QUANTIFICATION ANALYSIS

FOR THE

PROPOSED SUPPLEMENTAL PARTIAL FINAL JUDGMENT AND DECREE OF THE WATER RIGHTS OF THE NAVAJO NATION

Prepared in Furtherance of the
San Juan River Basin in New Mexico
Navajo Nation Water Rights Settlement Agreement

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I. INTRODUCTION

A. Background and Purpose

The "San Juan River Basin in New Mexico Navajo Nation Water Rights Settlement Agreement," dated December 17, 2010 (Settlement Agreement), proposed water rights for the Navajo Nation as described in Appendices 1 and 2 to the Settlement Agreement. The proposed "Partial Final Judgment and Decree of the Water Rights of the Navajo Nation" (Proposed Decree) that is Appendix 1 to the Settlement Agreement would provide water rights for the Navajo Nation's historic and future uses from the San Juan River, including Navajo Reservoir, and from the Animas River. The Proposed Decree also would provide water rights for the Navajo Nation for historic and future uses from underground water sources in the San Juan River Basin for uses other than those described in Appendix 2 to the Settlement Agreement. Appendix 2 to the Settlement Agreement provided a draft form for a supplemental partial final decree that would describe water rights for the Navajo Nation's historic and existing irrigation, livestock, industrial and recreational uses in the drainages of ephemeral tributaries to the San Juan River that are supplied from water sources other than the San Juan River, but did not quantify the Navajo Nation's water rights to be included in the supplemental partial final decree. The Settlement Agreement provided for the State of New Mexico, the United States and the Navajo Nation (the Settling Parties) to complete the quantification of the Navajo Nation's water rights for uses identified in Appendix 2 to the Settlement Agreement based on historic and existing uses.

The United States in December 2010 filed with the Court in the San Juan River Adjudication (Adjudication) the following documents: (1) "The United States' Statement of Claims of Water Rights in the New Mexico San Juan River Basin on Behalf of the Navajo Nation" (US Claims); and (2) "The United States' Hydrographic Survey of Navajo Lands in the San Juan River Basin" (US Survey). The US Survey was filed in support of the United States' reserved water right claims for the Navajo Nation described by the US Claims. In July 2011, the United States provided to the State of New Mexico electronic sets of aerial imagery and ArcGIS shapefiles covering Navajo lands in the basin in New Mexico that were used to determine: (1) amounts of historic agricultural lands claimed as irrigated acres by the US Survey; and (2) maximum surface areas and storage capacities of reservoirs claimed by the US Survey. During the period July 2011 through February 2012, the State of New Mexico gathered additional data and information relating to historic Navajo Nation irrigation uses, which data included annual crop reports and irrigated acres summaries for Navajo irrigation projects prepared by the US Bureau of Indian Affairs (BIA) for select time periods. Further data from the United States comparing reservoir surface areas measured in the field with surface areas interpreted by stereographically viewing aerial imagery were provided to the State of New Mexico in December 2011. In January 2012, the United States disclosed in the Adjudication several reports prepared by its technical experts in support of the US Claims and the US Survey, which reports describe the bases for quantifying the reserved water right claims for the Navajo Nation's historic and future uses. Information on measured reservoir depths was provided to the State of New Mexico in February 2012.

The purpose of this report is to: (1) provide an independent review of the water right claims made by the United States on behalf of the Navajo Nation for historic and existing uses of water from sources other than the San Juan River as these claims are described by the US Survey and associated supporting technical reports; and (2) provide analyses of available data and information concerning Navajo tributary water uses to determine the elements, quantities, terms and administrative conditions of the

Navajo Nation's water rights proposed by the "Supplemental Partial Final Judgment and Decree of the Water Rights of the Navajo Nation" that the Settling Parties submitted to the Court in the Adjudication on April 2, 2012 (Proposed Supplemental Decree). The review and analyses provided herein consider also data and information related to historic Navajo tributary water uses that are available from records of the New Mexico Interstate Stream Commission (ISC) and the New Mexico Office of the State Engineer (OSE).

B. Proposed Supplemental Decree

1. Navajo Nation Water Rights in the Proposed Supplemental Decree. The Proposed Supplemental Decree includes a quantification of the federal reserved and state law water rights of the Navajo Nation for lands held by the United States in trust on behalf of the Nation or on lands held in fee by the Navajo Nation based on historic and existing uses for: (1) tributary irrigation uses on project or non-project lands in the San Juan River Basin that are supplied water from sources other than the San Juan River; (2) reservoir filling from water sources other than the San Juan River, and associated reservoir evaporation, for reservoirs used for irrigation, livestock or recreation uses; (3) livestock water consumption from sources other than the San Juan River that may be associated with stock wells, springs, stock ponds, irrigation reservoirs, or other bodies of water in the basin; and (4) certain industrial ground water uses. The Proposed Supplemental Decree also includes administrative conditions to limit depletions and protect existing water uses in the San Juan River Basin in New Mexico.

