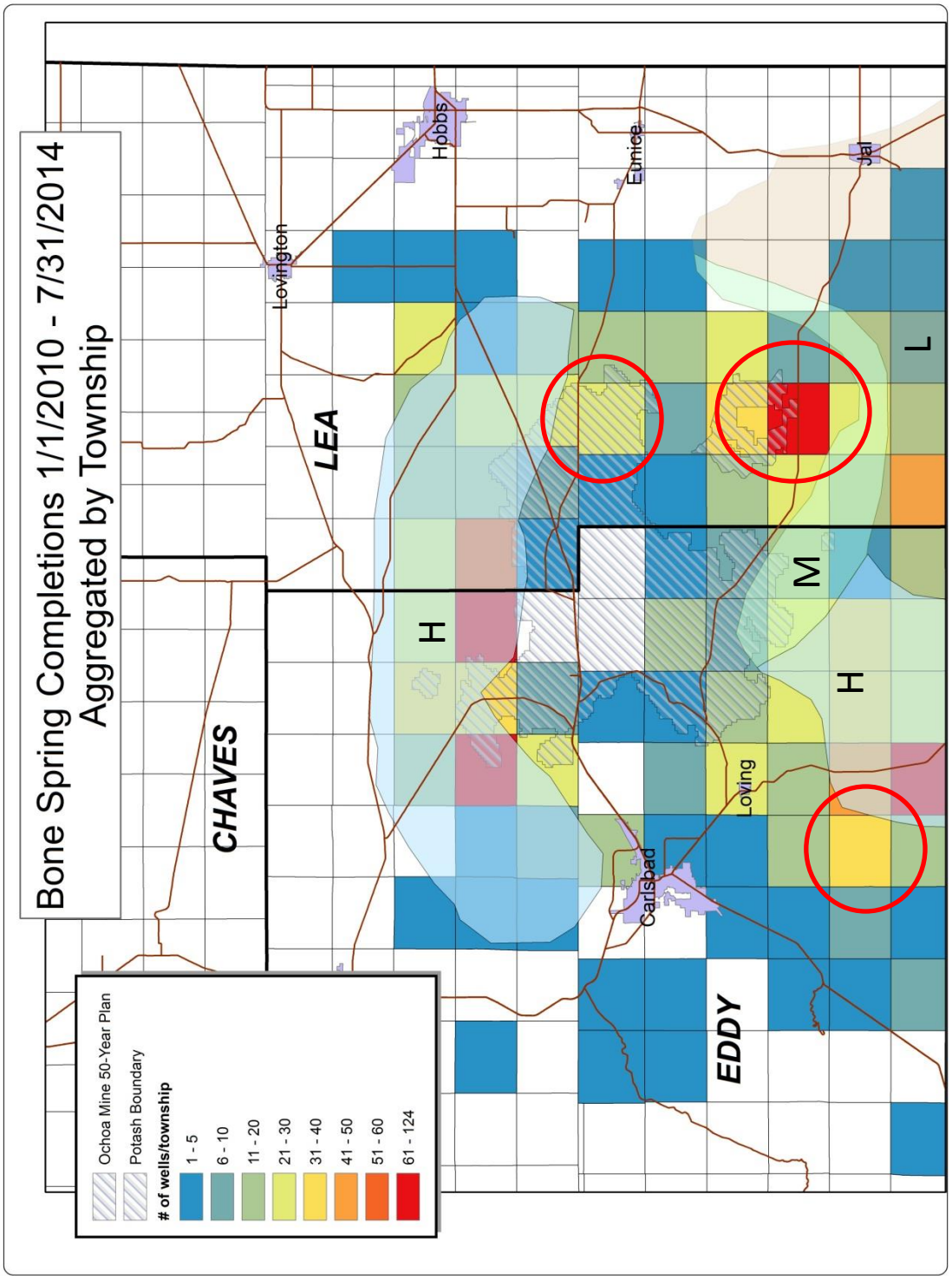
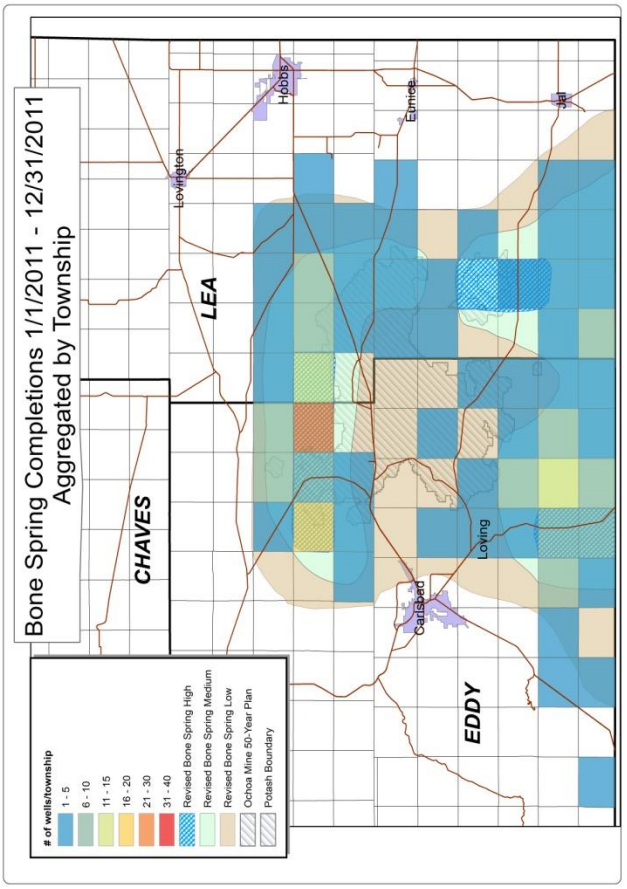
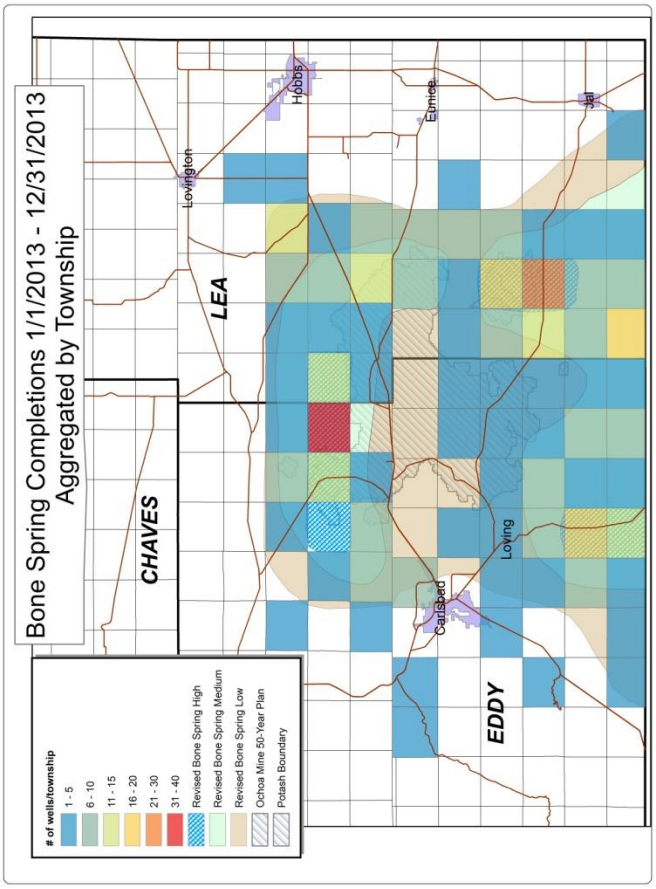


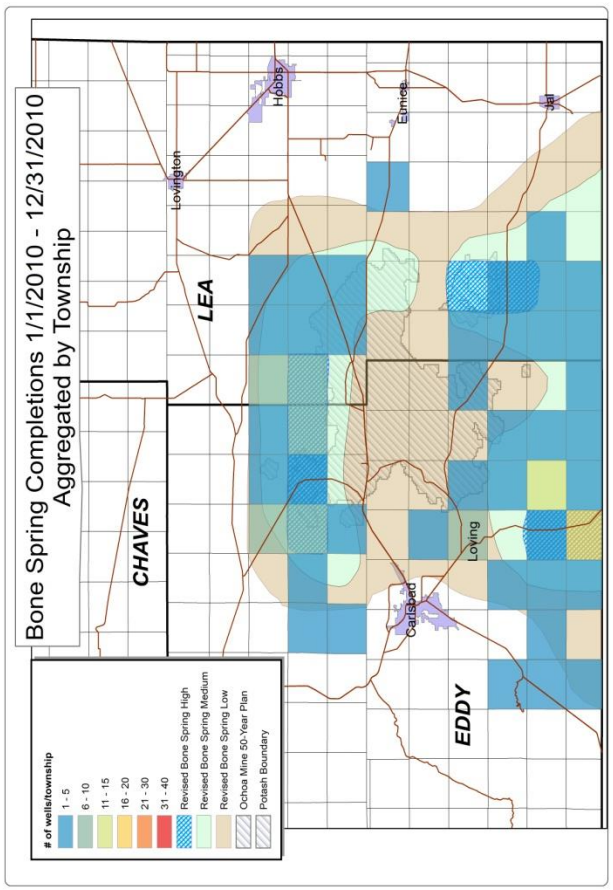
Figure 2 Cumulative Bone Spring completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions. Red circles indicate areas of activity not accounted for in the 2010 potential maps.

