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# Upper Platte River Basin Consumptive Use Change from New Reservoirs and New or Expanded Sandpit Lakes: 2005 to 2010

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## Background

As part of its commitment to the Platte River Recovery Implementation Program (Program), the Nebraska Department of Natural Resources (NeDNR) estimates the cumulative impacts of new surface water-related activities within the State's portion of the Program area (**Figure 1**). NeDNR monitors most new surface water-related activities in Nebraska through the surface water permitting process; however, small waterbodies like sandpits used in gravel and sand mining, and reservoirs smaller than 15 acre-feet (af), do not require surface water permits. Thus, the Department has conducted the following study to estimate the cumulative impacts of new surface water activities attributed to these small waterbodies.

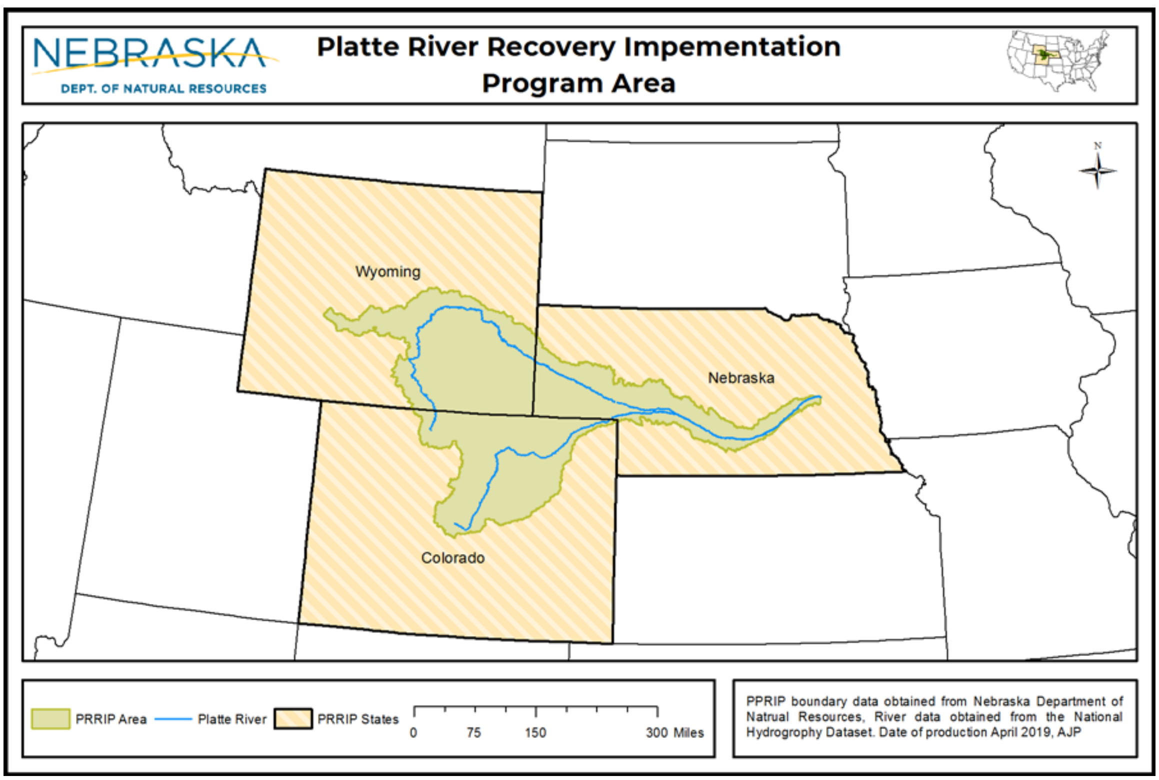


**Figure 1.** The Platte River Recovery Implementation Program in Nebraska, Wyoming, and Colorado.

### *History and Description of the Platte River Recovery Implementation Program*

On July 1, 1997, the states of Nebraska, Colorado, and Wyoming, and the US Department of the Interior, entered into a cooperative agreement to address the needs of four target species: the endangered whooping crane, interior least tern, and pallid sturgeon, and the threatened piping plover, along the central Platte River Basin. As part of that agreement, a Governance Committee formed of representatives from the three basin states, the US Bureau of Reclamation, the US Fish and Wildlife Service (USFWS), water users, and environmental groups, developed the foundation for the Program. In early 2006, the Governance Committee presented a final program document, which provided direction regarding the management of land and water resources for the benefit of the four target species. The Program officially commenced on January 1, 2007 after the Secretary of the Interior and the governors of Nebraska, Wyoming, and Colorado signed the final Program agreement.

The Program brings together the involved states, federal agencies, water users, and environmental groups to work collaboratively to improve and maintain the associated habitats for the designated, target species, in 13-year increments. The first increment spanned the years 2007 to 2019 and utilized an adaptive management approach supported by data and scientific research. This has allowed the Program to test hypotheses and adjust goals and targets accordingly, throughout the first increment.

The three main elements of the Program are to:

- Increase stream flows in the central Platte River during relevant time periods
- Enhance, restore, and protect habitat lands for the target bird species
- Accommodate certain new water-related activities.

The Program's Adaptive Management Plan, Land Plan, and Water Plan support these elements. The Adaptive Management Plan sets the framework for how Program management uses the best available science and data. The Land Plan details the Program's long-term objective to acquire land interests for habitat restoration. The Water Plan is the road map developed to meet water goals of the Program.

The USFWS has established stream flow targets for the Platte River based on the habitat needs of the Program's target species. As part of the Program's Water Plan, each of the collaborating states and the federal government developed "Depletion Plans" that describe mitigation, offsets, or prevention of any new stream depletions that started after July 1, 1997, and with regard to target flows. Nebraska's New Depletion Plan covers the surface water basin within the state of Nebraska and above Columbus, NE, and will hereinto be referred to as the "study area" (**Figure 2**).

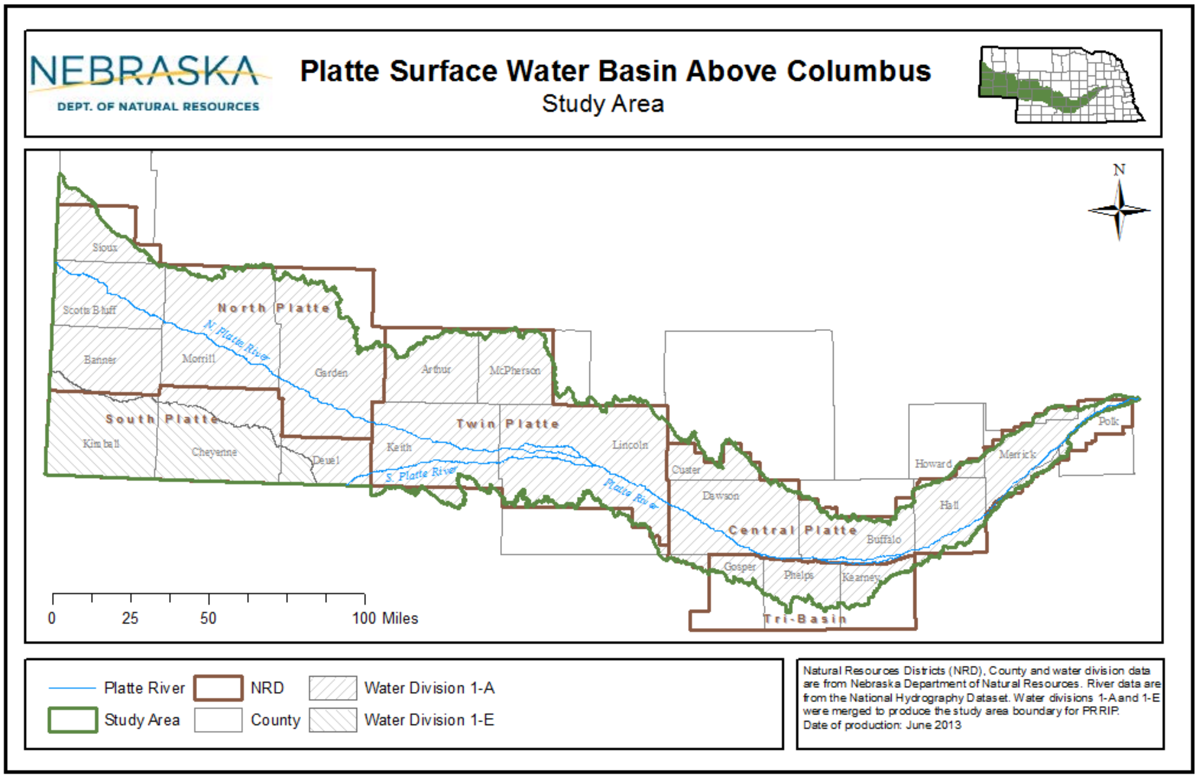


**Figure 2.** The study area consists of the Nebraska portion of the Program area, which is the Platte River Basin above Columbus, Nebraska.

In compliance with the Nebraska New Depletions Plan, the State must consider potential effects of new or expanded small water bodies on target flows. The purpose of this study is to assess the cumulative impact of new or expanded sandpit lakes and new, small reservoirs on target flows. This study has two overarching objectives:

1. Identify new or expanded sandpits and other small water bodies that do not require permits from NeDNR that occurred between the years 2005 and 2010.
2. Utilize the Natural Resources Conservation Service (NRCS) Evapotranspiration (ET) calculator to determine what water consumption impact, if any, could be attributed to the new or expanded small, unpermitted waterbodies.

## 2005 and 2010 waterbody inventories and change detection

### *Introduction*

This section describes the work performed to create an inventory of 2005 and 2010 waterbodies. It details the procedures used to compare inventories in order to identify potential new reservoirs and new or expanded sandpit lakes, and then determine whether the new or expanded waterbodies had permits, plans or mitigation already in place. NRD staff provided local expertise to review and further refine the dataset. A geospatial layer of new reservoirs and new or expanded sandpits was finalized for subsequent consumptive use analyses.

### *Creation of the baseline (2005) waterbody inventory*

In 2006, the NeDNR created a 2005 waterbody inventory to establish baseline conditions for this study. This GIS-based inventory was created using manual identification, digitization, and classification of waterbodies through interpretation of 2005 Farm Service Agency (FSA) orthophotography. NeDNR classified the waterbodies as follows:

- **Reservoirs** - Water bodies with a visible dam structure or those in upland drainages that had a linear edge perpendicular to an incised drain
- **Sandpits** - Human-made water bodies located within the flood plain of a river or stream
- **Lakes** - Irregular shaped water bodies in floodplains or upland depressions (not in a natural drain)
- **Miscellaneous** - Visible water bodies that do not fall into the other categories, including treatment plants, animal waste pits, etc.

The 2005 baseline inventory identified roughly 11,500 waterbodies (**Figure 3**). The methodology used in the creation of the 2005 baseline inventory was relatively labor intensive and required approximately 1,200 staff hours to complete.