2. Historic Water Uses on Navajo Allotments. The Proposed Supplemental Decree does not include water rights for historic uses on lands allotted by the United States to individual members of the Navajo Nation. The United States has separate trust responsibilities to Navajo allottees, and water rights for the allottees will be adjudicated separately from the water rights of the Navajo Nation at a later date. However, consistent with paragraph 12.3.2 of the Settlement Agreement, the Proposed Supplemental Decree provides that to the extent water rights are later adjudicated by the Court for or on behalf of allottees who are members of the Navajo Nation for uses in the San Juan River Basin in New Mexico that are in excess of historic and existing water uses on allotted lands as of the date of entry of the decree, such water rights for allotted lands shall be fulfilled or serviced by water rights adjudicated to the Navajo Nation by the Proposed Decree or the Proposed Supplemental Decree, or the depletions of flow of the San Juan River resulting from the use of water under such rights for allotted lands shall be fully offset by a forbearance of use of water rights adjudicated to the Navajo Nation by the two decrees. The US Survey identifies historic water uses on Navajo allotments in the basin.

C. Disclaimers

This report was prepared at the request of the State of New Mexico, and neither the United States nor the Navajo Nation participated in the preparation of this report. Any reliance herein on data and information provided by the US Survey should not be construed as the State of New Mexico's agreement or concurrence with the US Survey. The analyses and assumptions contained herein are based solely on a review of the data and information available at this time. No method or analysis contained herein that was relied on for negotiating a settlement of the quantification of water rights for the Navajo Nation in the Proposed Supplemental Decree should be construed as a precedent for quantifying other water rights in the San Juan River Basin in New Mexico or for computing actual depletions in the basin, or to prevent the State Engineer from requiring the use of different methods, data

and assumptions for computing actual depletions resulting from water uses of the Navajo Nation for administration of the water rights in the Proposed Supplemental Decree.

II. TRIBUTARY IRRIGATION USES

A. US Survey of Tributary Irrigation Uses on Navajo Lands

The US Survey includes claims for historic and existing irrigation uses in New Mexico from water sources other than the San Juan River within the drainages of ephemeral tributaries to the San Juan River, principally within the Chaco River and Chinle Wash drainages. Water rights for Navajo Nation irrigation uses in New Mexico from surface water or ground water originating within the drainages of ephemeral tributaries to the San Juan River are included in the Proposed Supplemental Decree.

The US Survey claims water rights for tributary irrigation projects and for tributary irrigation non-project lands in New Mexico within the drainages of ephemeral tributaries to the San Juan River. The US Survey defines a tributary irrigation project as an organized irrigation project with a water source other than the San Juan River that was operated by the BIA, its predecessor the US Indian Service, or another group that required significant investment in irrigation ditch construction, reservoir development, well development, and/or spring development. The US Survey defines tributary irrigation non-project land as land outside of identified tributary irrigation project areas that did not involve the significant investment and development associated with tributary irrigation projects. The US Survey states, however, that tributary non-project lands may nonetheless be associated with ditch-irrigated field systems, reservoirs, wells, and/or improved springs (see US Survey, page 8). The United States' water right claims for irrigated acreage, depletions and diversions for tributary irrigation projects are listed in table I-1 of Appendix I to the US Survey and for tributary irrigation non-project lands are listed in table J-1 of Appendix J to the US Survey. Maps showing the locations of field parcels for claimed tributary irrigation uses are provided in Appendix E, maps E-13 through E-64, but the maps do not cross reference the parcels to field numbers or use data (for example, acreage) for each parcel. A summary of the irrigated acres, depletions and diversions claimed by the US Survey for each identified Navajo tributary irrigation project is provided in table 1 attached hereto. A summary by quadrangle map of the irrigated acres, depletions and diversions claimed by the US Survey for Navajo tributary non-project irrigation uses is provided in table 2 attached hereto. Table 3 attached hereto includes a summary of the total irrigated acres, depletions and diversions claimed by the US Survey for Navajo tributary irrigation projects and for Navajo tributary irrigation non-project lands within the Chaco River drainage, the San Juan River drainage below the Chaco River confluence to Four Corners, and the Chinle Wash drainage. The US Survey at pages 11 and 12 indicates that the amounts of acres claimed by the US Survey to have been irrigated historically were determined for both tributary irrigation projects and tributary irrigation non-project lands by field inspection and by review of government records and aerial photography; however, it appears that tributary non-project irrigation lands were determined primarily by interpretation of aerial imagery with few field inspections.