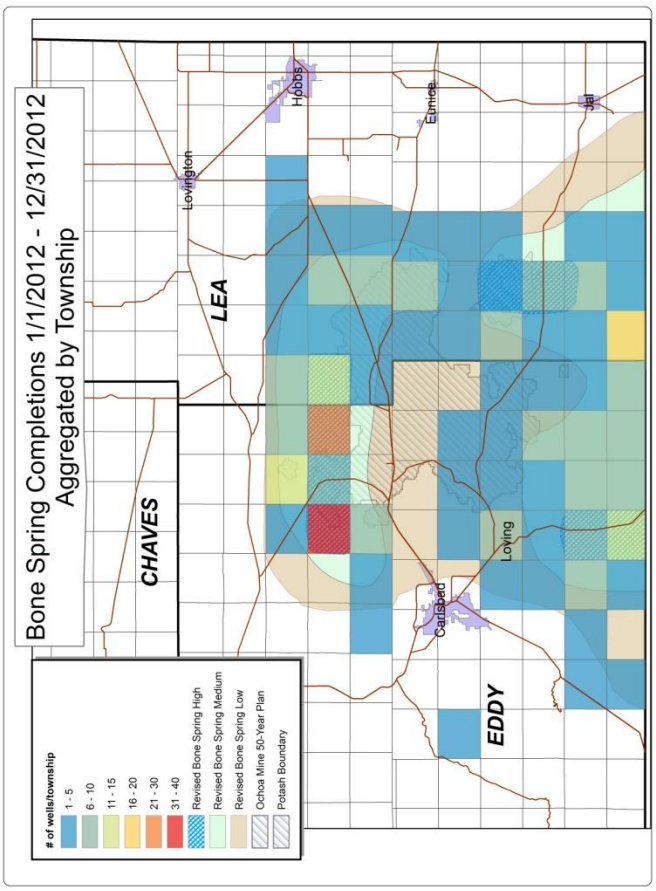


B-2. Annual Bone Spring completions by year from 2010 to 7/2014

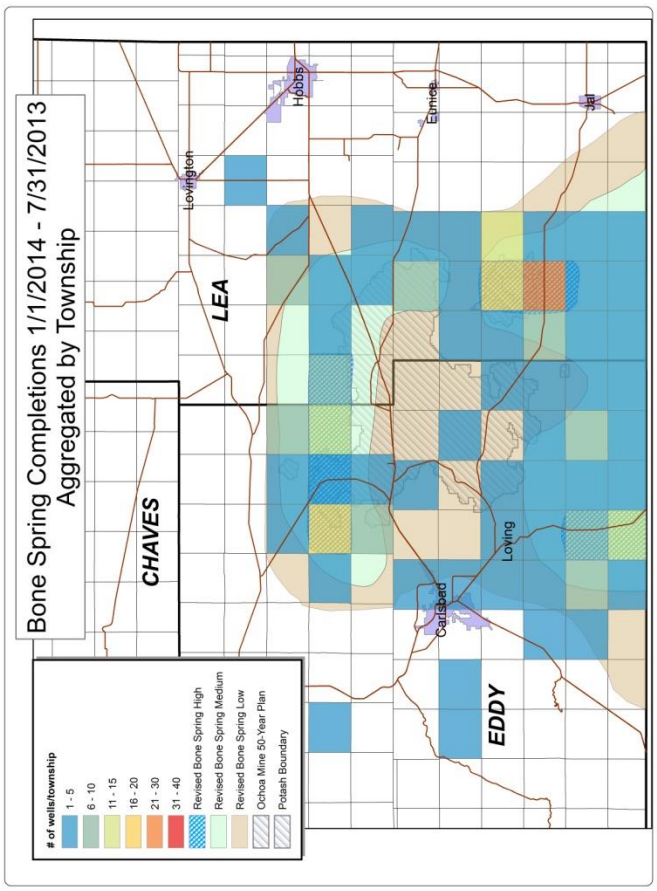








B-2. Annual Bone Spring completions by year from 2010 to 7/2014



B-3. Progression of cumulative Leonard completions from 2010

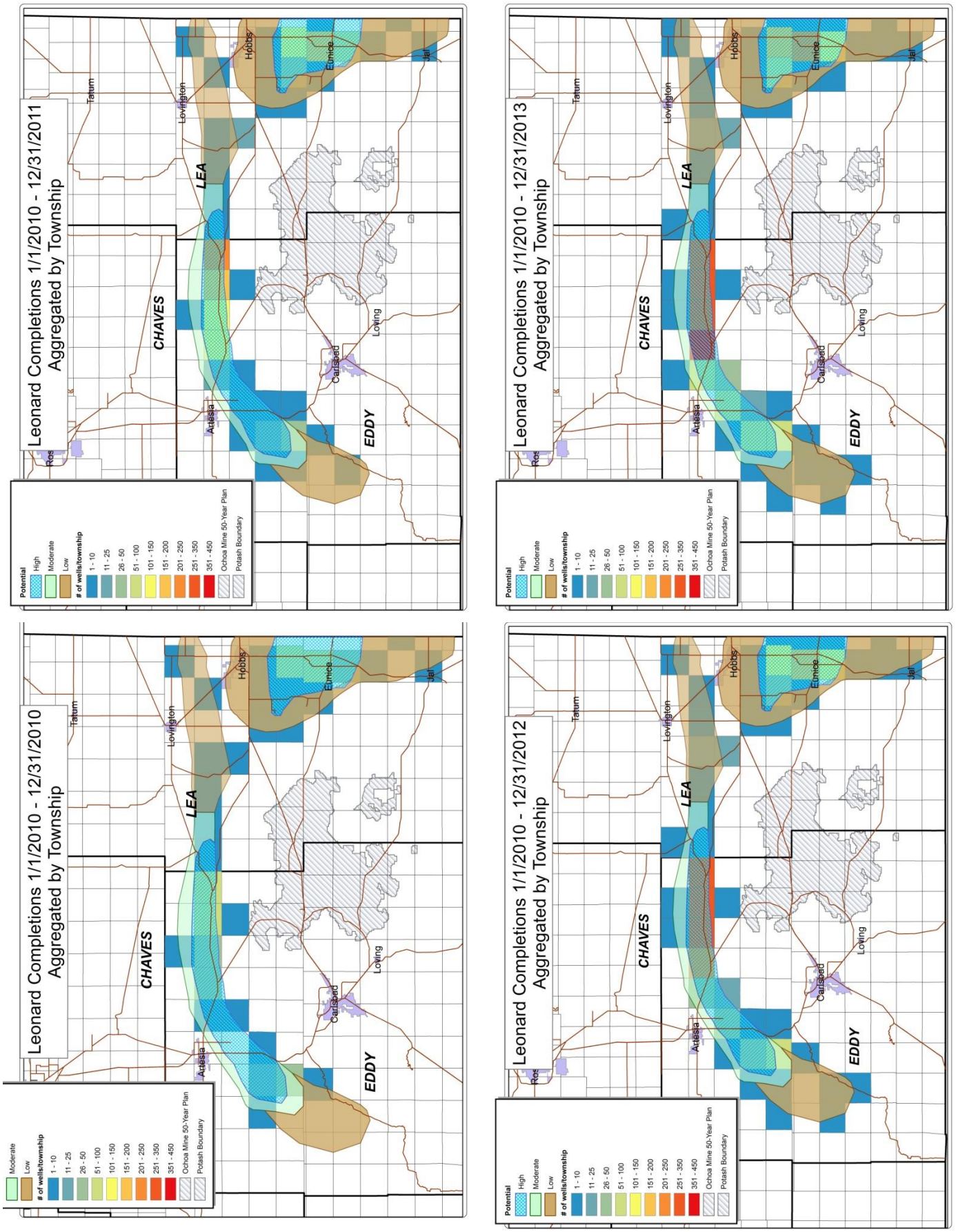
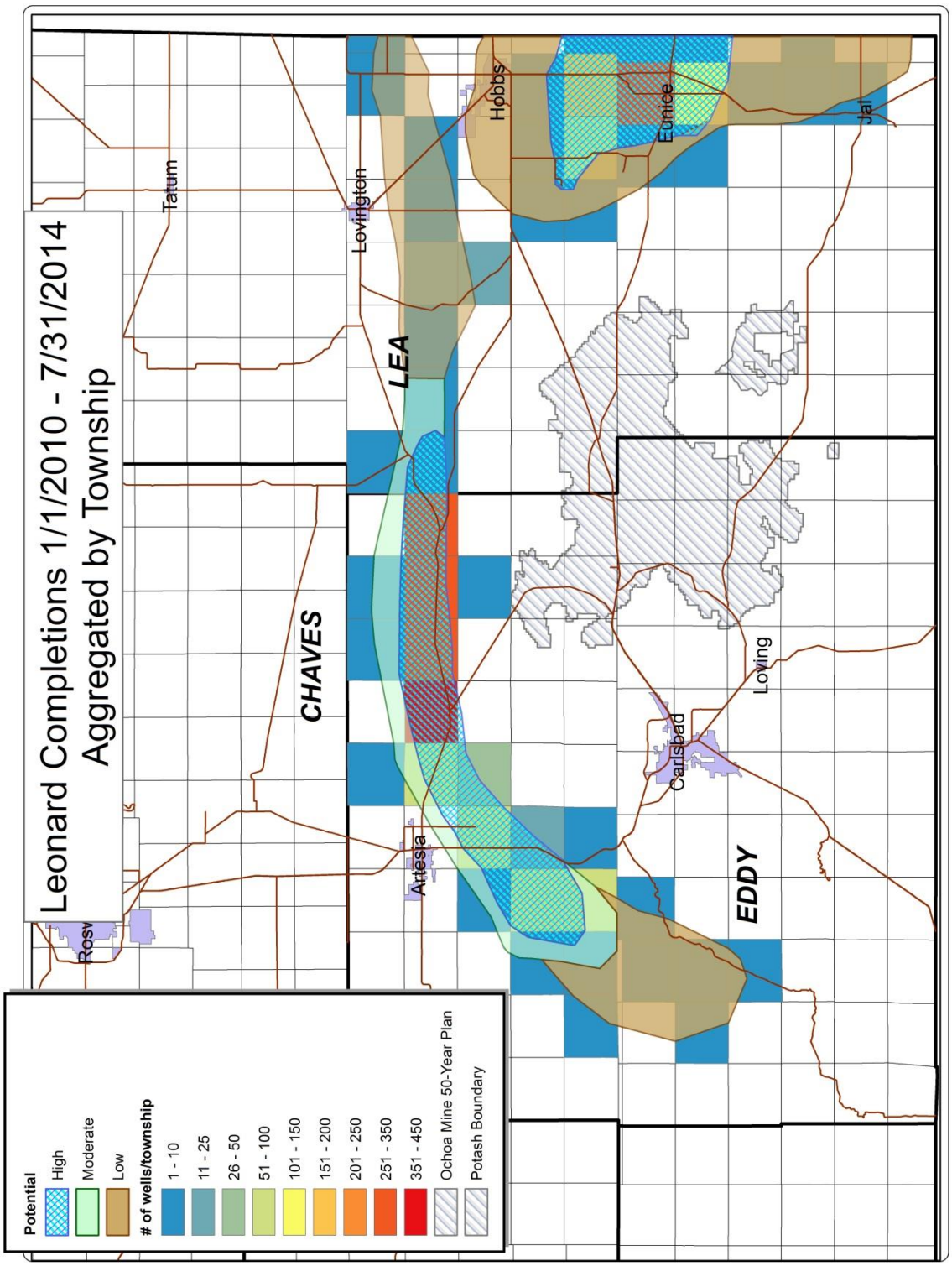
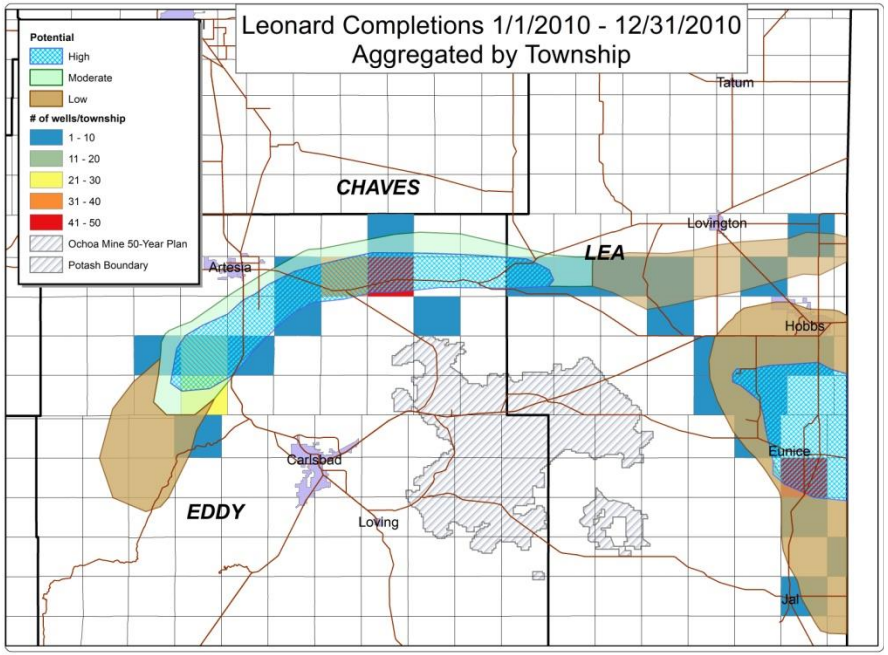
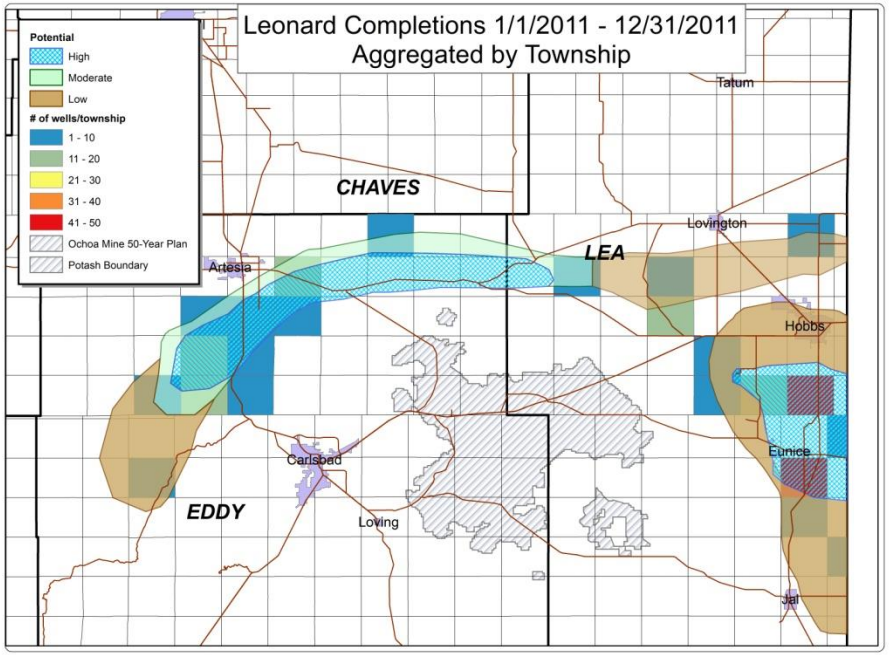
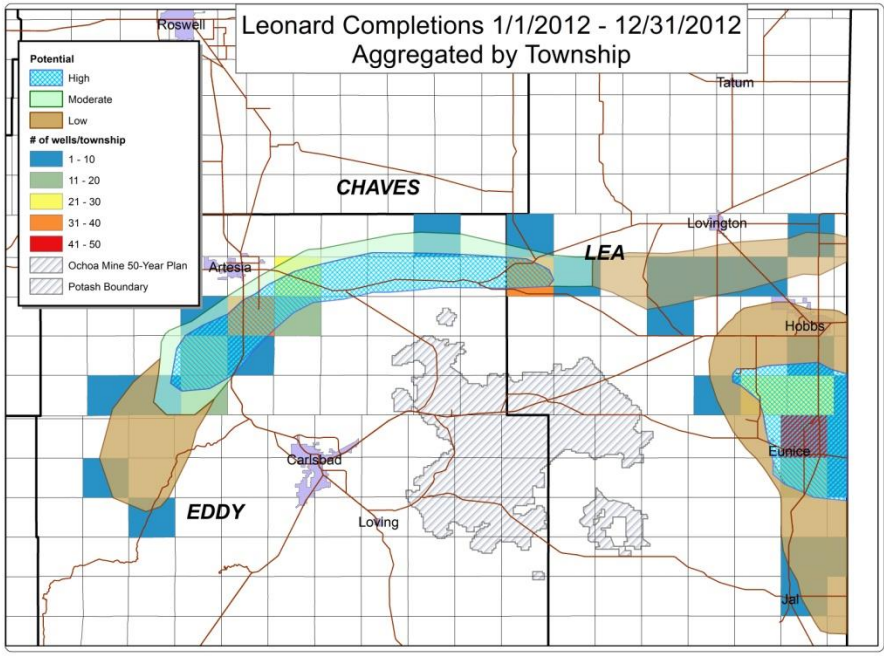