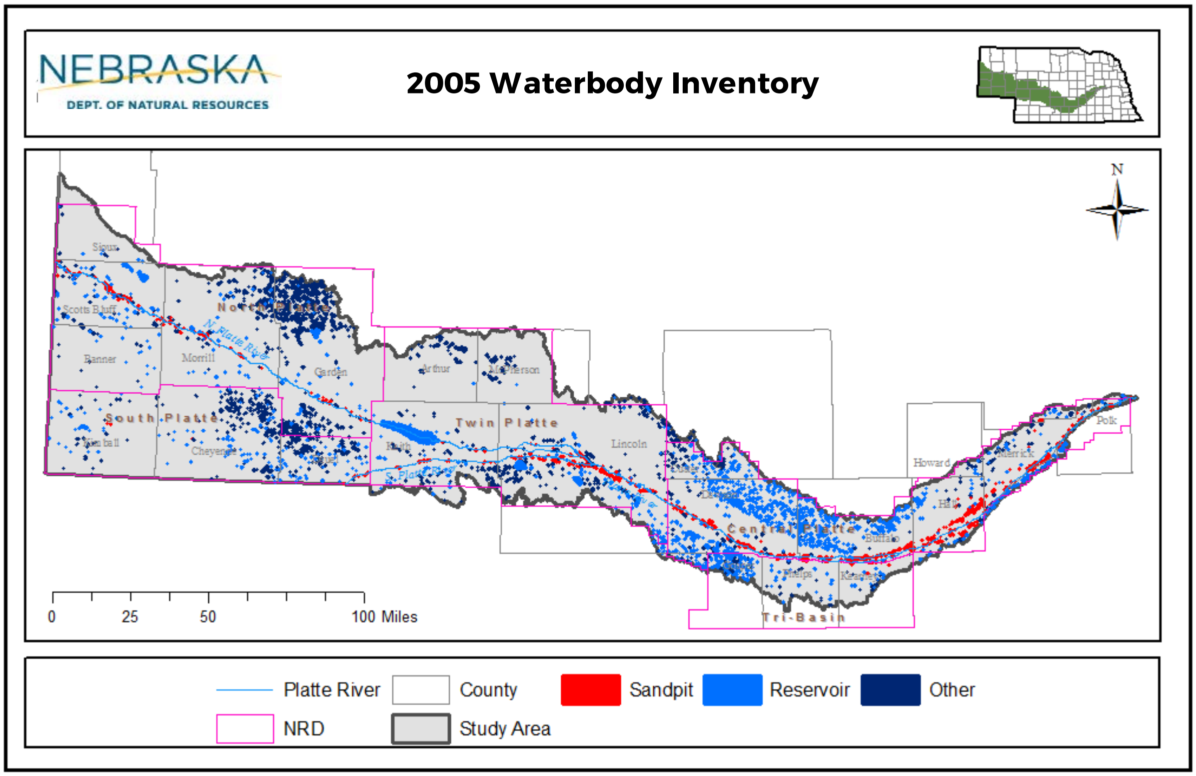


**Figure 3.** The 2005 waterbody inventory used as a baseline for the change analysis.

### *Creation of the 2010 waterbody inventory*

<u>Preparation</u>

In 2011, and inventory of 2010 waterbodies was created using a semi-automated classification methodology. An initial comparison of 2005 and 2010 aerial imagery showed a considerable increase in waterbodies in 2010 due to it being a much wetter year than 2005. **Figure 4** shows FSA imagery of the same area in 2005 and 2010, and provides a visual example of the significant increase in surface water from 2005 to 2010. It was estimated that the 2010 inventory would take approximately 4,000 hours to complete if the same manual methods employed in 2005 were used. As such, a semi-automated classification was employed as a first-cut to identify waterbodies. This classification utilized 2010 FSA National Agriculture Imagery Program (NAIP) one-meter resolution aerial imagery to discriminate waterbodies based on the unique spectral reflectance characteristics of open water.

**Figure 4**. Aerial imagery showing differences in surface water between a drier year (2005, left) and a wetter year (2010, right)

County-level FSA images were combined using ERDAS IMAGINE software to create a single image of all counties within the study area. The Nebraska Sandhills region in the northern portion of the study area was removed because waterbodies in this region were assumed to be natural features. Because dataset size was an issue, the 2010 imagery mosaic was resampled to a resolution of 5-meters as visual inspection showed that 5-meter pixels were appropriate for the waterbody discrimination. This step greatly reduced the file size of the dataset.

<u>Classification</u>

To conduct the classification, values from the near infrared (NIR) band of FSA imagery were evaluated visually to determine the difference in NIR reflectance between vegetation and waterbodies. Reflectance values represent the amount of light at specific wavelengths (in this case near infrared) reflected back to the sensor by specific land cover type. Vegetation and waterbodies have uniquely different reflectance in the NIR band, which ranges from 0.7 to 1.2 micrometers in the electromagnetic spectrum. Vegetation has high reflectance in the NIR band, while open water has high absorption in this region. As a result, NIR reflectance values for vegetation are generally high while values for open water tend to be low.

A pixel-based threshold (0-128) was determined through visual inspection and used to isolate potential pixels that represented waterbodies. This threshold represented the left “tail” of the bell-shaped histogram of all land cover types and associated pixel values from 0-255 in the study area (**Figure 5**). Groups of contiguous pixels that would theoretically constitute a waterbody were then isolated and converted to polygons (shapes). Polygons smaller than 1-acre were removed as visual examination revealed that these were generally artifacts or ephemeral water bodies.

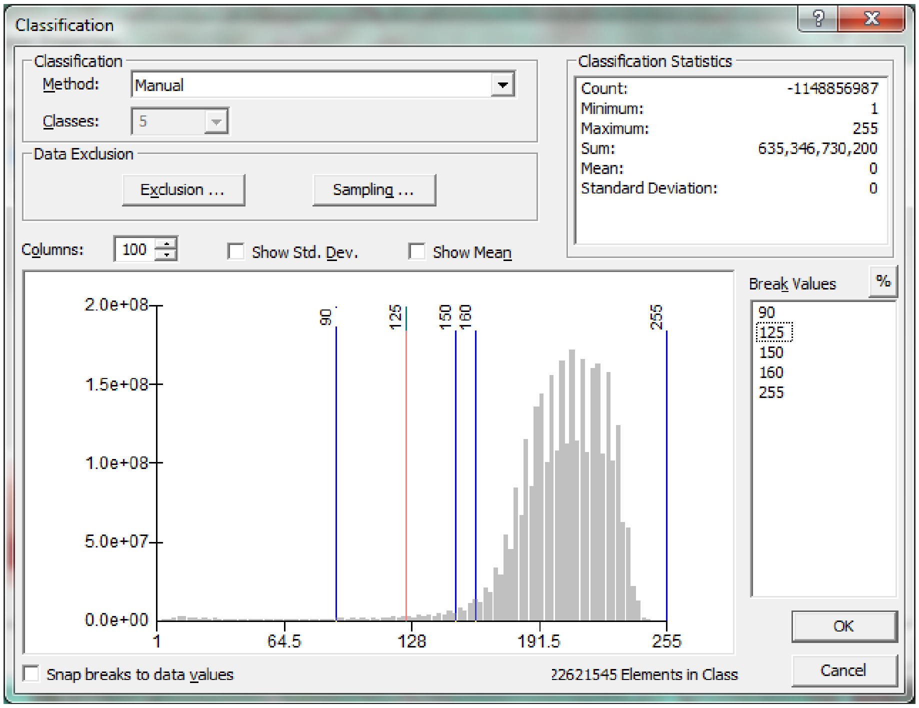


**Figure 5.** Histogram showing all near-infrared pixel values in the study area. Values of 0 to 128 were selected as a first-cut to isolate waterbodies.

An example of 2010 FSA imagery during the classification process is shown in **Figure 6**. In this image, waterbodies appear as black or very dark grey, indicating high levels of near-infrared absorption. Vegetation, on the other hand, appears light gray or white due to high reflectance in the near-infrared band. Of note, there were some issues with the classification of FSA imagery for this project. For example, high levels of suspended solids in some reservoirs produced confusion in the classification due to higher reflectance of soils and other particles within the waterbodies. Additionally, very wet soils, shadows of clouds, trains, and other features also had high absorption in the near-infrared spectrum and produced unwanted features (i.e. "artifacts").

There were also inconsistencies between aerial imagery tiles across the study area because FSA imagery is captured at different times and from different angles. Satellite-based imagery, which is acquired at the same time and from the same vantage point, generally produces more consistent classification results, but at the expense of resolution. Landsat imagery was considered for this study, but it was determined that the 30-meter resolution was not sufficient to discriminate small waterbodies. As such, the FSA approach was used to retain a fine spatial resolution (5 m after resampling); however, this approach did require substantial manual editing.

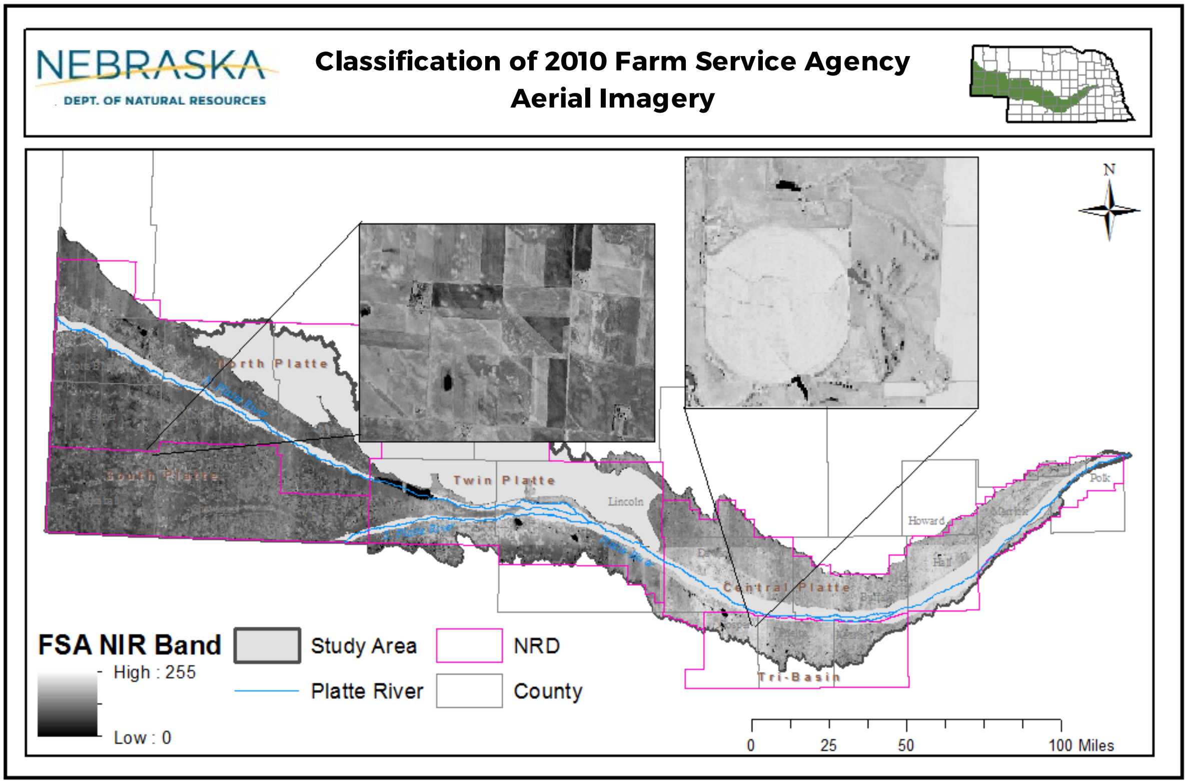


**Figure 6**. FSA aerial imagery near-infrared (NIR) band classification. Waterbodies appear dark grey or black due to strong absorption in the NIR band.

<u>Manual editing of first-cut waterbody features</u>

The initial image classification for the 2010 small waterbody inventory required substantial manual work. For this process, NeDNR staff members methodically reviewed the entire study area, using 1-meter FSA imagery as a backdrop to inspect and edit roughly 20,000 features. All scanning, editing, and digitizing occurred at a minimum scale of 1:10,000. GIS editing tools were employed to remove artifacts (e.g. shadows, wet soils) produced from the classification process. Likewise, editing tools were used to digitize "missing" waterbodies; e.g., waterbodies that were misclassified typically due to a high sediment content. The automated classification process performed the best for sandpit waterbodies, which are generally clear and have low levels of suspended materials, resulting in high absorption of the NIR wavelengths. Staff also categorized the waterbodies as they reviewed the dataset (discussed further in next section). **Figure 7** shows the results of the 2010 waterbody inventory, which included classification, manual editing, and categorization of the features.

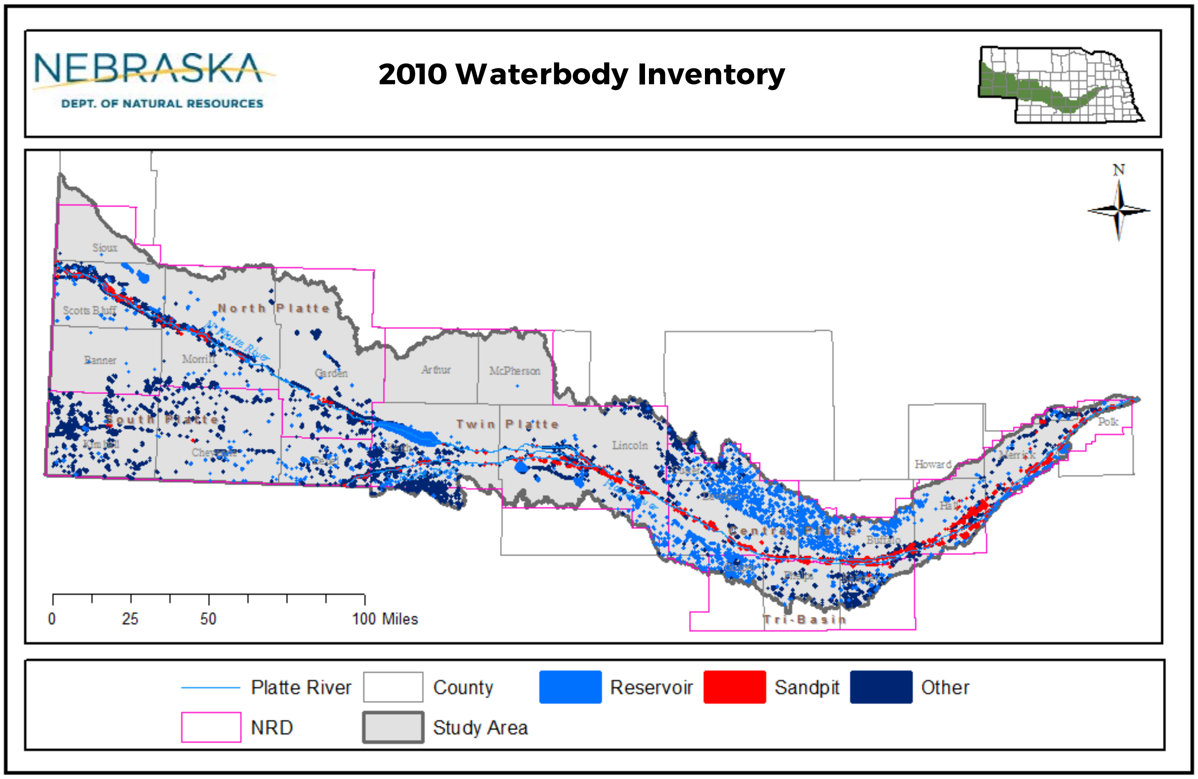


**Figure 7**. Classification and editing results of 2010 waterbodies.

## Categorization of Waterbodies

During the editing process, staff categorized waterbodies based on 18 surface water classification as shown in **Table 1**. The process of categorizing these waterbodies took into consideration the shape, size, and association with other identifiable features, such as proximity to the Platte River, farmlands, or towns and cities. For example, staff categorized waterbodies that intersected streams and/or had visible embankments as “reservoirs”; and features within the Platte River valley that had the characteristic sandpit shape as “sandpits”. Other feature classifications used to categorize waterbodies in this step included reuse pits, natural lakes, and water treatment facilities.

It should be noted that features in the 2005 waterbody inventory had been classified using four broad categories (lake, reservoir, sandpit, and miscellaneous), and therefore needed to be recategorized to match the 2010 waterbody categories. To accomplish this, staff kept the 2005 dataset in the GIS mapping project view and compared it with the 2010 inventory throughout manual editing. Waterbodies from both years were reviewed and edited as necessary to ensure features were lining up and that categories were consistent between the years.

After digitizing and initial categorization, staff merged the waterbody categories into six general categories: Active Sandpit, Inactive Sandpit, Reservoir, Feedlot, Industrial/Municipal, and Other (**Table 1**). Features classified as Feedlots, Industrial/Municipal, or Other were removed (but preserved as a supplemental dataset) from the database because the Department has other mechanisms in place to account for depletions due to these uses. Features categorized as Reservoirs or Sandpits (Active and Inactive) were retained for both the 2005 and 2010 datasets.

**Table 1.** Waterbody categories used in the 2010 inventory.

| Waterbody Category | Generalized Category |
|---|---|
| Feedlot | Feedlot |
| Industrial | Industrial/Municipal |
| Municipal | |
| Golf Course | Reservoir |
| Reservoir | |
| Reservoir-off NHD and Large | |
| Urban Recreation | |
| Sandpit-active | Sandpit Active |
| Sandpit-inactive | Sandpit Inactive |
| Natural Lake | Other |
| Natural Other | |
| Natural Reservoir | |
| Other | |
| Question | |
| Re-use pond/Natural Field Depression | |
| Re-use pond-engineered with banks | |
| Water Backup from Road | |
| Watering Hole | |

### *Waterbody Change Analysis: 2005 to 2010*

<u>Identification of potential new reservoirs and new or expanded sandpits</u>

The 2010 waterbody inventory revealed 1,578 features classified as reservoirs and 1,005 features classified as sandpits. Staff overlaid the features onto the 2005 inventory layer to identify non-overlapping features, which would indicate potential new reservoirs, or new or expanded sandpits. From this overlay process, it was determined that there were 573 potentially new reservoirs and 185 sandpits with significant area change in 2010. In all, the first-cut change analysis dataset identified 758 potentially new or expanded waterbodies with a cumulative surface area of 3,723 acres (**Figure 8**).

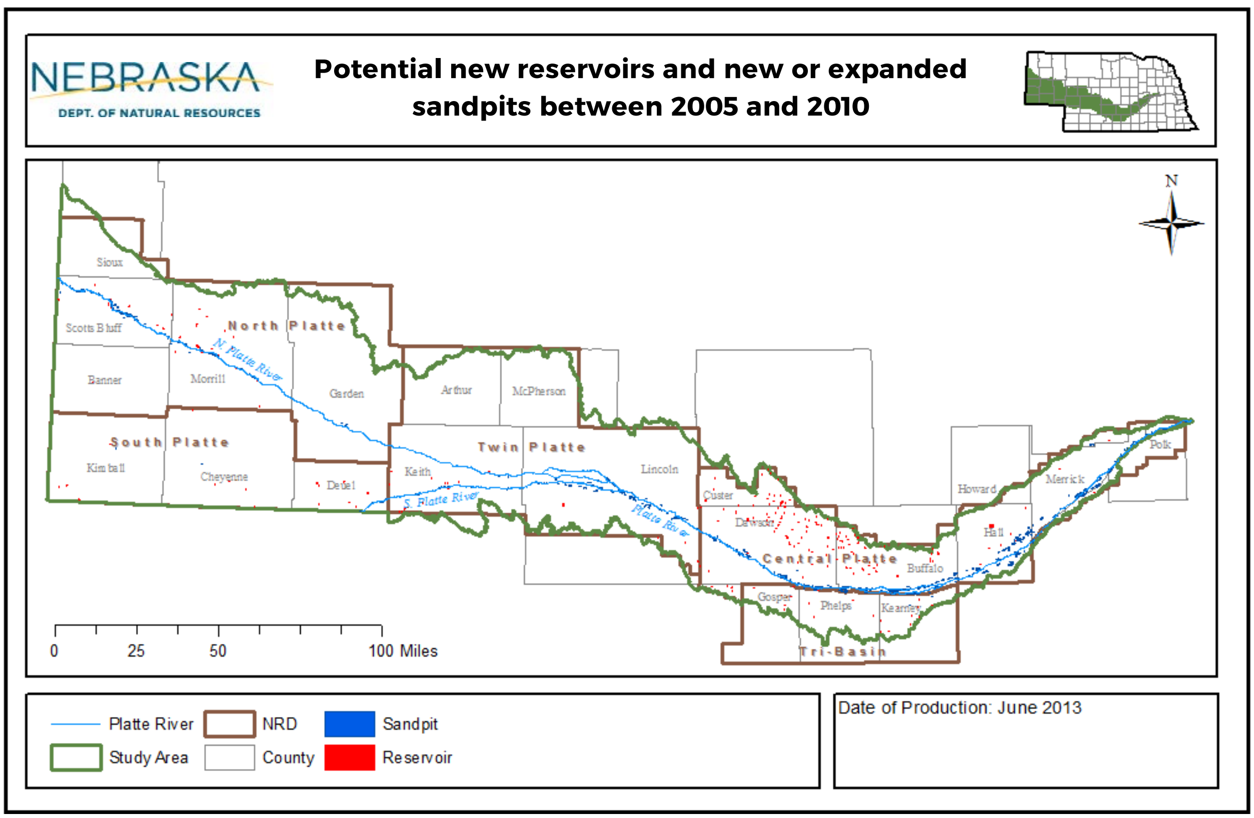


**Figure 8.** Map of potential new reservoirs or new or expanded sandpits between 2005 and 2010.

<u>Evaluation of potentially changed waterbodies</u>

Next, staff conducted additional research to determine if any of the potentially new or expanded waterbodies were actually new, and if so, if these had existing permits, plans, offsets, and/or mitigation. For reservoirs, staff utilized aerial imagery to evaluate whether potentially new reservoirs had embankments built between 2005 and 2010. Examples of two reservoirs with new embankments are shown in **Figure 9**. If there was a pre-existing embankment, the reservoir was removed from further analyses as it had had the capability to store water in 2005, even if there was no water present in that year. As a result, only 11 out of the 573 reservoirs identified in the first-cut analysis were determined to be “new” by the presence of a new embankment.

**Figure 9.** Aerial imagery from 2005 (left) and 2010 (right) shows enbankments and surface water from two new reservoirs, detected as a part of this study.

Reservoirs were then evaluated for existing permits to store water or for plans on file with NeDNR’s dam safely section. It was determined that two of the reservoirs had either a surface water permit or a dam safety plan on file with NeDNR, and were therefore removed from the dataset. At this point, there were nine new reservoirs retained for further analysis regarding consumptive use.

The 185 sandpit lakes that had been determined to have significant area change from 2005 to 2010 were also reviewed. NeDNR records were reviewed to check if there were any pre-existing offsets in place. The sandpit lakes were visually inspected using aerial imagery to determine whether they had actually changed and what, if any, mitigation measures were already in place. **Figure 10** shows an example of mitigation that occurred for a sandpit lake between 2005 and 2010. Although the sandpit had increased in size due to expanded mining, there had been some filling in of the open water (mitigation) along one end of the sandpit. These areas of expansion and mitigation were separated geospatially and would be evaluated separately in the subsequent consumptive use analyses. Of the 185 sandpits with significant area change, 98 were determined to be sandpits with actual change. Of those, four had some level of mitigation in place.


**Figure 10.** An example of a sandpit lake from 2005 (top left), 2010 (top right), with both mitigation and expansion change (bottom left).

<u>Review of waterbody features by NRD staff</u>

As a final check, the geospatial dataset of new reservoirs and new or expanded sandpits was separated by NRD and sent to each respective NRD for review. An example of one feature identified as “changed” that had not actually changed, per NRD staff evaluation, is shown in **Figure 11**. In this instance, a sandpit lake had been identified as expanded, but NRD staff with local knowledge indicated that the enlarged shape was due to high stream flows that spilled into the lake. As such, this feature was removed from the “changed waterbody” database.