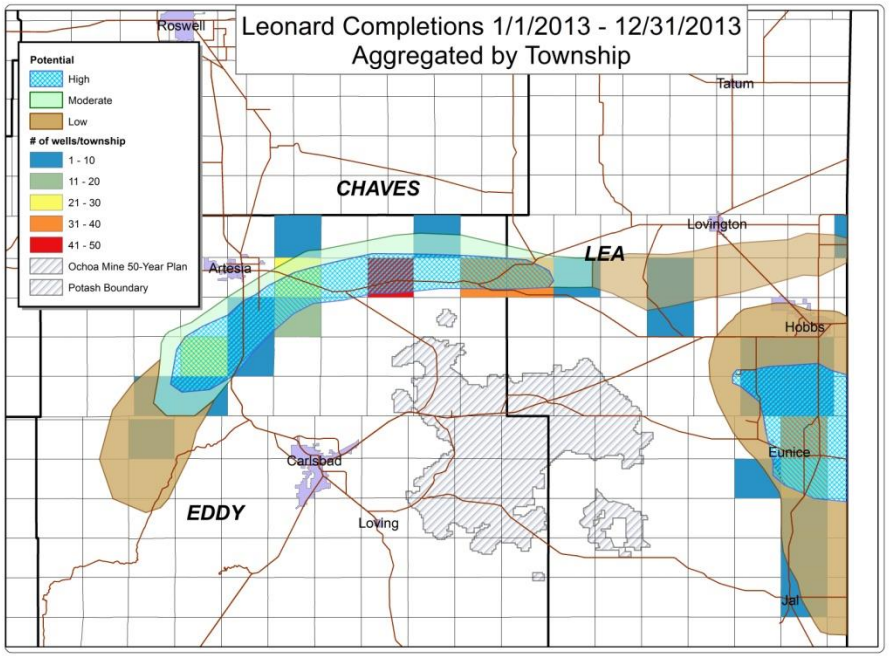
Figure 6 Cumulative Yeso/Leonard completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.





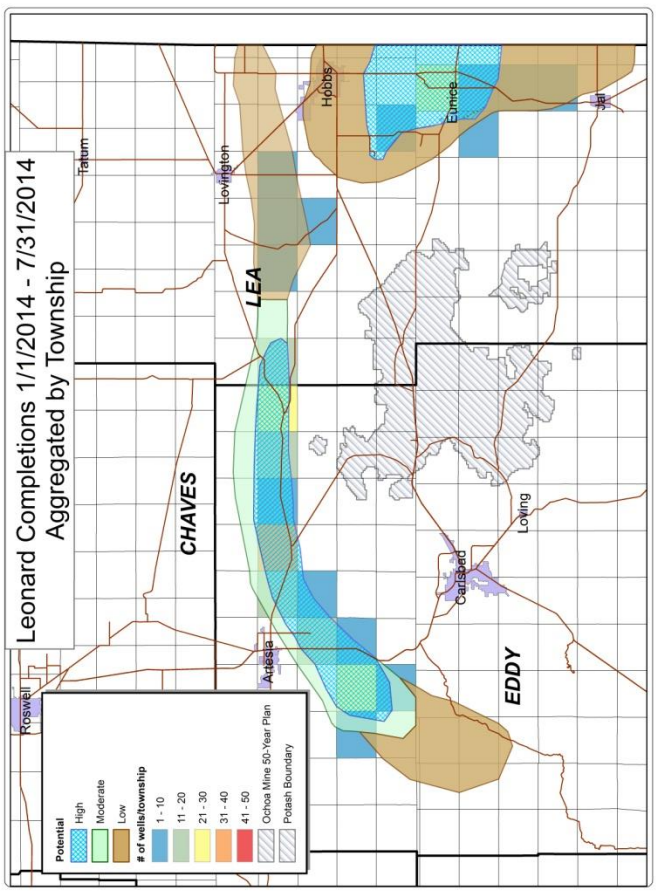




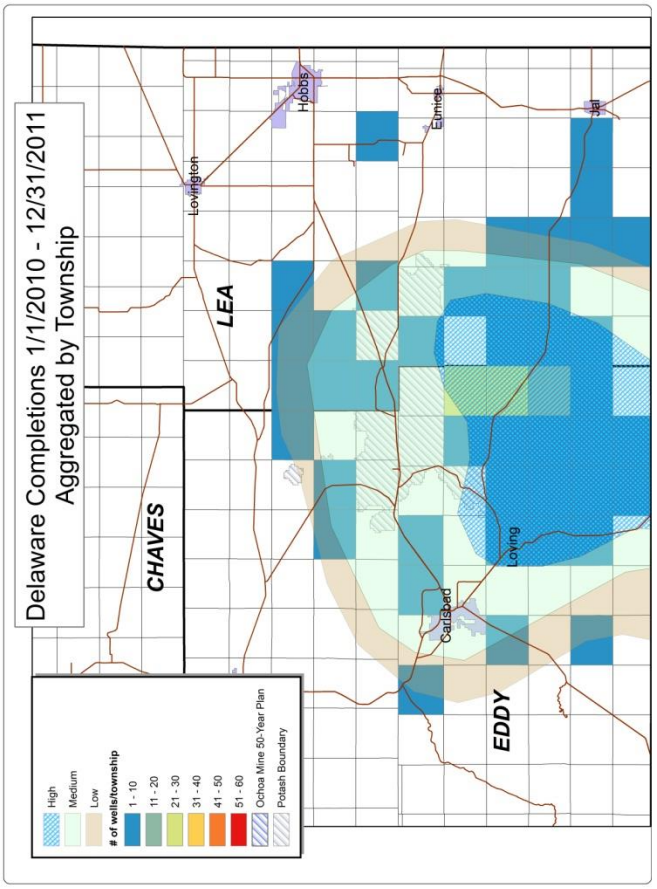


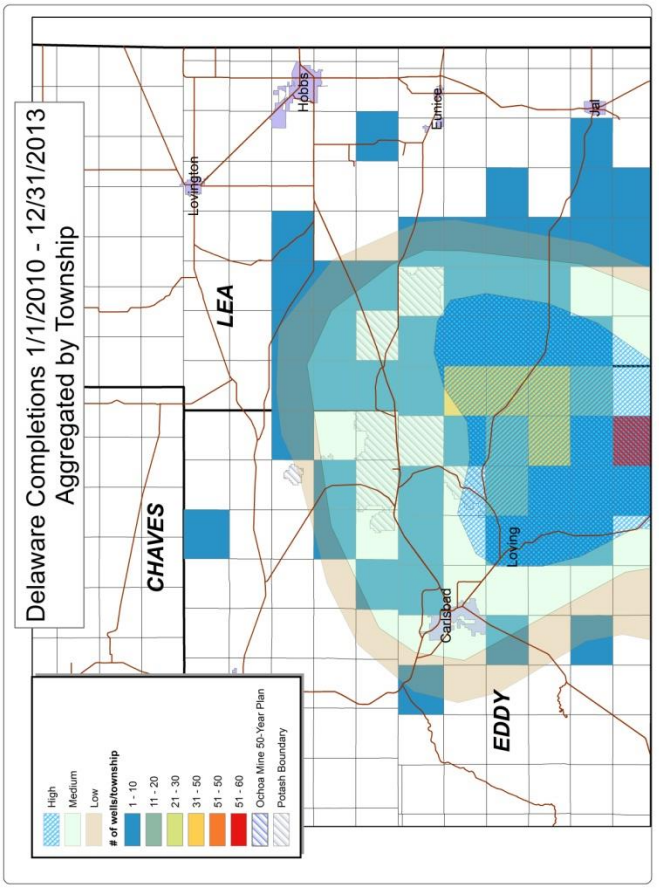
B-4. Annual Leonard completions by year from 2010 to 7/2014

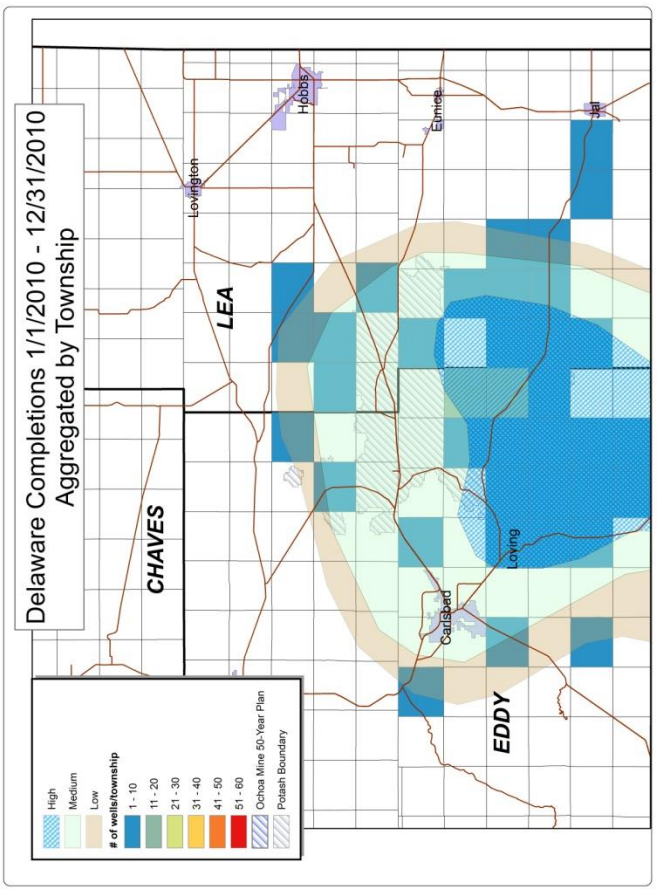
B-4. Annual Leonard completions by year from 2010 to 7/2014