**Figure 11.** Example of a sandpit lake with a size increase that was not due to mining expansion, as identified by NRD staff.

<u>Synopsis of Procedure and Final Dataset for Changed Small Waterbodies</u>

A map displaying the final dataset of new reservoirs and new or expanded sandpit lakes for the entirety of the study area is shown in **Figure 12**. In all, 9 new reservoirs and 94 new or expanded sandpit lakes were identified within the PRRIP study area. The vast majority of these lie along the North Platte, South Platte, or Platte Rivers, with a few new reservoirs in or near South Platte NRD. The process of identifying these 103 total features was extensive and involved several steps. A synopsis of this change analysis and the number/area of features identified in each step is shown in **Table 2.**

In summary, the change analysis process started with a classification that yielded roughly 20,000 features for 2010, of which, many were artifacts with a reflectance similar to water. Staff members systematically analyzed these features and identified 2,500 reservoir or sandpit lake features. The analysis was then conducted by first overlaying the 2005 and 2010 waterbody inventories, which identified roughly 750 features as “potentially changed” from 2005. These features were verified through: 1) visual inspection of aerial imagery, 2) comparison to permits, plans and offset documentation on file with NeDNR, and 3) NRD staff review. In total, 103 features were retained for subsequent consumptive use analysis discussed in the next sections.

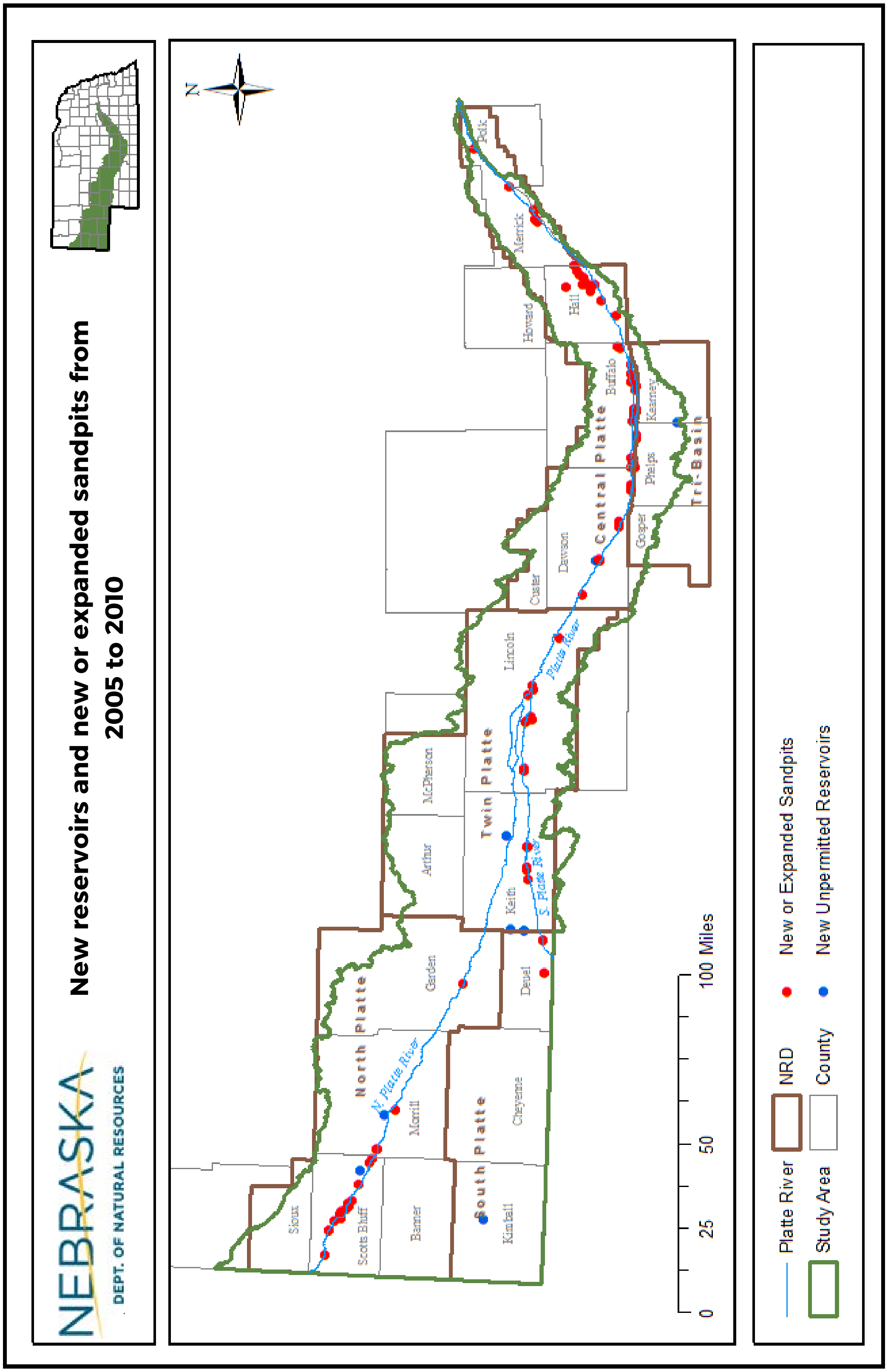


**Figure 12**. New reservoirs and new or expanded sandpits results between 2005 and 2010.

**Table 2.** Synopsis of change analyses and features/area in each step.

| Change Analysis: Reservoirs | | |
|---|---|---|
| **Procedure** | **Features** | **Area (acres)** |
| Reservoirs classified from 2010 imagery | 1,578 | 45,507 |
| Reservoirs with no overlap with 2005 inventory | 573 | 1,521 |
| Reservoirs with new embankments between 2005 and 2010 | 11 | 405 |
| New reservoirs with permits between 2005 and 2010 | (2) | 386 |
| New unpermitted reservoirs between 2005 and 2010 | 9 | 19 |
| **Change Analysis: Sandpit Lakes** | | |
| **Procedure** | **Features** | **Area (acres)** |
| Sandpits classified from 2010 imagery | 1,005 | 8,050 |
| Sandpits with area change from 2005 | 185 | 2,202 |
| New/expanded sandpits (no offsets and post-visual inspection) | 98 | 736 |
| New sandpits with mitigation | (4) | 8 |
| New/expanded sandpits between 2005 and 2010 | 94 | 728 |

## Consumptive Use (ET) Calculations for New or Expanded Waterbodies

The next step in evaluating the effects of changes in small waterbodies was to determine differences in ET due to the change from the prior land cover to open water. This was accomplished using the NRCS Consumptive Use Calculator (Calculator). The Calculator is Excel-based and has been used by the NRCS and USFWS for consumptive use calculations for biological opinions.

The Calculator uses reference crop ET that is translated to land use consumptive use using monthly coefficients that are hard-coded into the calculator. Estimation of consumptive use using this Calculator requires several inputs, including surface area, soil texture, land cover, and location within one of eight pre-defined climate zones.

### *Creation of Input Layers for the NRCS Consumptive Use Calculator*

The following sections describe the process of creating the necessary inputs for the Calculator. Here, GIS data pertaining to soils, land cover, and climate zones were assembled and adapted for Calculator inputs.

<u>Soil texture</u>

The Calculator requires soil texture (relative percentage of sand, silt, and clay in soils) data for the location(s) where consumptive use calculations will be applied. For this study, GIS data to describe soil texture were acquired from the 1:250,000 State Soil Geographic Database (STATSGO). This widely used US dataset for soils has extensive data about soil characteristics, not only on the land surface, but also within the soil profile. For this study, information about soil textures at the surface was extracted for Calculator inputs. The entire study area was processed and then specific areas with new waterbodies were extracted for Calculator use. The STATSGO soil texture classifications were more refined than the Calculator pre-defined classes, so the STATSGO classes were reclassified for use as inputs for the Calculator. **Table 3** shows the reclassification scheme used to adapt STATGSO data for use in the Calculator, and **Figure 4** shows the spatial distribution of the soil texture (post-reclassification) for the entirety of the study area.

**Table 3**. STATSGO soil textures reclassification to adapt texture classes to the NRCS Consumptive Use Calculator.

| STATSGO Soil Texture | NRCS Calculator Soil Texture |
|---|---|
| Fine Sand | Sand |
| Fine Sandy Loam | Sandy Loam |
| Sandy Loam | |
| Very Fine Sandy Loam | |
| Loamy Fine Sand | Loamy Sand |
| Loamy Sand | |
| Loamy Very Fine Sand | |
| Loam | Silt Loam |
| Silt Loam | |

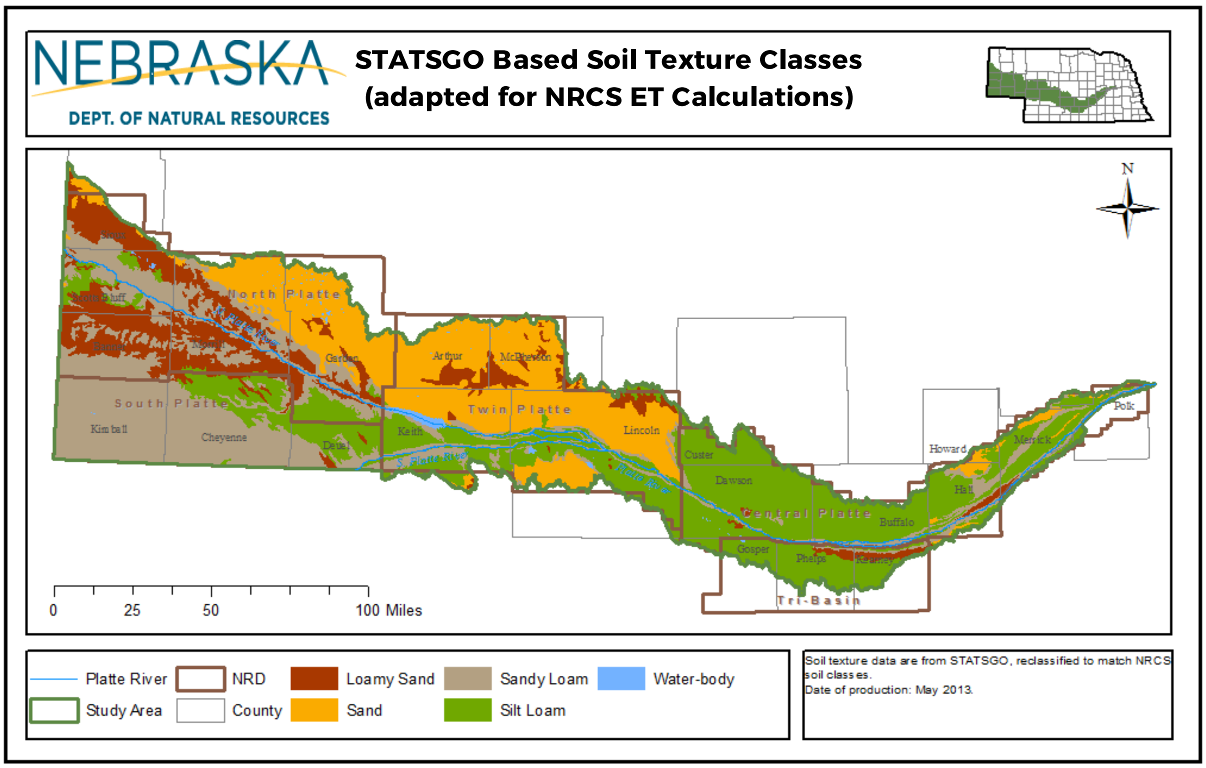


**Figure 13**. Spatial distribution of soil texture classes used to define soils at specific waterbody locations for consumptive use calculations.