B-5. Progression of cumulative Delaware completions from 2010







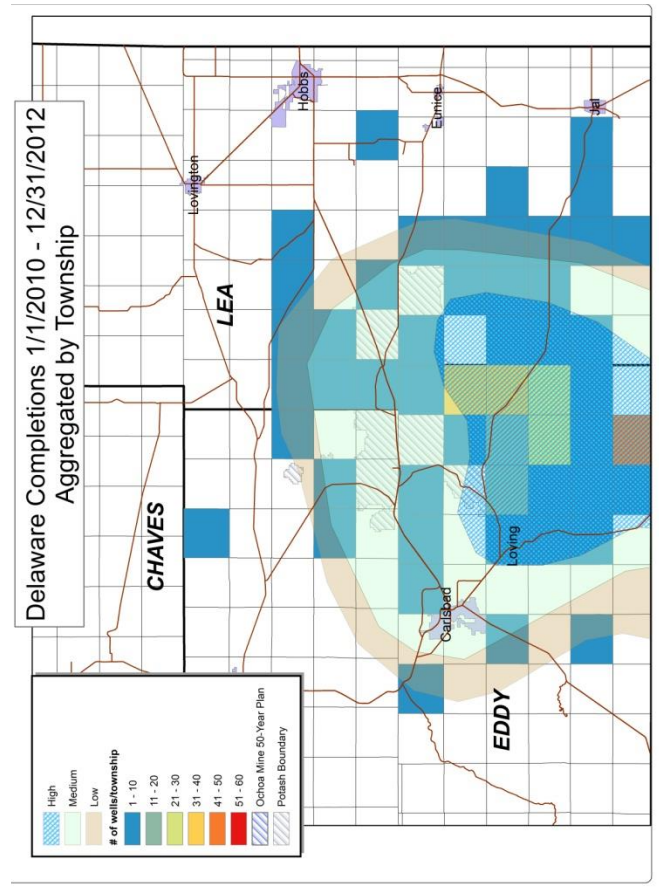
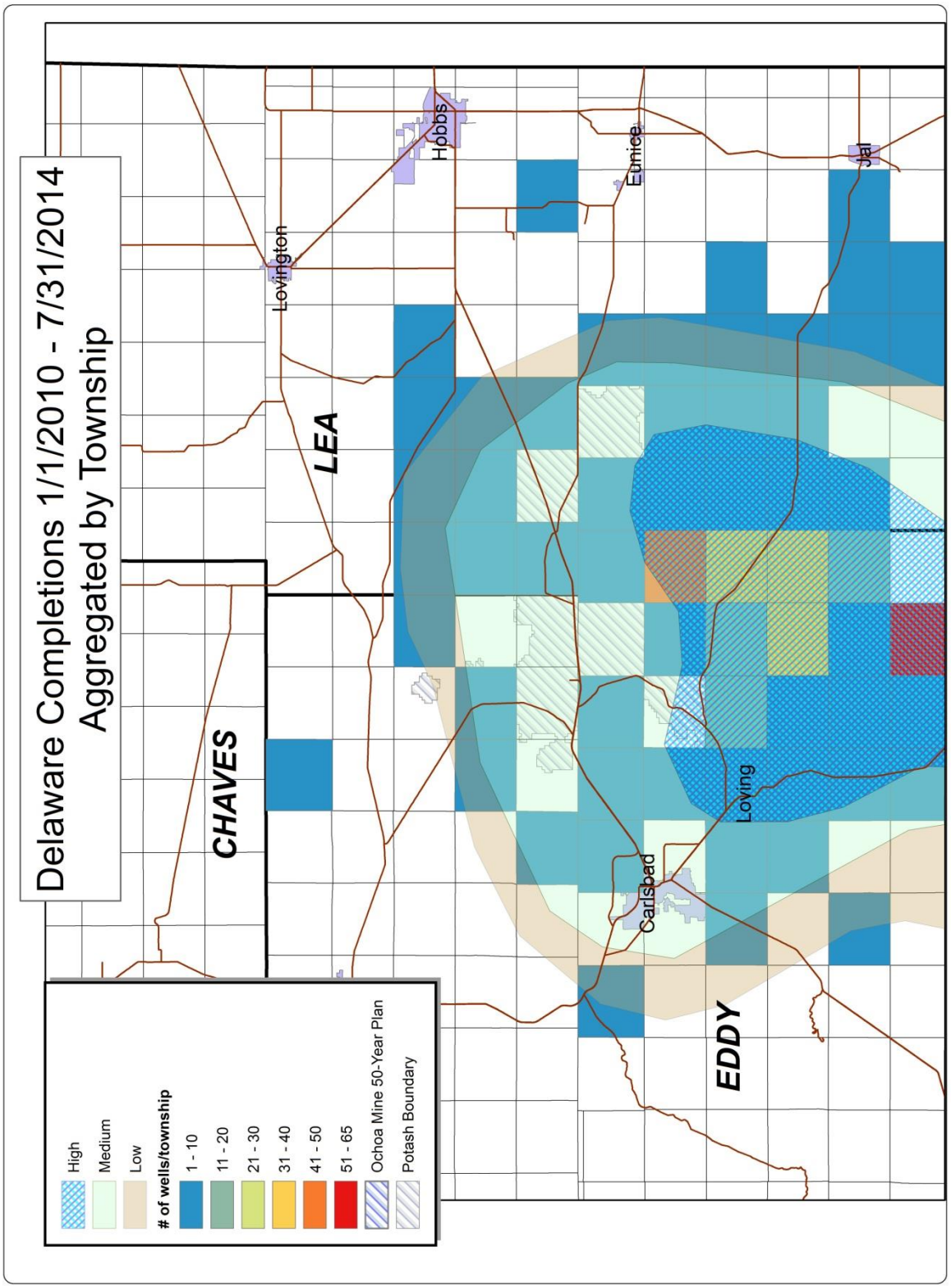
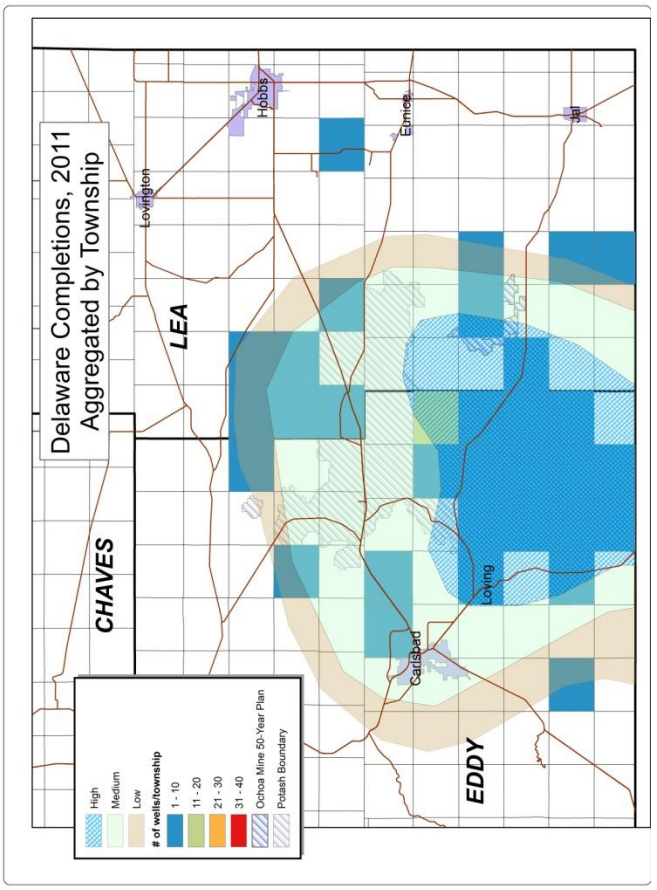
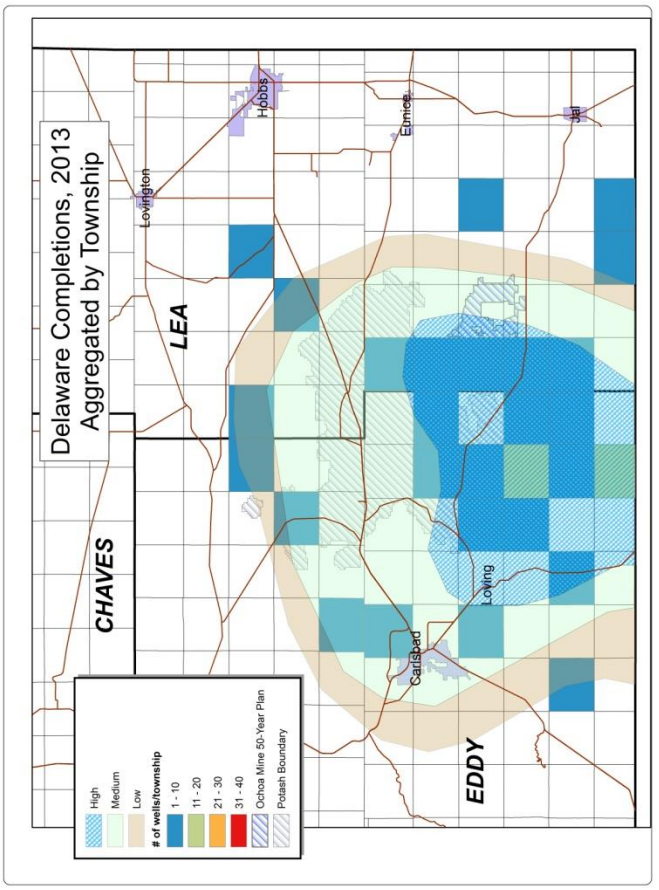


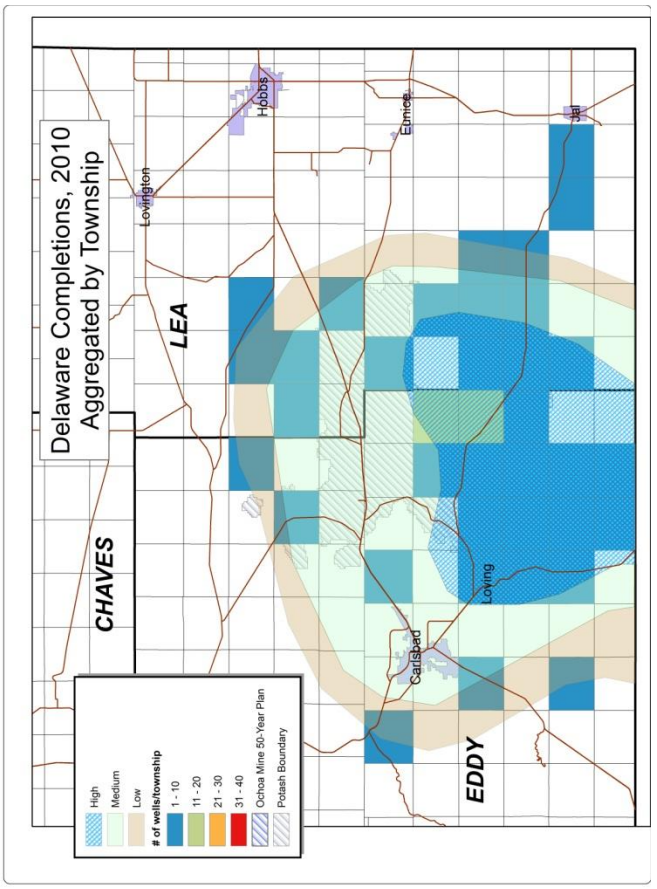
Figure 10 Cumulative Delaware completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.