Land cover

The Calculator provides 46 different land cover coefficients, including many vegetation types, bare soil, and open-water surfaces. Two statewide GIS data sources were used to determine land cover classes for use in the Calculator. The first GIS dataset that was used was the Center for Advanced Land Management Information Technologies (CALMIT) 2005 Land Use-Land Cover dataset, which is a 30-meter spatial scale raster dataset with 25 land cover classes that focus on agricultural crop types (**Figure 14**). The land use portion of CALMIT's 2005 dataset is also in vector format and provides information about irrigated vs. dryland agricultural areas. The CALMIT land cover/land use categories were reclassified to adapt to the Calculator categories as shown in **Table 4**.

The Calculator provided more options for grassland categories than did the CALMIT dataset, which was more focused on agricultural categories. As such, data from the 1993 UNL Conservation and Survey Division native vegetation map were utilized for areas where the CALMIT land cover class was either 'Range, Pasture, Grass' or 'Summer Fallow' (**Figure 14**). The native vegetation types were reclassified to correspond with the Calculator grassland options as shown in **Table 5**.

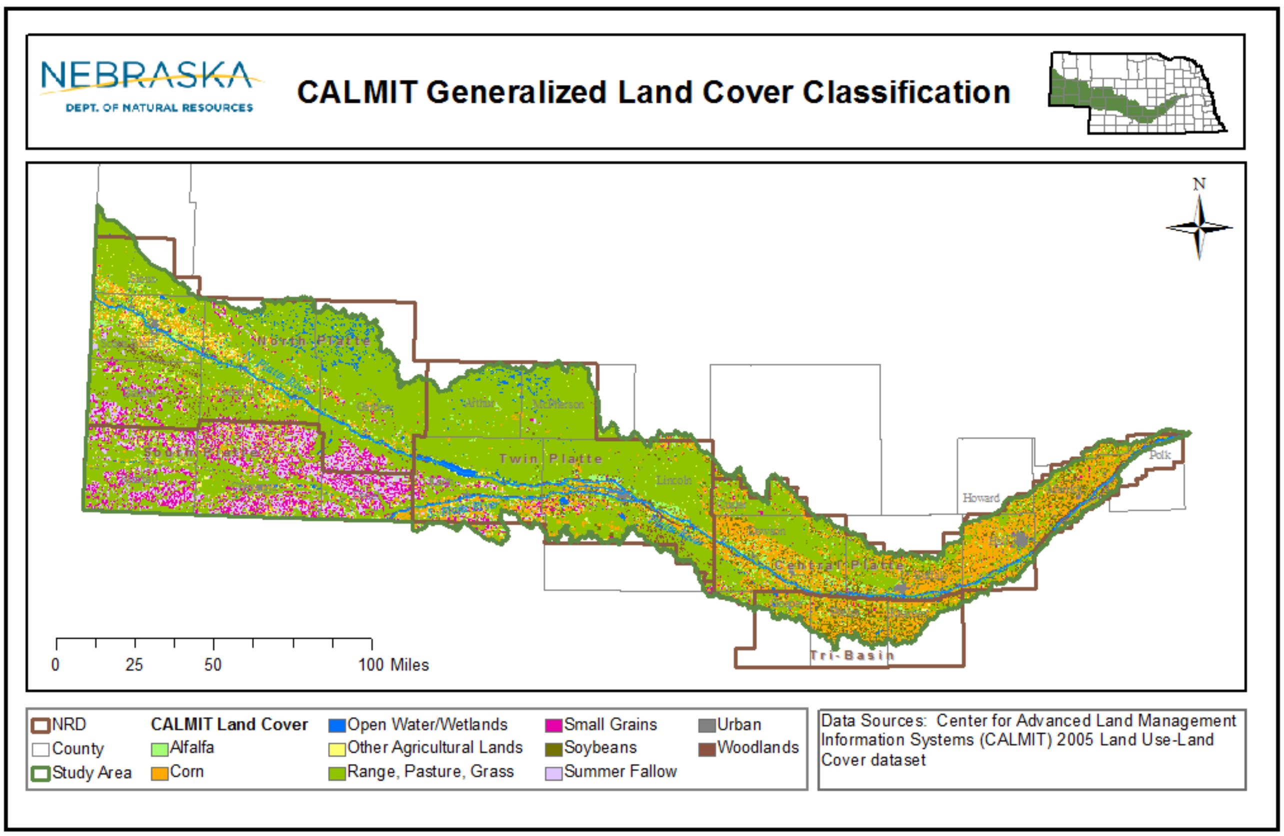


**Figure 14.** CALMIT land cover/land use dataset with generalized categories.

**Table 4**. Reclassification scheme for CALMIT land use-land cover adaption to Calculator categories.

| CALMIT Land Use/Cover Class | NRCS ET Calculator Land Use/Cover Class |
|---|---|
| Dryland Alfalfa | Dryland Alfalfa |
| Irrigated Alfalfa | Irrigated Alfalfa |
| Barren | Bare Soil |
| Other Agricultural Land | |
| Roads | |
| Urban Land | |
| Dryland Corn | Dryland Corn |
| Irrigated Corn | Irrigated Corn |
| Irrigated Sugar Beets | |
| Irrigated Potatoes | |
| Range, Pasture, Grass | Refer to Table 4 for a breakdown of this land cover type |
| Summer Fallow | |
| Dryland Small Grains | Dryland Millet |
| Irrigated Small Grains | Irrigated Millet |
| Dryland Sorghum (Milo, Sudan) | Dryland Sorghum |
| Irrigated Sorghum (Milo, Sudan) | Irrigated Sorghum |
| Dryland Dry Edible Beans | Dryland Soybeans |
| Dryland Soybeans | |
| Irrigated Dry Edible Beans | Irrigated Soybeans |
| Irrigated Soybeans | |
| Dryland Sunflower | Dryland Sunflower |
| Irrigated Sunflower | Irrigated Sunflower |
| Open Water | Water (Deep) |
| | Water (Shallow) |
| Wetlands | Wet Tall Grasses |
| Riparian Forest and Woodlands | Trees (Average of Cottonwood and Willow) |

**Table 5**. Reclassification scheme for UNL-CSD native vegetation adaption to Calculator categories.

| UNL CSD Native Vegetation Types | NRCS Land Cover Class |
|---|---|
| Gravelly Mixed-grass Prairie | Grass Warm Short/ Grass Cool Short |
| Loess Mixed-grass Prairie | Grass Warm Tall |
| Lowland Tall grass Prairie | Grass Warm Tall/ Grass Cool Tall |
| Mosaic of Mixed-grass/Short grass Prairie | Grass Warm Short |
| Ponderosa Pine Forests and Savannas | Conifers |
| Riparian Deciduous Forests | Trees (Cottonwood and Willow) |
| Salt Marsh and Flats | Wetlands |
| Sand Hills Borders Mixed-grass Prairie | Grass Warm Mid |
| Sand Hills Mixed-grass Prairie | Grass Warm Mid |
| Upland Tall grass Prairie | Grass Cool Tall |

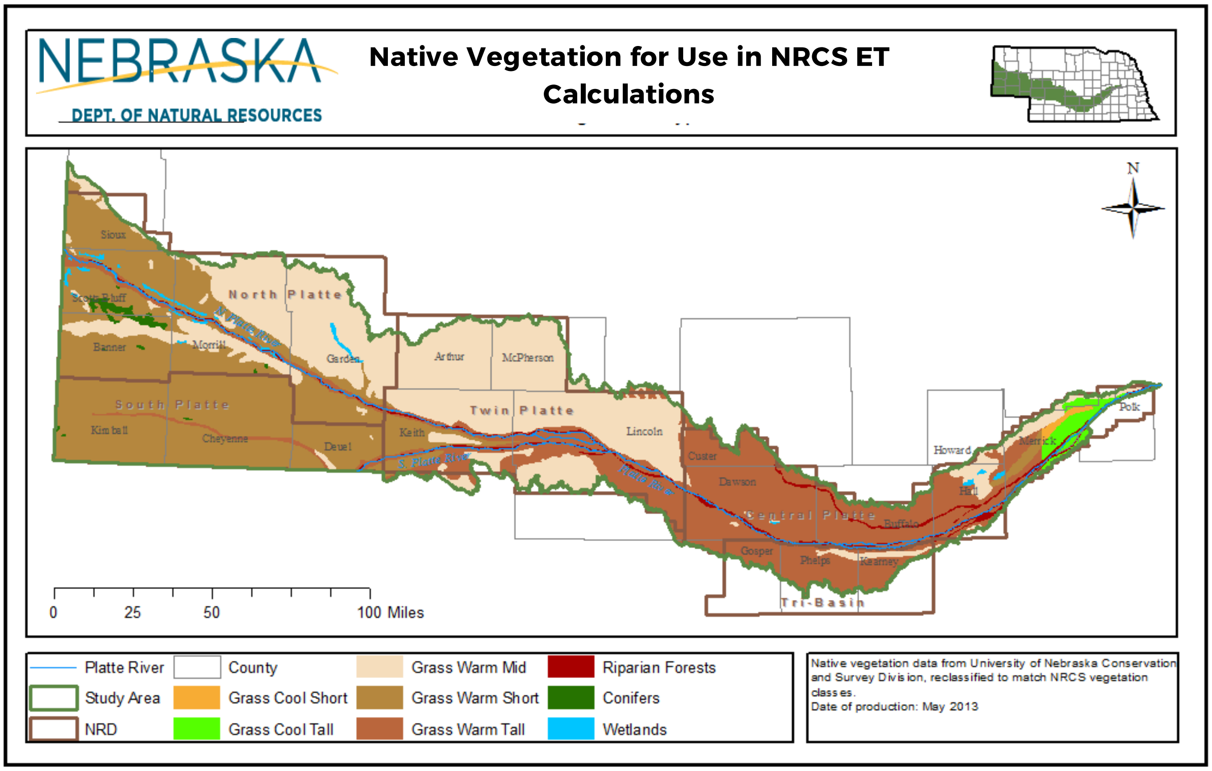


**Figure 15.** Spatial distribution of native vegetation in the study area; these were used to sub-divide grassland depicted in the 2005 CALMIT land cover dataset.

Climate zones

The NRCS consumptive use calculator documentation designates eight unique climate zones for the Platte River Basin, to be used for ET calculations (**Figure 16**). These areas have unique combinations of vegetation phenology, seasonal evaporation, and other climatic conditions.