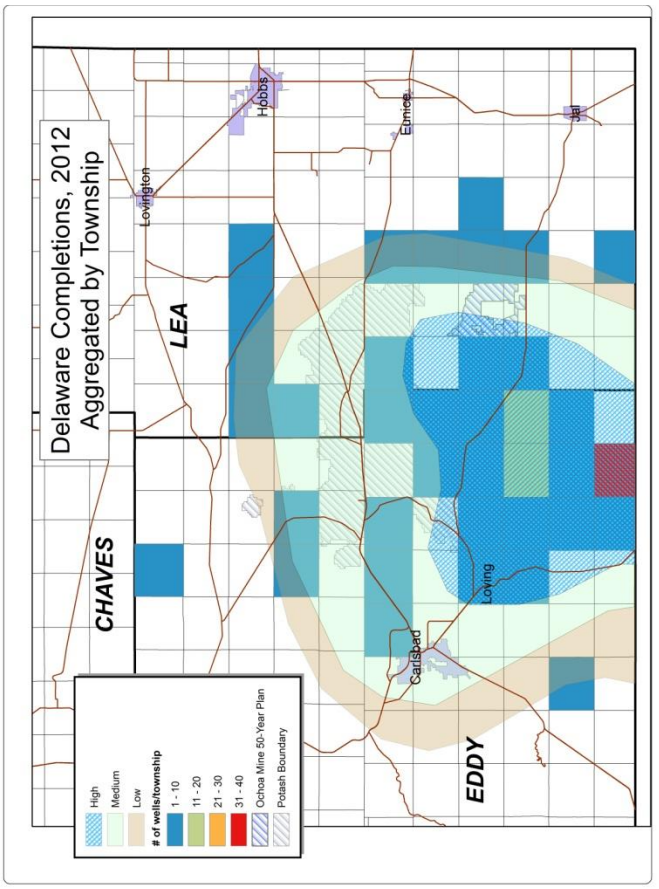


B-6. Annual Delaware completions by year from 2010 to 7/2014

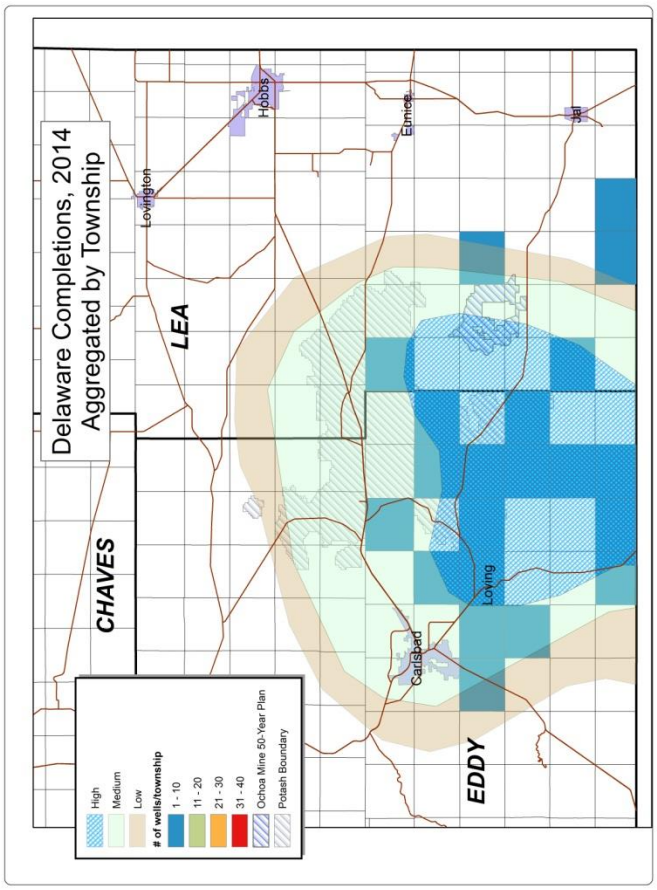




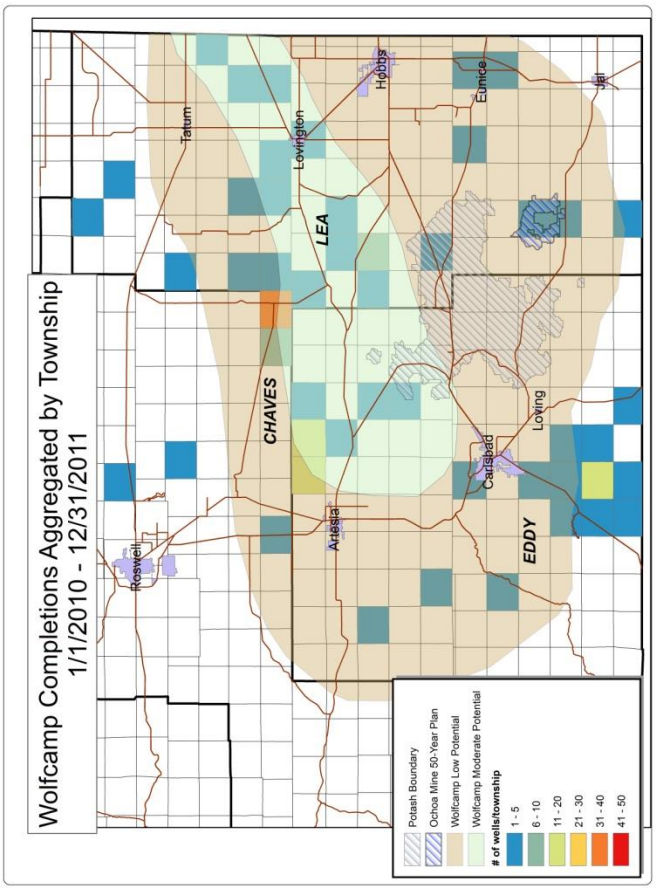


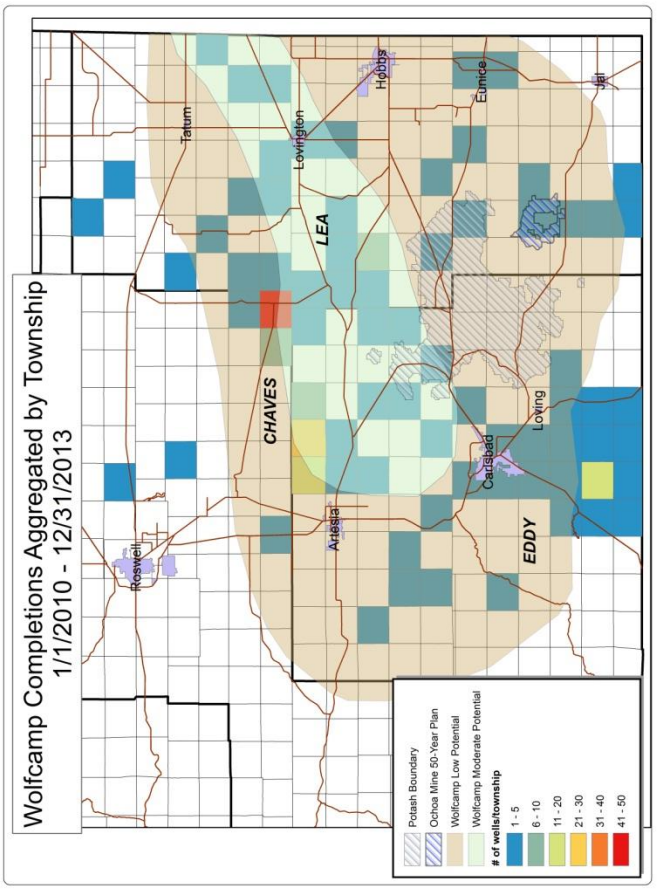


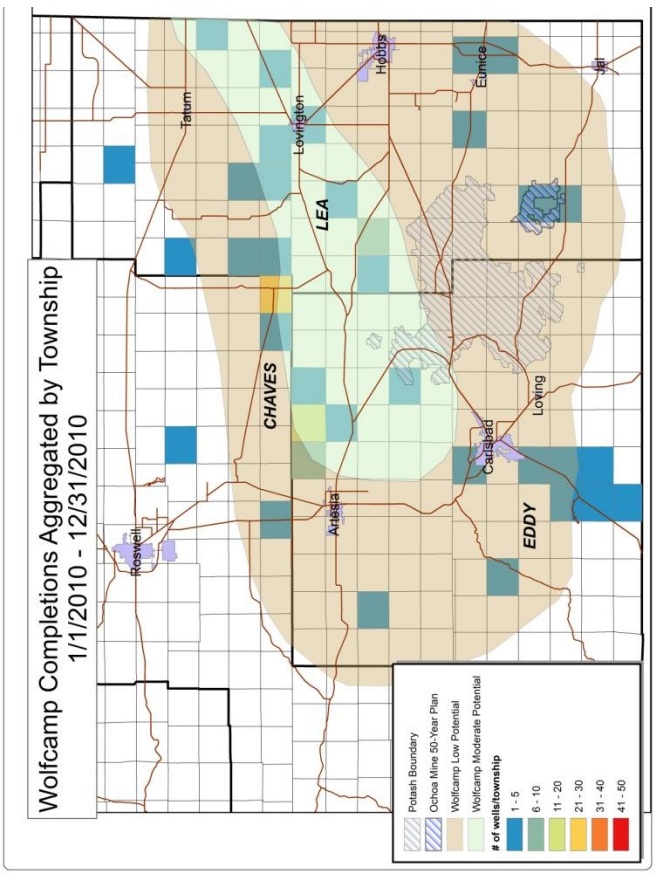
B-6. Annual Delaware completions by year from 2010 to 7/2014



B-7. Progression of cumulative Wolfcamp completions from 2010







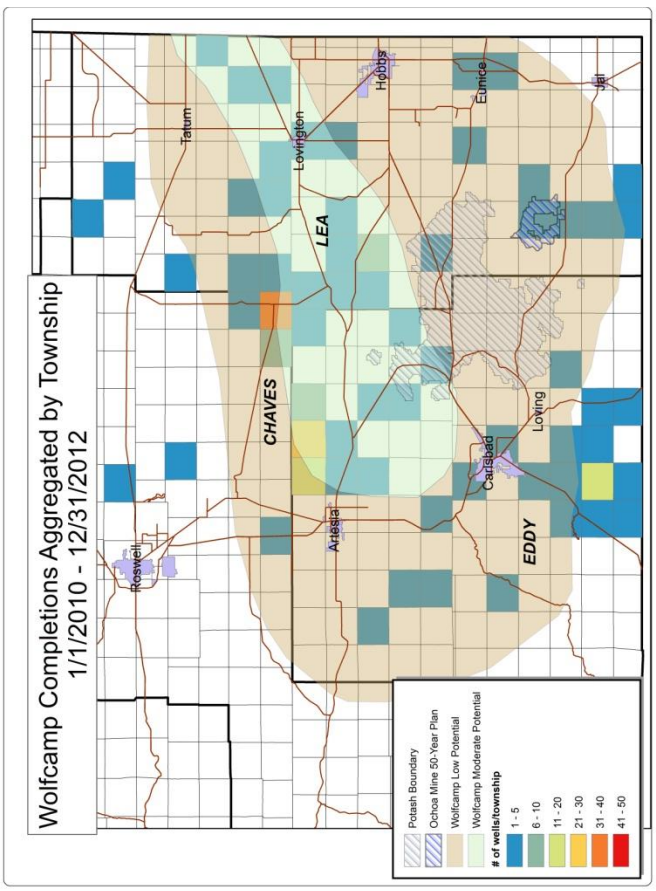
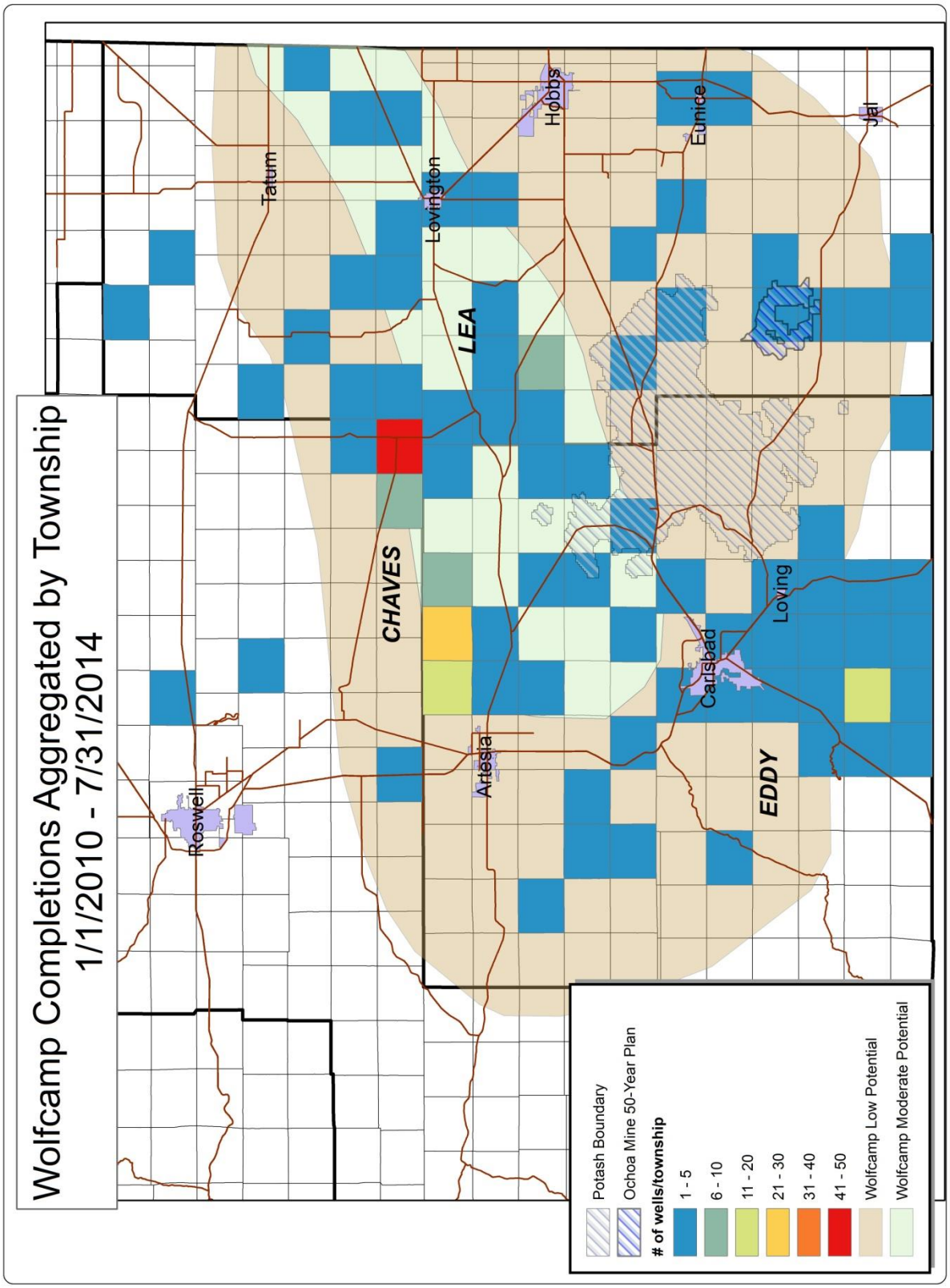
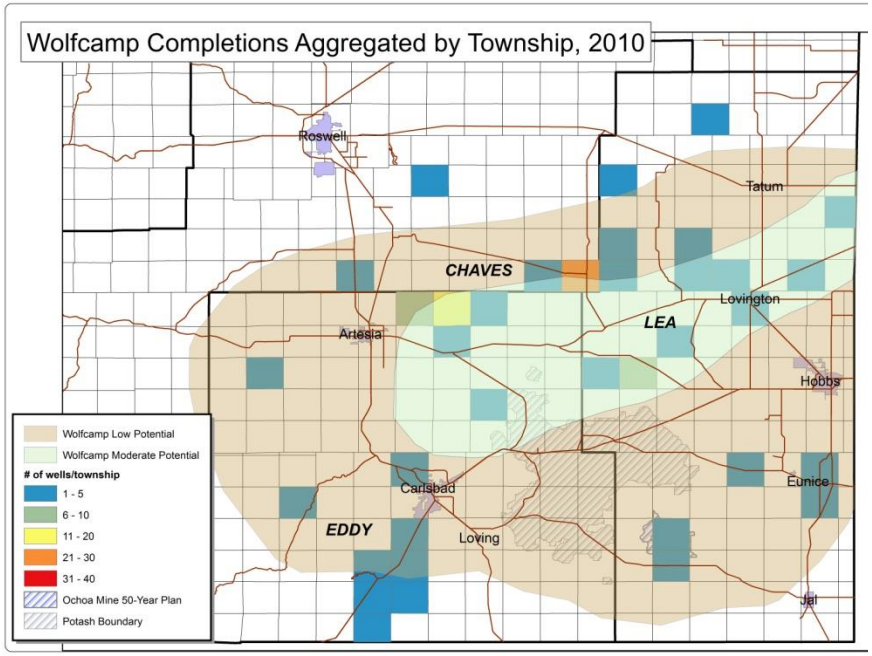
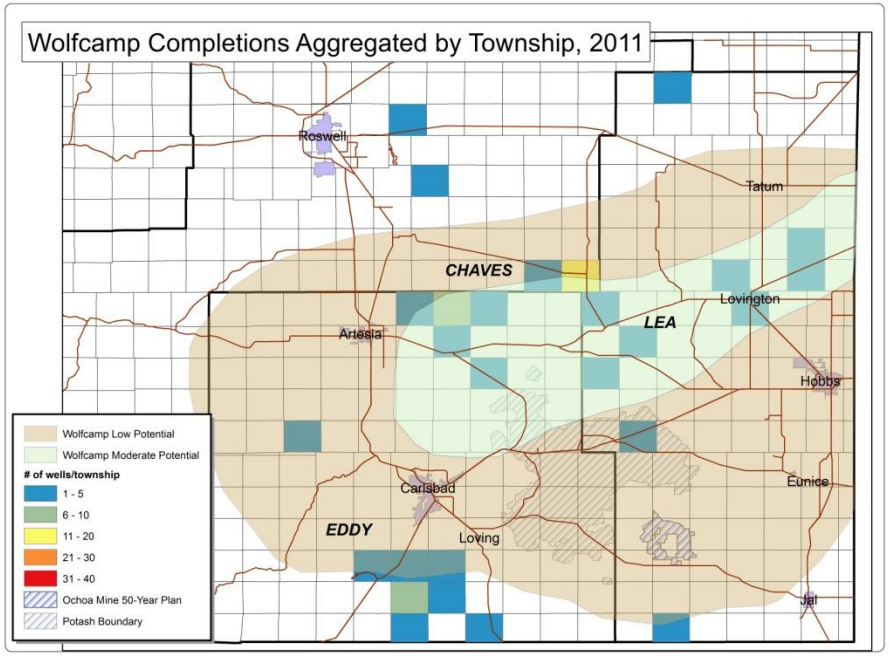
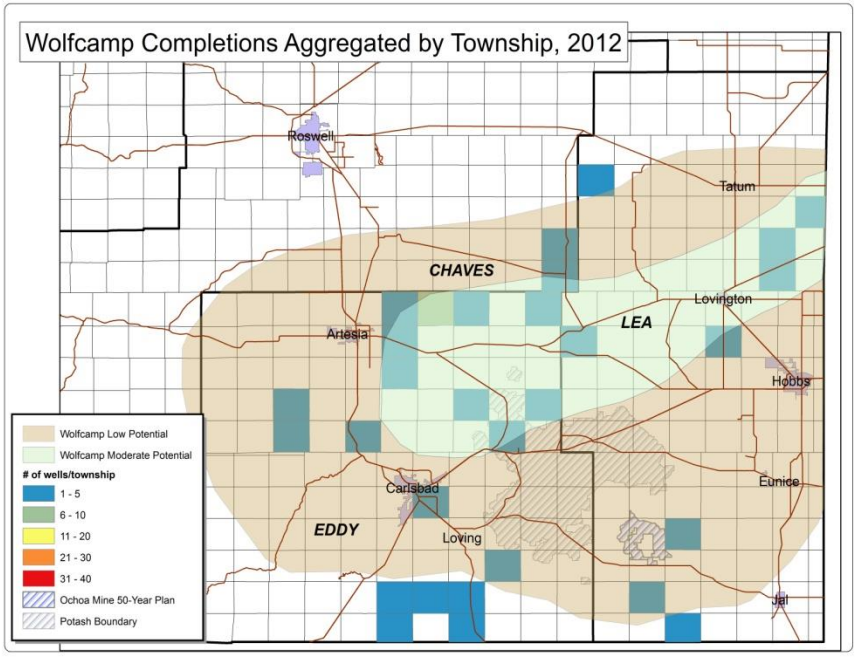


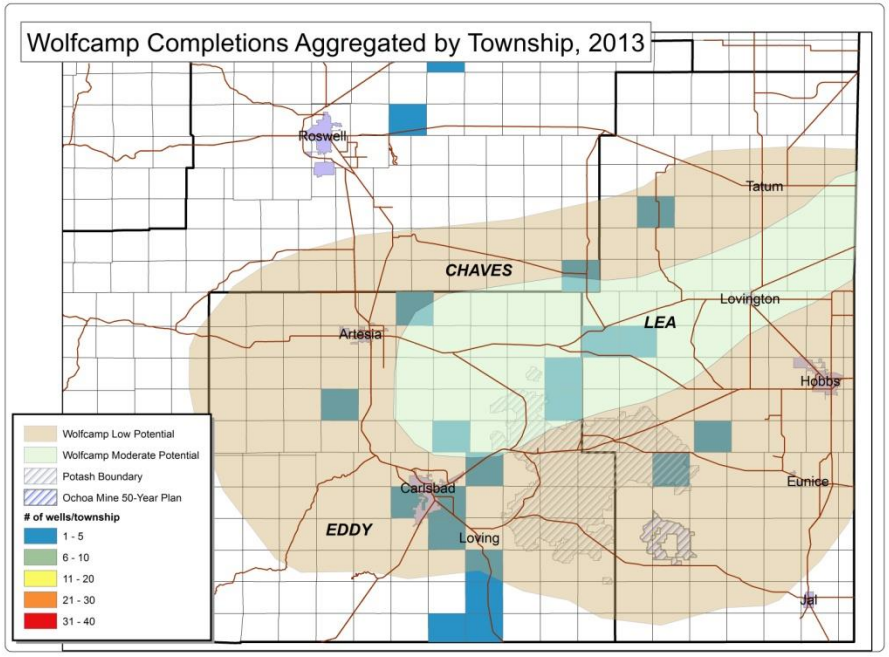
Figure 12 Cumulative Wolfcamp completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.