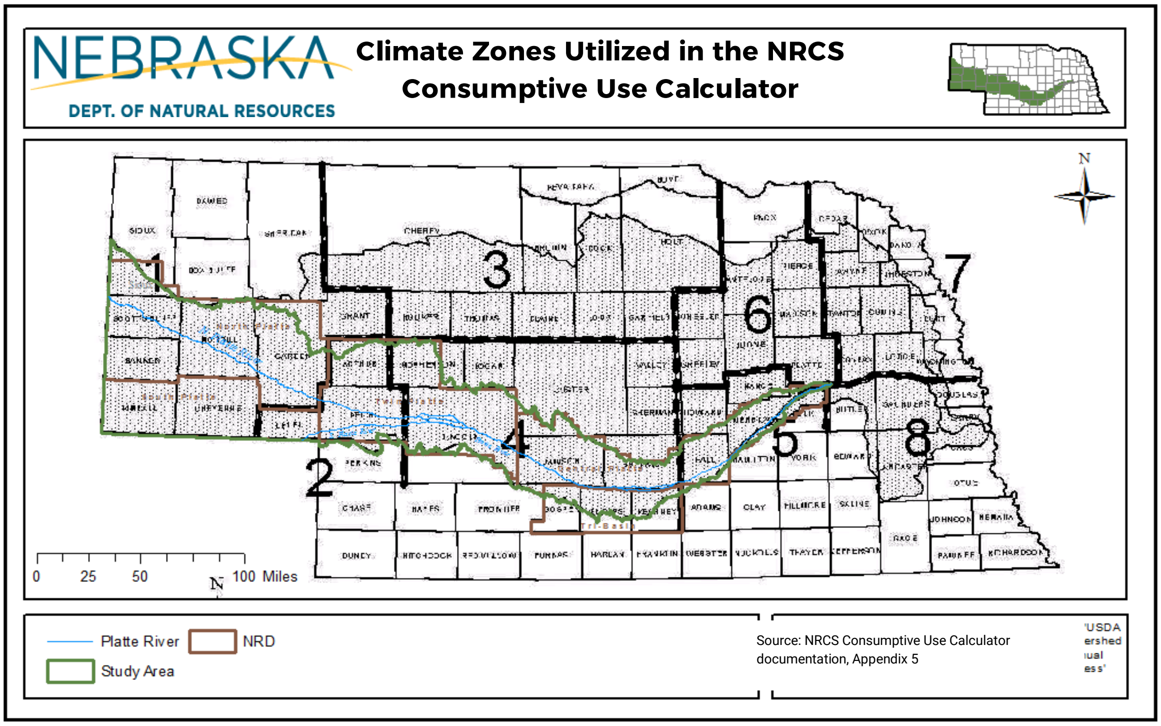


**Figure 16.** NRCS climate zones used in calculations of consumptive use for the study area.

### *Implementation of NRCS Calculator*

The NRCS calculator was used to estimate ET for the 103 waterbodies identified as new or expanded. A before (2005) and after (2010) calculation was run for each of the waterbodies, and the difference was used to determine change in ET. In using the Calculator to estimate ET, the following assumptions and decisions were made:

- Cottonwoods and willows were used to represent riparian trees.
- Wet tall grasses were used to represent wetlands.
- Daily irrigation was set to run from May to September for irrigated crops.
- Small reservoirs represented shallow water (less than 1 meter averaged over the water area)
- Sandpits represented deep water (over 1 meter when averaged over the water area)
- Mitigated areas of expanded sandpits were modeled as follows: ET for deep water (2005 condition) to ET for sand (2010 condition).

## Results

This section presents the results of analyses on the changes to ET due to new or expanded small waterbodies with no surface water permits, dam safety plans, or offsets by the Department between 2005 and 2010. The first set of results discusses the effects on ET from reservoirs, and the second set of results discusses the effects on ET from sandpits.

### *Consumptive Use Change for New Reservoirs*

There were nine "unregulated" reservoirs, accounting for 18 acres in total, constructed within the study area between 2005 and 2010 **(Figure 17)**. The term "unregulated" refers to new reservoirs that had no surface water permits, dam safety plans, or offsets in place upon construction and through 2010.

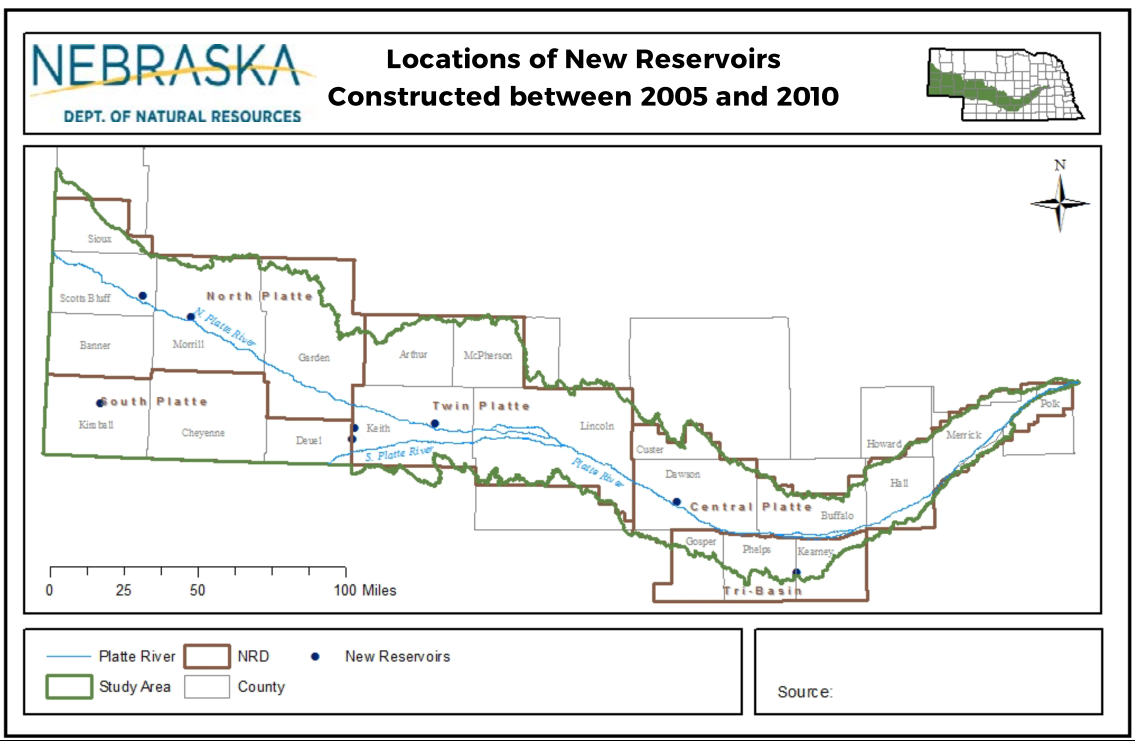


**Figure 17**. Locations of new reservoirs for consumptive use analysis.

The distribution of land cover/land use types that existed in the locations of the reservoirs prior to conversion to open water is provided in **Table 6**. Combined grassland (modeled as native types) comprised about 63 percent, irrigated crops comprised 26 percent, and dryland crops comprised 11 percent of the area prior to conversion to open water. The associated ET with these land cover/land use types resulted in 7 af for dryland crops; 9 af for grassland; and 16 af for irrigated crops, with 10 af of the total irrigated crops associated with irrigated alfalfa. In all, about 32 af of consumptive use per year was occurring in these areas prior to reservoir development. Nearly half of the consumptive use was associated with irrigated crops, 30 percent associated with grassland, and the remainder (22 percent) associated with dryland crops. Please see Appendix A to access more detailed information about how specific land cover/land use types are modeled in the Calculator with regard to ET.

**Table 6**. Land cover/land use types and associated ET of new reservoir areas prior to conversion to open water.

| Prior Land Cover and Associated Evapotranspiration (ET) for New Reservoir Areas | | | | |
|---|---|---|---|---|
| **Prior land cover (2005)** | **Acres** | **ET (af)** | **Acres (%)** | **ET (%)** |
| **Dryland Alfalfa** | 1 | 4 | 6 | 12 |
| **Dryland Millet** | 1 | 3 | 7 | 10 |
| **Grass Warm Mid** | 1 | 2 | 5 | 7 |
| **Grass Warm Short** | 10 | 4 | 50 | 14 |
| **Grass Warm Tall** | 1 | 3 | 6 | 9 |
| **Irrigated Alfalfa** | 3 | 10 | 15 | 30 |
| **Irrigated Corn** | 1 | 6 | 11 | 18 |
| **Total** | **18** | **32** | **100** | **100** |

The modeled ET for the combined prior land cover/land use against the post-land cover (open, shallow water) is shown in **Figure 18**. Monthly change in consumptive use that occurred from conversion of the initial land cover/land use to a reservoir (modeled as open, shallow water) is presented in **Figure 21**. When summed, there was a total increase of 18.4 af of ET due to the conversion of 19 acres to shallow, open water. A little less than half (9 af) of that ET increase occurred in the non-peak season months of March, April, October, and November (winter months are not included in the Calculator due to minimal ET). The highest monthly differences were in April, May, September, and October, where agricultural vegetation would be in initial growth stages, or senescence and harvest. The lowest differences were at the height of the growing season where more ET would be occurring in agricultural areas, which as modeled, would be close to the amount of evaporation occurring on open, shallow water.

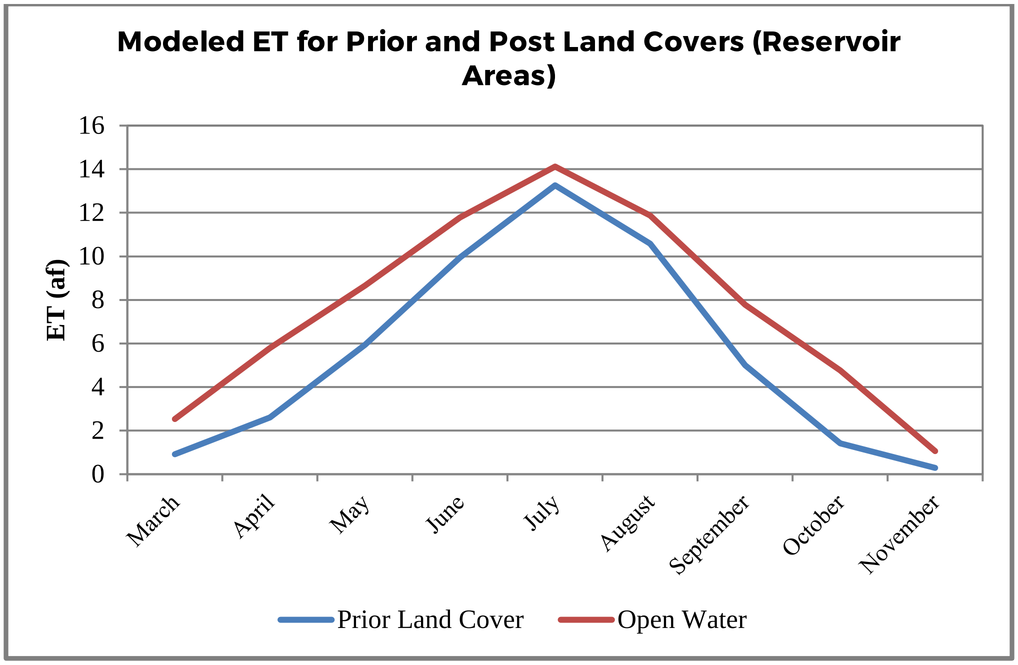


**Figure 18**. Modeled ET for prior and post land covers in new reservoir areas.

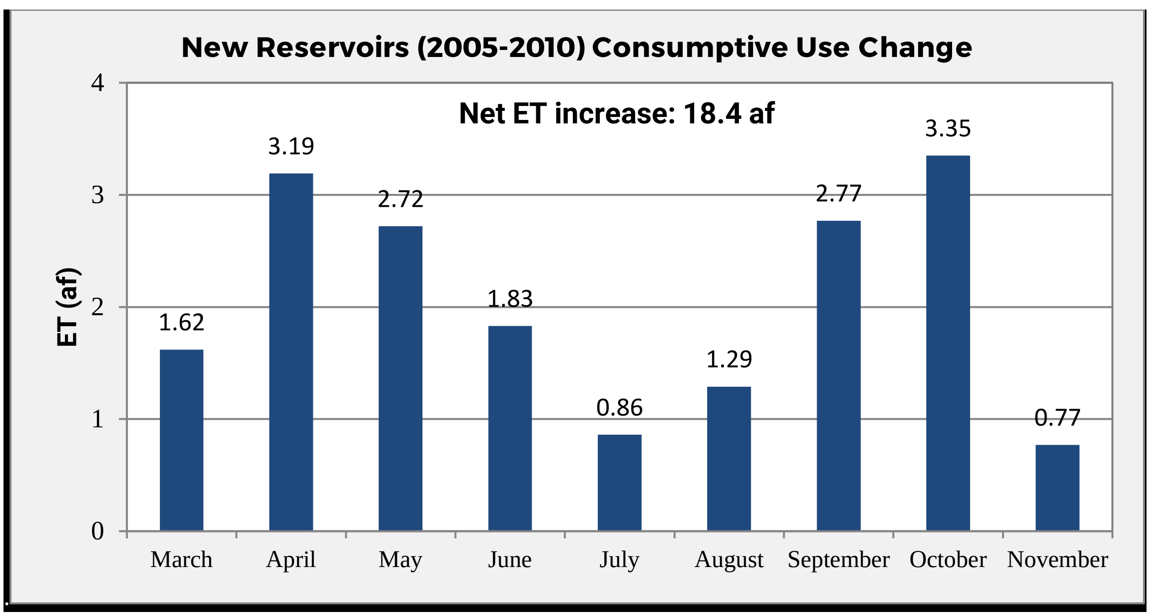


**Figure 19**. Change in ET due to land coversion to reservoirs, expressed in monthly values from March to November.

### *Consumptive Use Change for New or Expanded Sandpits*

Between 2005 and 2010, 94 sandpits were either built or expanded within study area. The total area of land that the new and expanded sandpits encompassed was 734 acres. The total area of active sandpits that reduced in size between 2005 and 2010 was 145 acres. This resulted in 879 sandpit-related acres that underwent a change in land cover type between 2005 and 2010. The locations of new or expanded sandpits are shown in **Figure 20**.