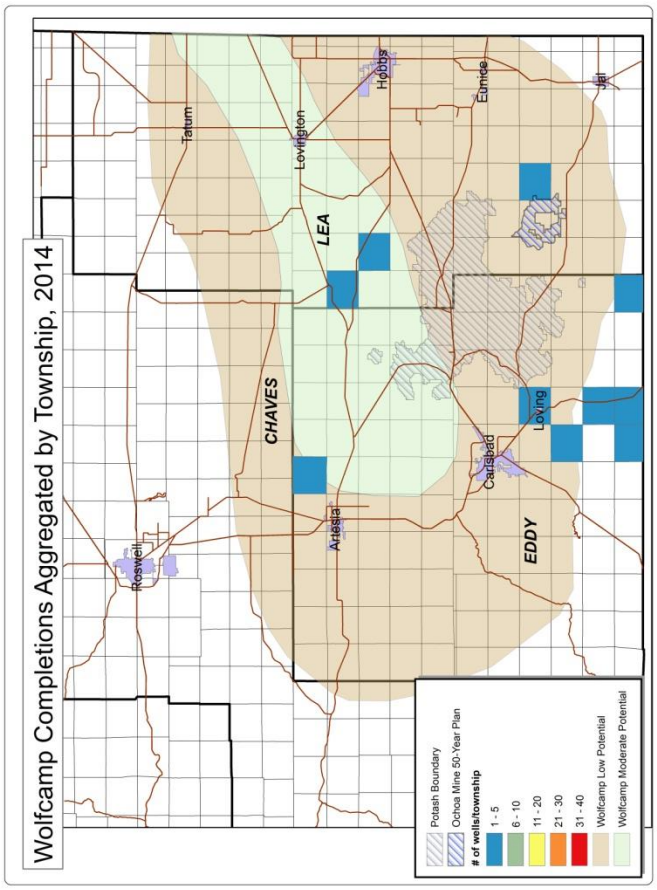




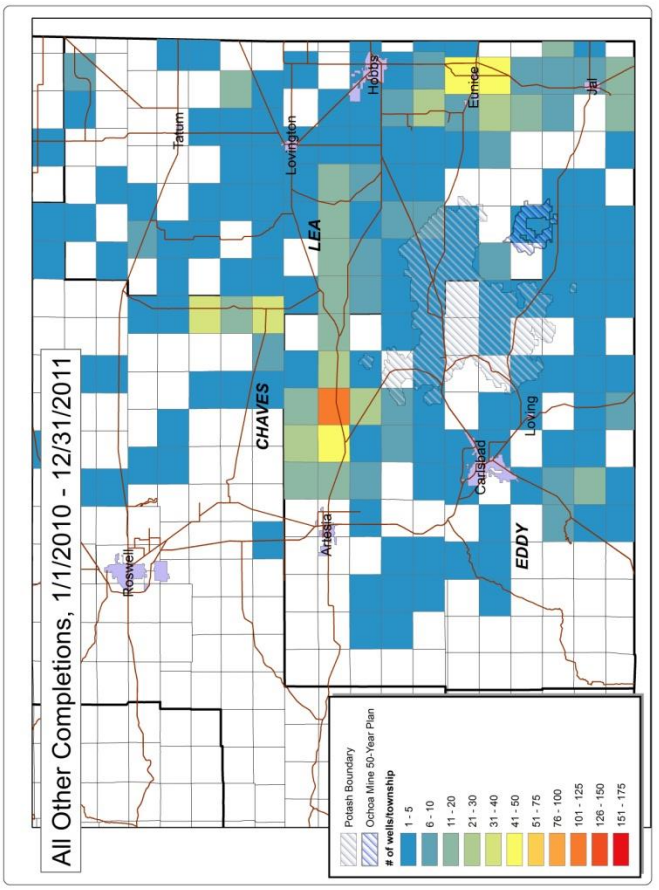


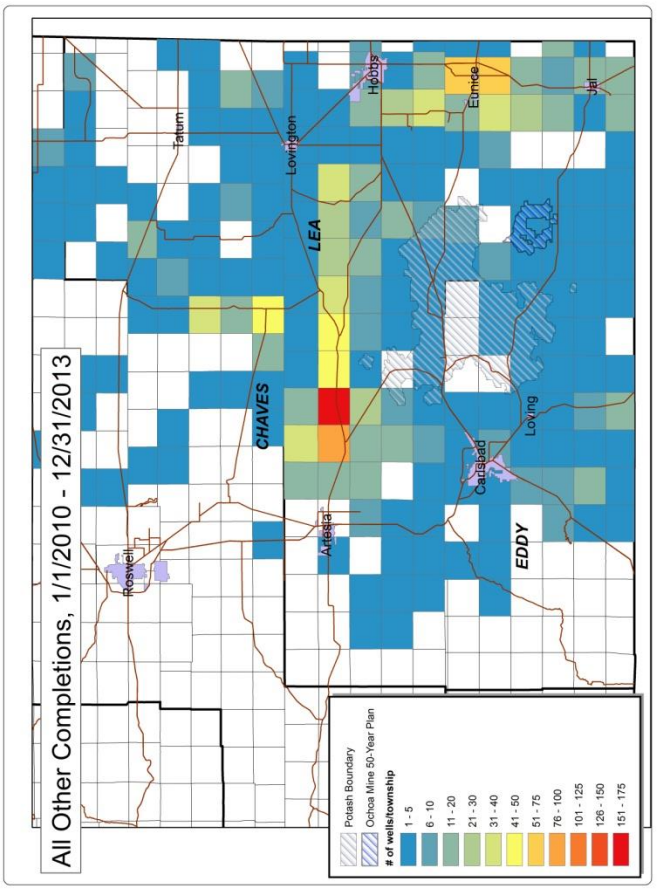
B-8. Annual Wolfcamp completions by year from 2010 to 7/2014

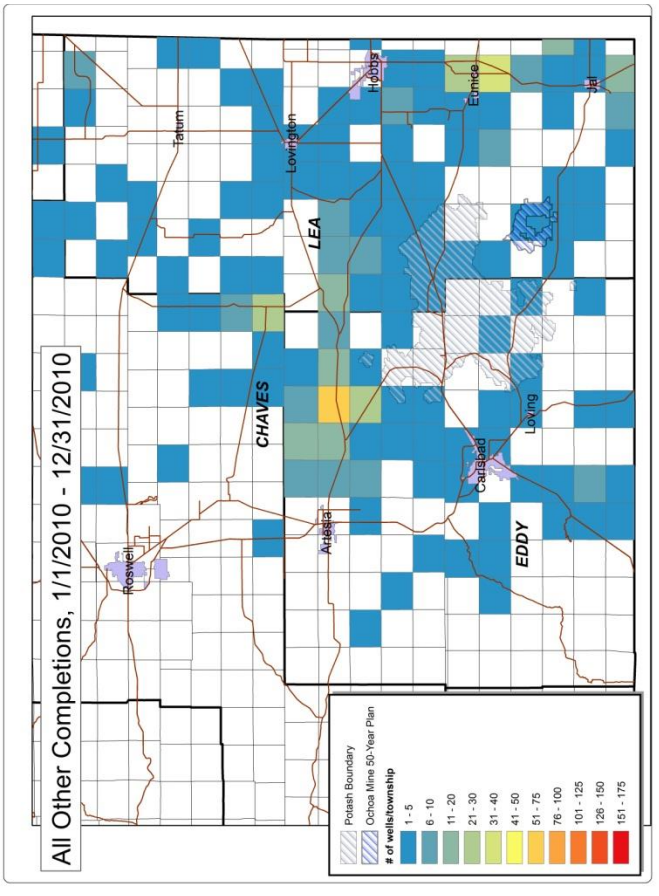
B-8. Annual Wolfcamp completions by year from 2010 to 7/2014



B-9. Progression of cumulative completions (other plays) from 2010







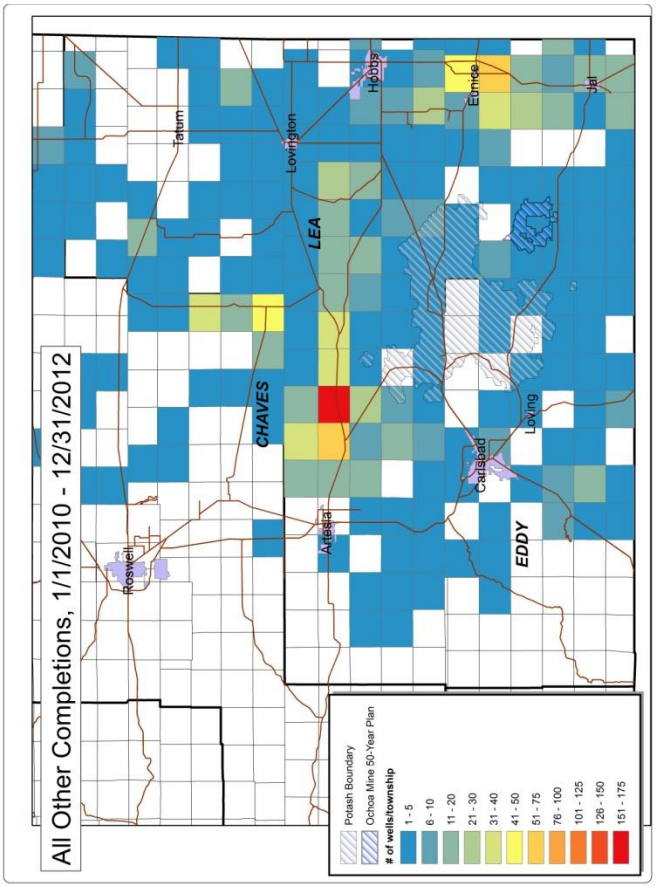
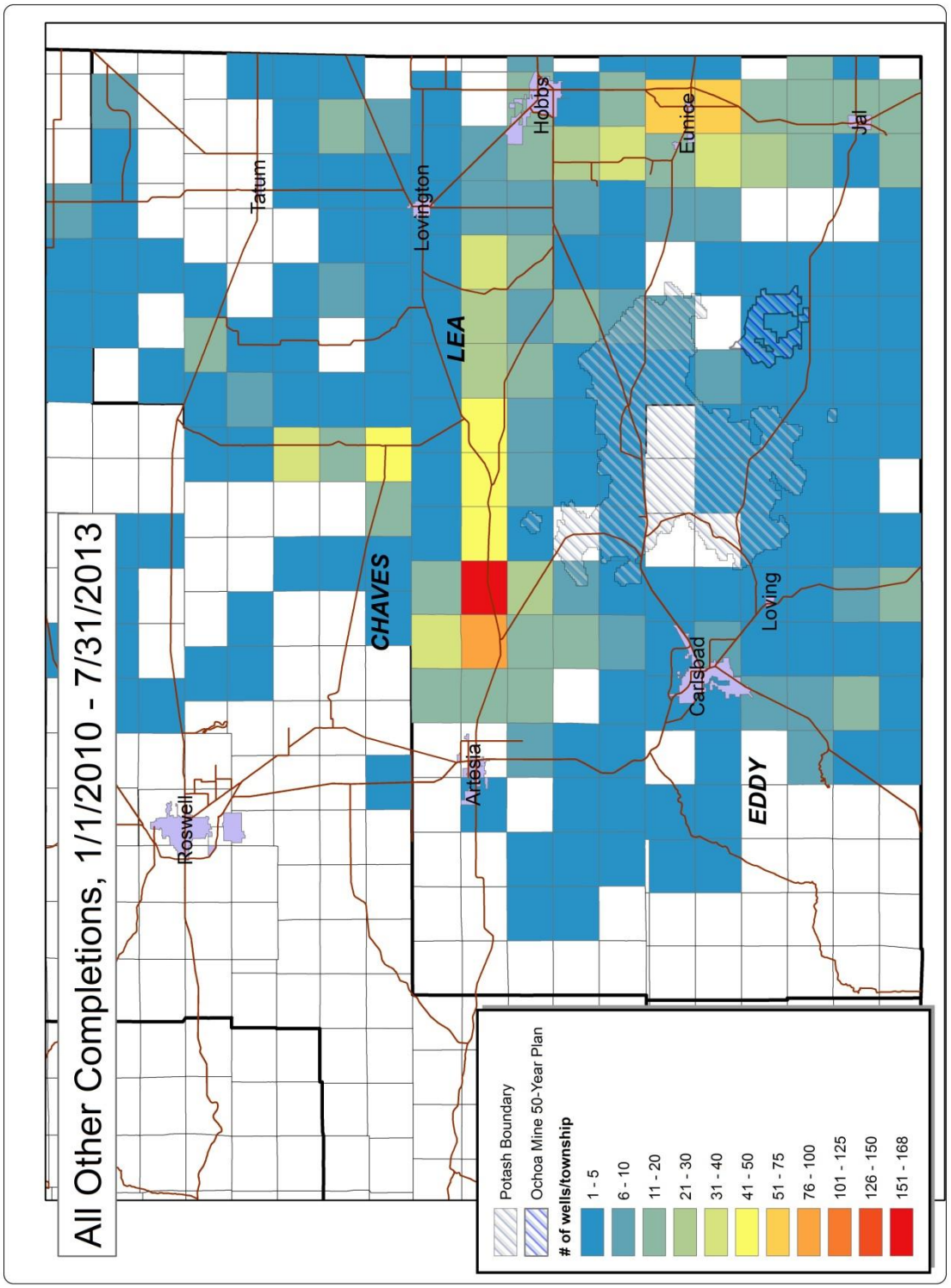
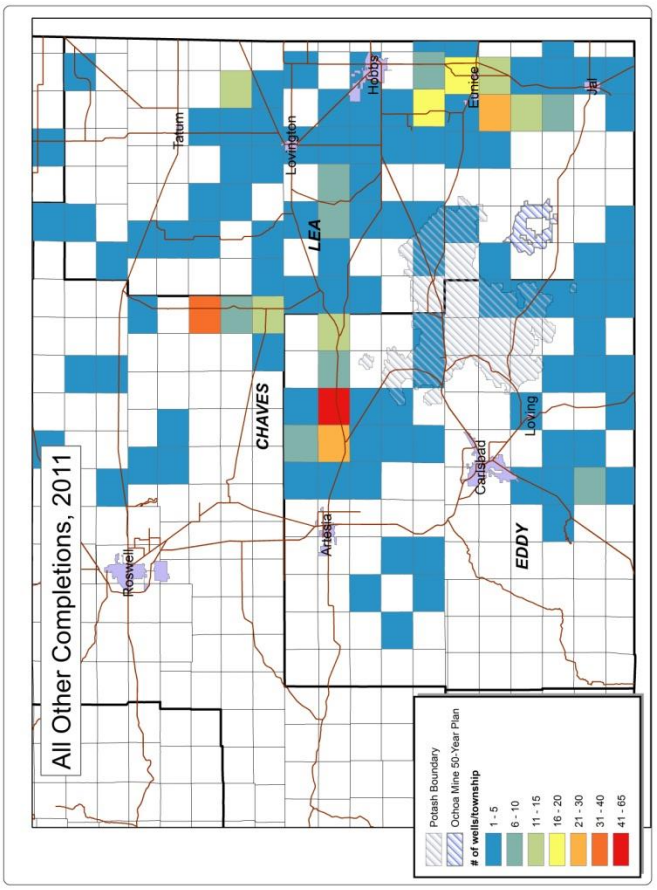
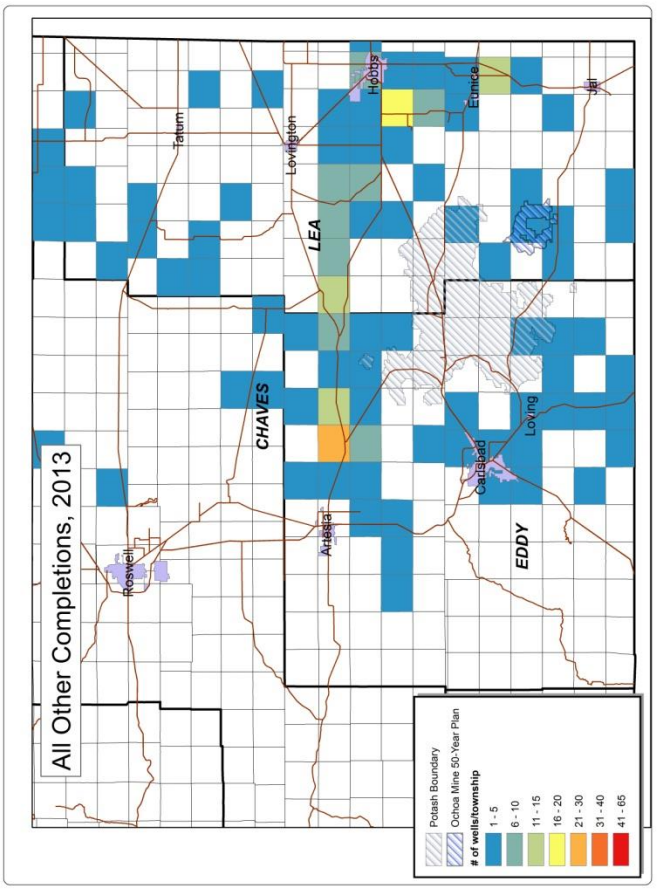