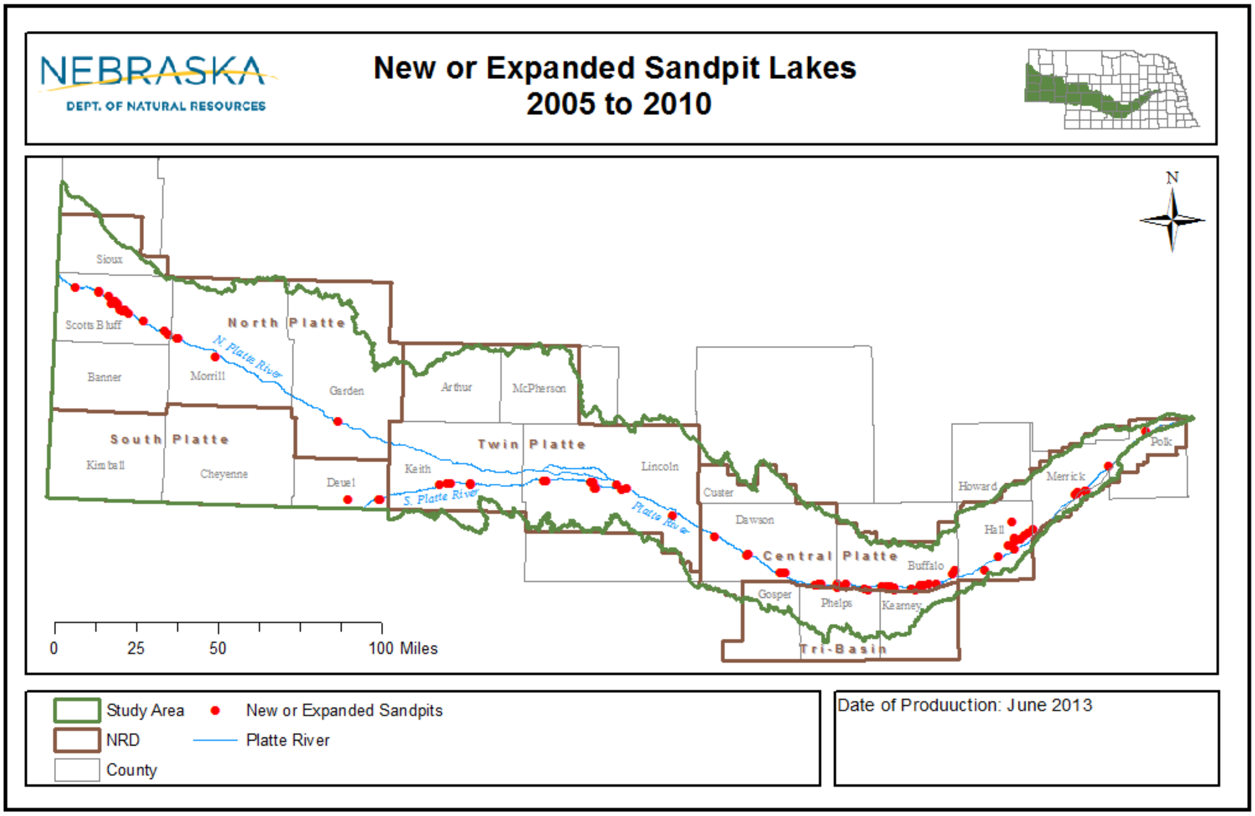


**Figure 20**. Locations of new or expanded sandpits within the Platte Surface Water Basin above Columbus.

The distribution of land cover/land use type that existed in the locations of new or expanded sandpits prior to conversion to open water is provided in **Table 7**. Most (85 percent) of the pre-sandpit lake area was comprised of riparian forests and woodlands, wetlands, and grasslands, as would be expected in areas close to the Platte River. About 15 percent of the land cover/land use, most of which was irrigated (13 percent), was devoted to agriculture prior to sandpit development. As discussed earlier, some new or expanded sandpits also had mitigation in certain areas, which totaled 145 acres across the study area. These areas were modeled as a land cover change from deep, open water to sand. Please refer to Appendix A for more information about Calculator ET values for specific land cover/land use.

**Table 7.** Total acres of generalized land cover and the percent contribution of each group to the total number of sandpit acres within the study are. All figures have been rounded to the nearest whole number.

| Land Cover Groups to Prior New or Expanded Sandpits in the Platte SW Basin above Columbus | | |
|---|---|---|
| **Prior Land Cover Groups (2005)** | **Acres** | **Acres (%)** |
| **New/Expanded Sandpits** | | |
| **Dryland Crops** | 18 | 2 |
| **Irrigated Crops** | 93 | 13 |
| **Grasslands** | 167 | 23 |
| **Riparian Forest and Woodlands** | 275 | 37 |
| **Wetlands** | 181 | 25 |
| **Sub-total (new or expanded)** | 734 | 84 |
| **Reduced Sandpit Areas** | | |
| **Open Water to Sand** | 145 | 16 |
| **Total New/Expanded and Reduced Acres** | **879** | **100** |

A graphical comparison of the monthly ET associated with active sandpits in 2005 and 2010 (all prior and post-land cover groups were combined) is shown in **Figure 21**. Note that the prior land cover ET is much higher during the peak growing season compared to ET for the sandpit lakes. This is related to higher heat storage capacities for deep water, compared to heat storage capacities for shallow water. Solar energy is stored in the deep water and does not evaporate as readily as in shallow water. The NRCS Consumptive Use calculator modeling parameters reflect this concept, and the vegetation opposed to deep water is modeled as having higher ET for the sandpit lake areas.

Monthly change in consumptive use that occurred from conversion of the initial vegetation to a sandpit lake (or vice versa for mitigated areas) is presented in **Figure 22**. When summed, there was a total decrease of 698 af of ET due to the combined conversion of 784 acres to deep, open water (expanded or new areas), and 145 acres from sand to deep, open water (mitigated areas). The majority of the calculated ET differences occurred in the hottest summer months (June, July, and August), when sandpit lakes had less evaporation than the previous land cover due to the storage of solar energy (opposed to evaporation) in the deep, open water. Conversely, more evaporation occurred with the open, deep water than ET that occurred in the previous land cover (vegetation) for the months of March, April, October, and November.

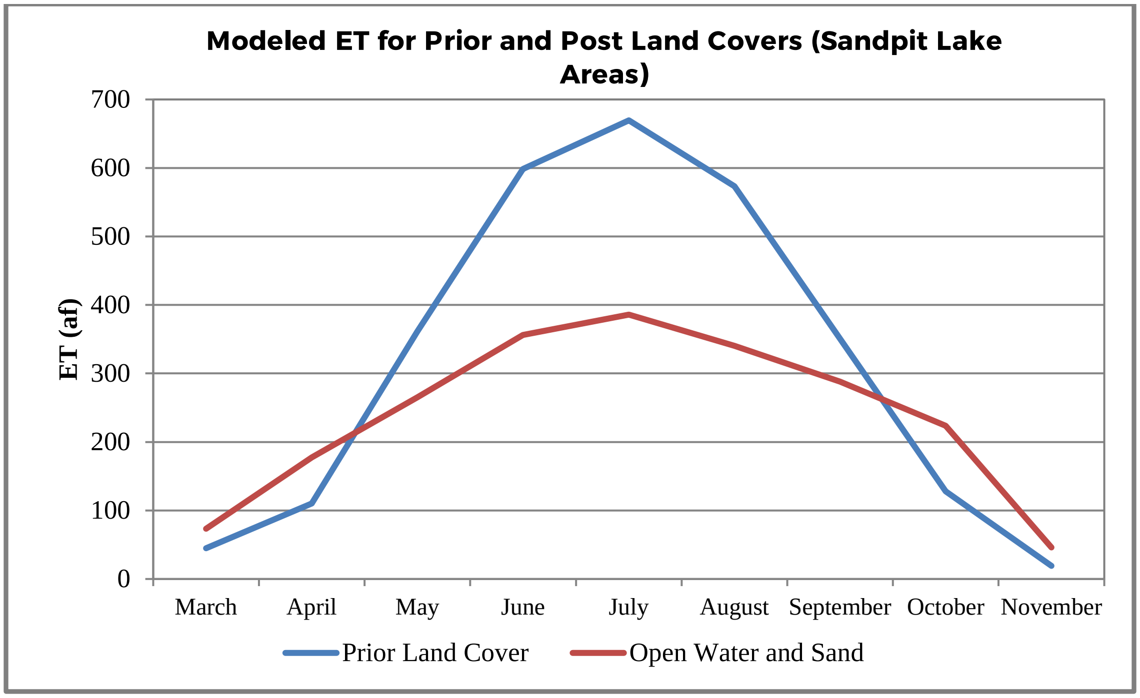


**Figure 21**. Modeled ET for prior and post land covers in new or expanded, or mitigated sandpit lake areas.

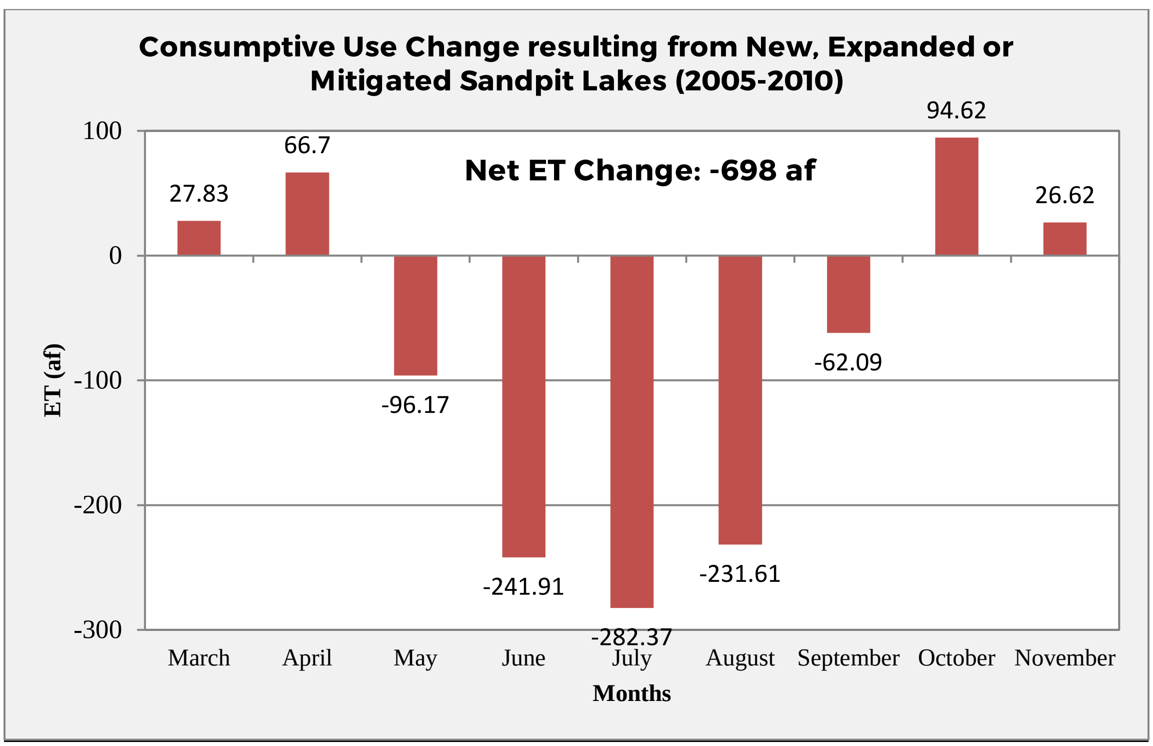


**Figure 22.** Change in ET due to land coversion associated with sandpit lake construction or mitigation, expressed in monthly values from March to November.