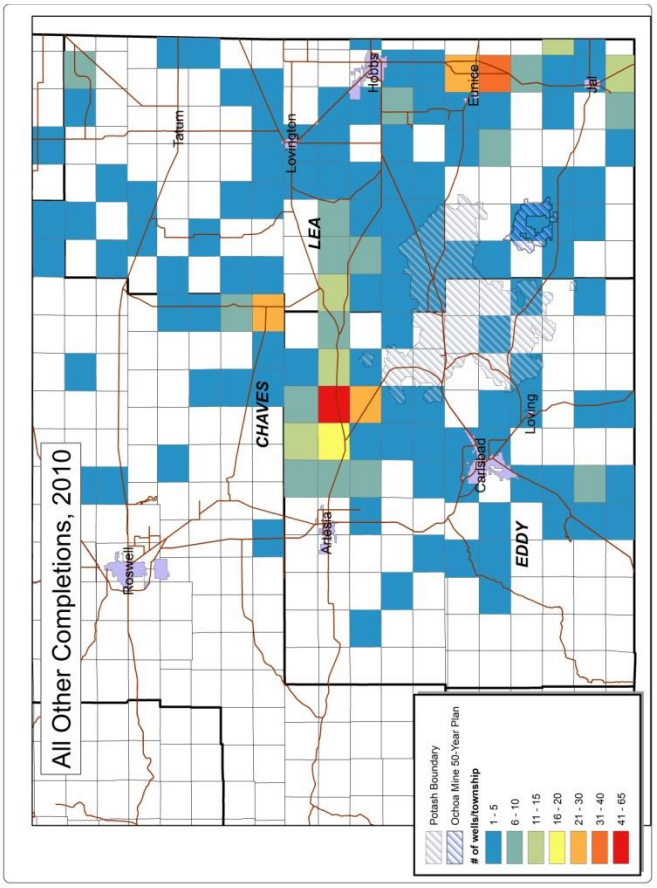
Figure 15 Cumulative other completions from 1/1/2010 through 7/31/2014 superimposed on the 2010 potential regions.

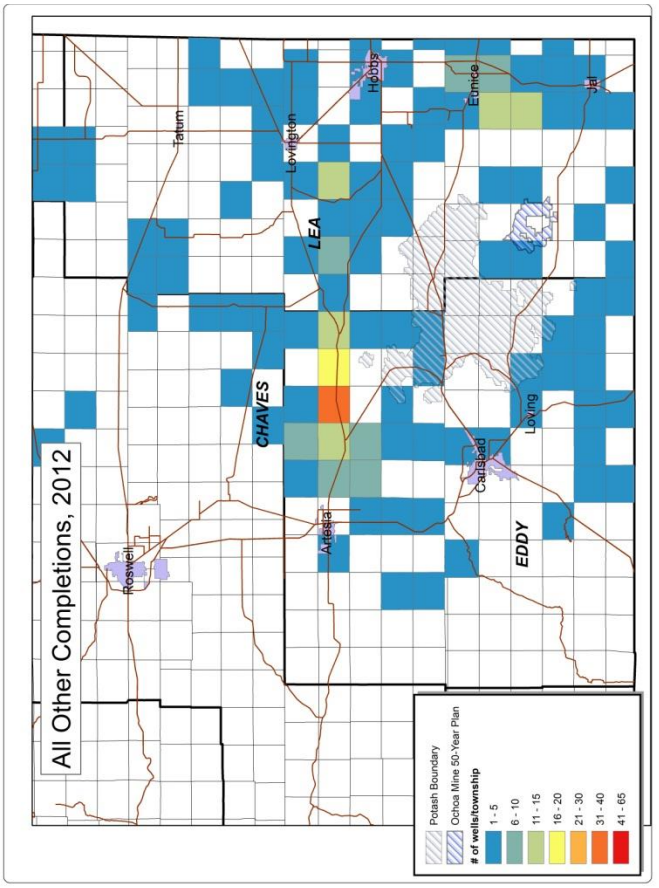


B-10. Annual completions (other plays) by year from 2010 to 7/2014

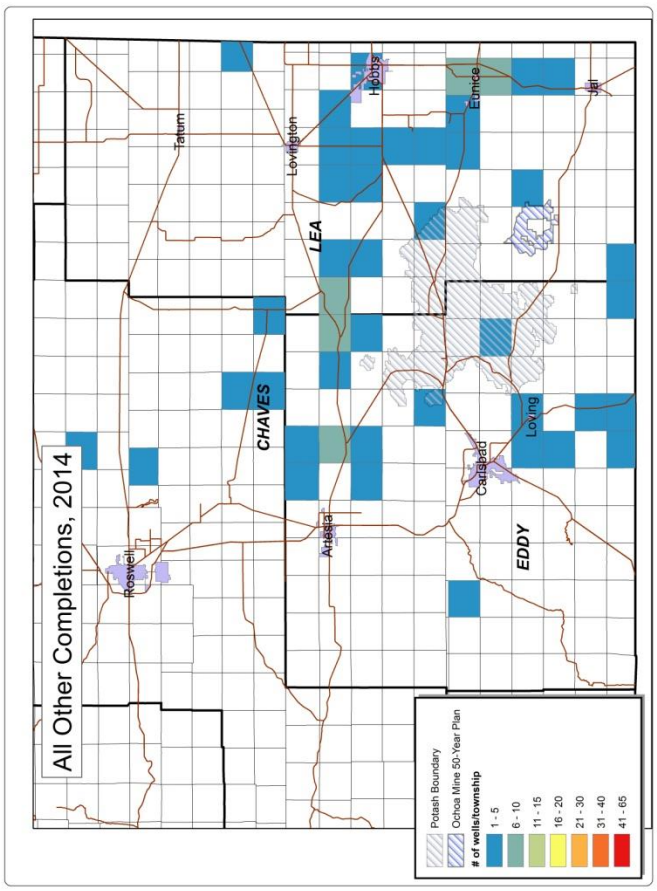
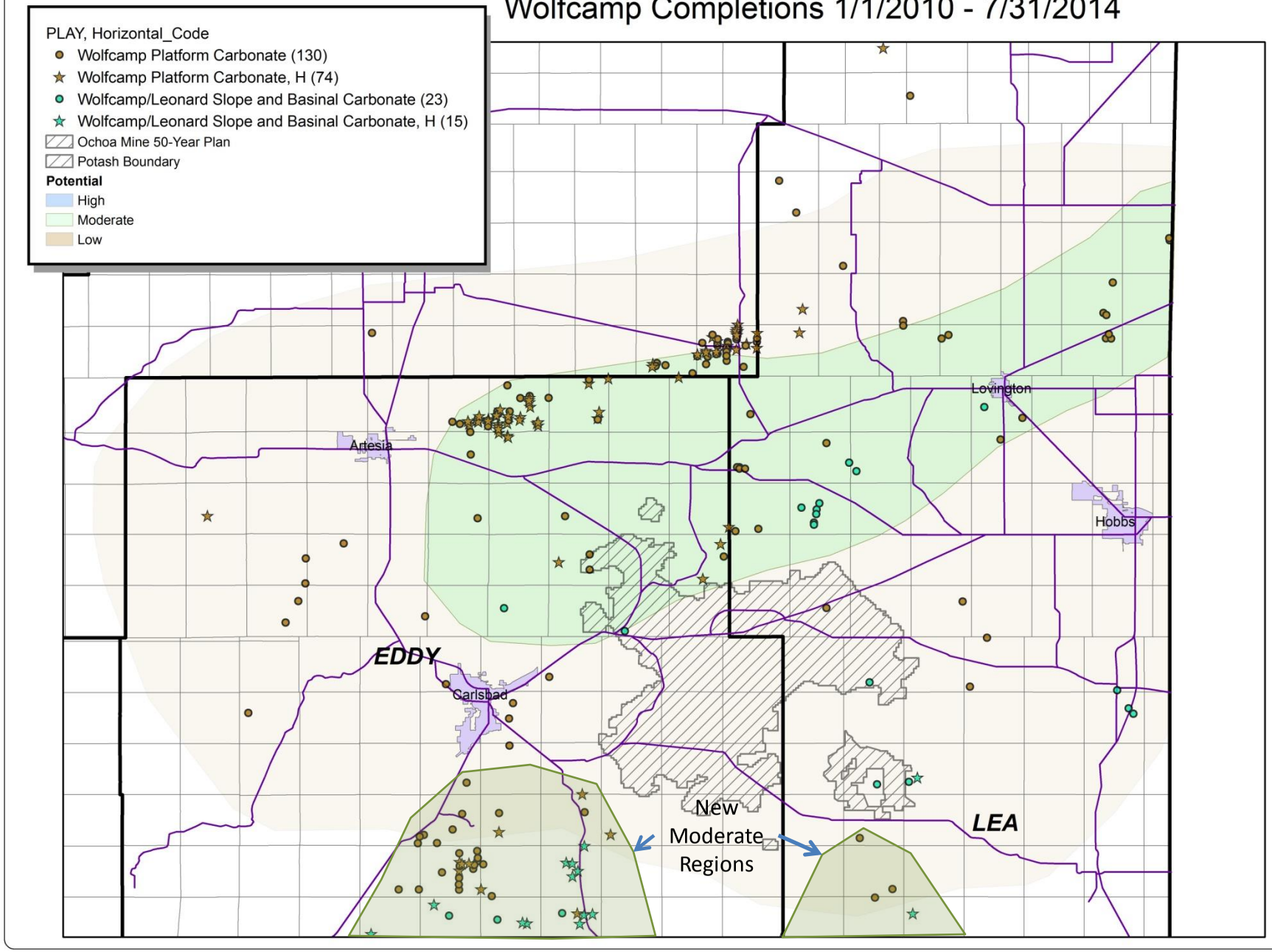








B-10. Annual completions (other plays) by year from 2010 to 7/2014



Wolfcamp Completions 1/1/2010 - 7/31/2014