## Combined Results

When combining the results of land area change to reservoirs and sandpit lakes together, the overall ET decreased by 678 af. **Figure 23** shows the total ET monthly change from new, expanded, or mitigated sandpit lakes and new reservoirs. The ET change from various sandpit lake construction dwarfs the ET change from new reservoirs in the graph; but more than 700 acres are associated with changes due to sandpit lakes, opposed to only 18 acres associated with new reservoir areas. The total ET change appears to be most affected by the conversion of vegetation to deep open water, as the deep, open water of sandpit lakes stores solar energy in the summer months that would otherwise be evaporated.

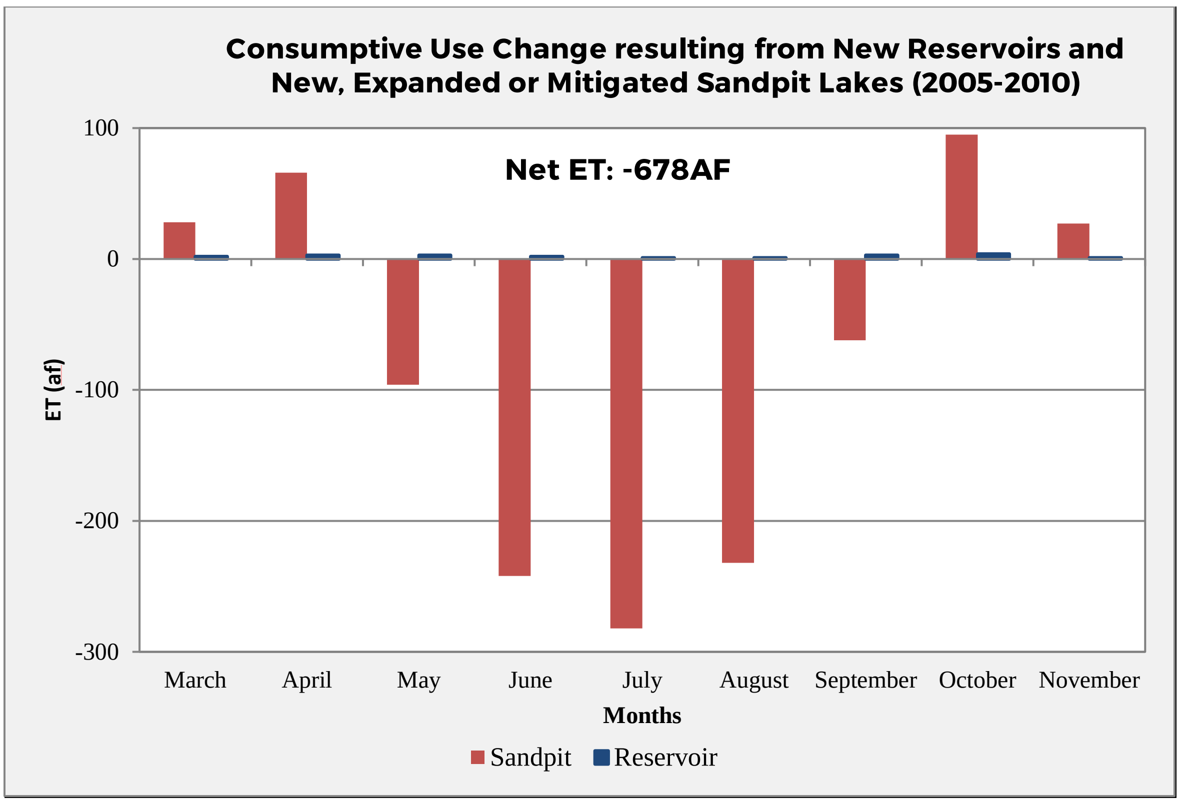


**Figure 23.** Overall change in ET by month, for conversion of land to new reservoirs and new or expanded sandpit lakes.

## Summary

- A large effort was undertaken to create inventories of water bodies in 2005 and 2010 for the Platte River Basin above Columbus, Nebraska. An extensive amount of manual work was involved, and took an estimated 2,500 hours of NeDNR staff time to conduct.
- The extent of water bodies was affected greatly by the different precipitation amounts for each year (2010 was a wet year, so more water features were apparent on the aerial imagery).
- The inventories were compared to determine changes in water bodies that occurred between 2005 and 2010.
- The results of the inventory comparison were distilled by removing water bodies that did not have certain, apparent physical features (e.g. construction of new dams); had permits, plans, or offsets in place; and were determined by local expertise to not have actual change. What began as an analysis of thousands of features was reduced to just over 100 features that would be included in consumptive use change analysis.
- A total of 95 new or expanded sandpits and 9 new reservoirs were used for land cover/land use ET change analysis. The NRCS Consumptive Use Calculator was used to determine ET for the prior land cover/land use and for the post-land cover/land use (shallow or deep open water). Sandpit lakes with mitigation in place were also modeled to account for deep, open water that had been converted to sand.
- In all, the modeled results showed that there was an annual decrease in ET of 678 af due to new reservoirs and new, expanded or mitigated sandpit lakes, over the previous land cover/land use. These results were largely affected by the much higher acreage in sandpit lakes compared to new reservoirs and the modeled deep, open water, which stores solar energy in hot summer months, whereas vegetation in the same location would have a higher ET during these months as modeled.

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# APPENDIX A.

## NRCS Consumptive Use Calculator ET values for specific land covers

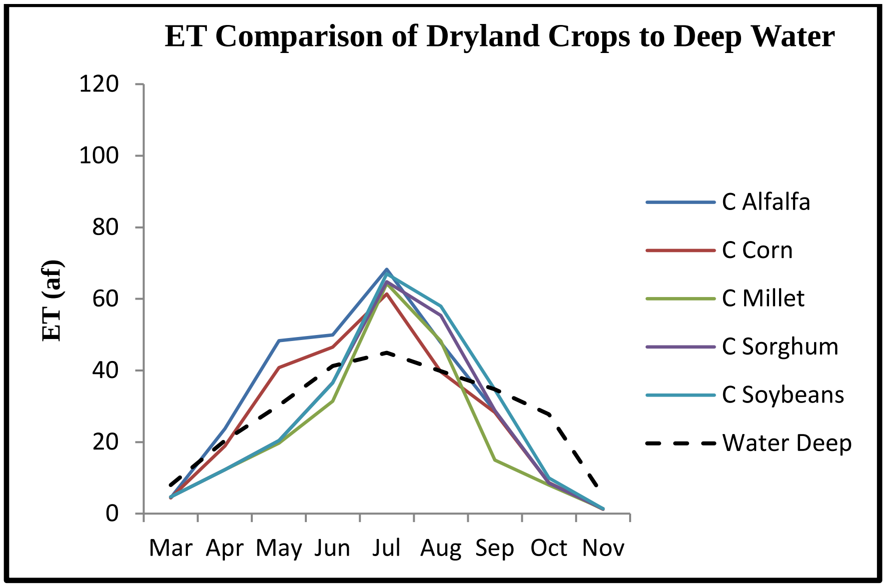


**Figure B-1.** The ET pattern of dryland crops per 100 acres of each dryland crop type within the study area.

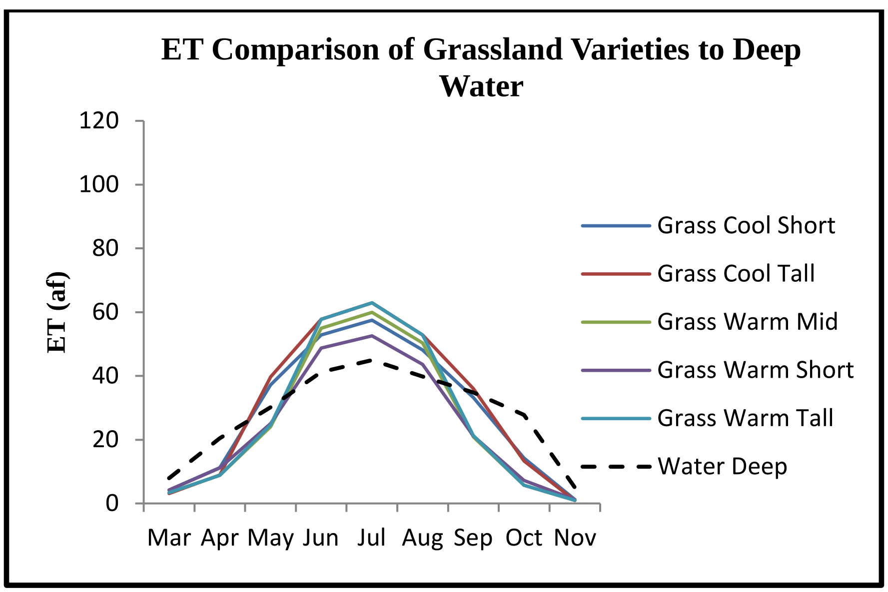


**Figure B-2**. The ET pattern of grasslands per 100 acres of grassland type in the study area.

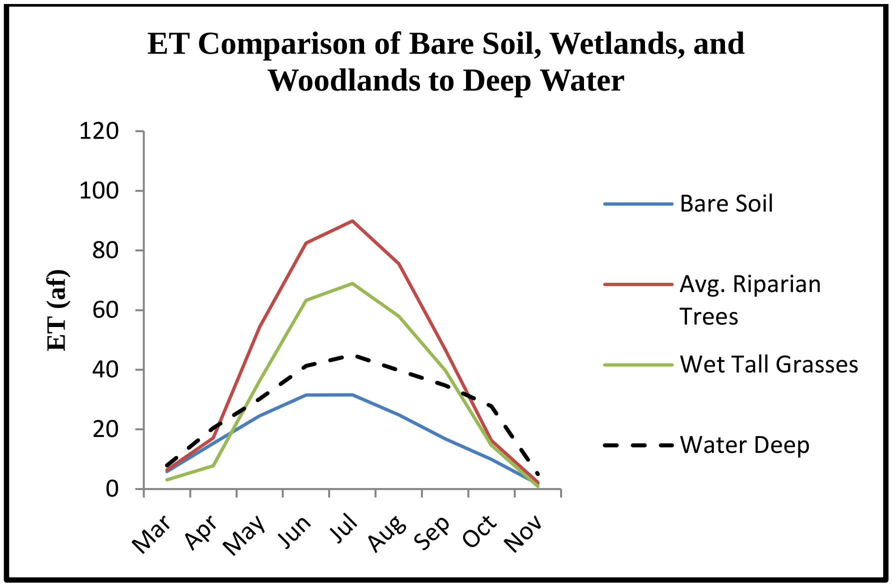


**Figure B-3**. The ET pattern of bare soil, wetlands, and woodlands per 100 acres of each land cover type in the study area.