B. Irrigated Acres

1. Tributary Irrigation Project Acreage Claims. The US Survey at page 11 claims that approximately 9,954 acres of Navajo land have been or are currently being irrigated under tributary irrigation projects that utilize water from the drainages of ephemeral tributaries to the San Juan River. Of this acreage, about 8,425 acres are located on lands held by the United States in trust for the Navajo Nation, about 1,431 acres are located on lands held by the Navajo Nation in fee, and about 98 acres are located on lands allotted by the United States to individual members of the Navajo Nation (see table 1). Most of

the acreage on Navajo Nation fee lands or Navajo allotments, and some of the acreage on Navajo Nation trust lands, is associated with the spreader dams and irrigation uses identified by the 1938 State Engineer Hydrographic Survey of the San Juan River Basin (1938 State Engineer Hydrographic Survey), which uses apparently originated as private non-Indian irrigation development.

The Navajo Nation tributary irrigation projects identified by the US Survey in table I-1 of Appendix I and in maps E-13 through E-64 of Appendix E include several projects not previously identified by the BIA or the Soil Conservation Service (SCS), namely the Tocito Springs, Tocito Lake, Porcupine Canyon, Red Rock Canyon, Sand Springs, Long Lake and White Rock projects. In addition, as compared to project descriptions used previously, the US Survey apparently segregates the Captain Tom Project into the Upper Captain Tom and Lower Captain Tom projects, the Grey Mesa Project into the Two Grey Hills and Grey Mesa projects, the Toadlena Project into the Toadlena and Toadlena NE projects, and the Crystal Project into the Crystal, Lower Crystal and Sonsela projects.

2. Tributary Irrigation Non-Project Lands Acreage Claims. The US Survey at page 12 claims that approximately 3,969 acres of Navajo land have been or are currently being irrigated on tributary irrigation non-project lands that utilize water from the drainages of ephemeral tributaries to the San Juan River. Of this acreage, about 3,734 acres are located on lands held by the United States in trust for the Navajo Nation, about 26 acres are located on lands held by the Navajo Nation in fee, and about 209 acres are located on lands allotted by the United States to individual members of the Navajo Nation (see table 2). Most of these non-project irrigation uses are claimed to have been developed with surface water.

3. General Discussion of Historic Irrigated Acreage Claims. Table 4 attached hereto provides for the tributary irrigation projects a comparison of the total amount of historic irrigated acres claimed by the US Survey to total planned, farmed or irrigated acreage reported by the Department of the Interior or the State of New Mexico. For the Tocito, Toh Al Sissy, Stinking Water, Captain Tom, Grey Mesa, and Choiska projects along the Chuska Mountains in the Chaco River drainage, the irrigated acres claimed by the US Survey are similar within about 10 percent difference to the amounts of acres under ditch for each project as of 1946 reported by "The Navajo Report," prepared by J.A. Krug, Secretary of the Interior, and dated March 1948 (1948 Navajo Report). Overall, the total amount of irrigated acres claimed by the US Survey for Navajo Nation irrigation projects along the Chuska Mountains in the Chaco River drainage exceeds the total amount of acres under ditch as of 1946 reported by the 1948 Navajo Report by about 635 acres. This result may be explained in part by the US Survey including claims for about 506 acres of irrigation on tributary irrigation projects not included in previous Department of the Interior tabulations of Navajo irrigation projects.

For the tributary irrigation projects in the Chaco River drainage not associated with the Chuska Mountains, the total amount of irrigated acres claimed by the US Survey for Navajo Nation irrigation projects is similar to the total amount of acres under ditch as of 1946 reported by the 1948 Navajo Report. Also, the amounts of irrigated acres claimed by the US Survey for irrigation uses or projects that were described by the 1938 State Engineer Hydrographic Survey generally are similar to the acres for each designated use or project shown in the 1938 State Engineer Hydrographic Survey map sheets.

For the Chaco River drainage overall, the US Survey claims on behalf of the Navajo Nation a total of about 9,160 acres of historic irrigation use by tributary irrigation projects, as compared to a maximum

total acres under ditch of about 8,506 acres based on BIA and OSE records. For the Chinle Wash drainage, the US Survey claims on behalf of the Navajo Nation a total of about 709 acres of historic irrigation use by tributary irrigation projects, as compared to a maximum total acres under ditch as of 1946 of about 508 acres reported by the 1948 Navajo Report.

4. Available Data on Historic Acres Irrigated. The BIA prepared annual crop reports for several of the Navajo tributary irrigation projects generally for the period 1936-1959, which crop reports indicate for each project the acres of each crop grown, the amount of acres double-cropped, and the net acres irrigated. The BIA also prepared annual irrigated acres summaries for Navajo tributary irrigation projects generally for the same period. In addition, the BIA Branch of Land Operations or Division of Economic Development prepared annual Irrigation Land Data reports for the years 1963-1968, which reports include data on the amounts of acres used or irrigated on Navajo irrigation projects for each of these years.[1] Table 5 attached hereto provides for the tributary irrigation projects the net acres irrigated for each year of the period 1936-1959 for which BIA crop reports or annual irrigated acres summaries are available, and the acres used or presently irrigated for each year of the period 1963-1968 as indicated by BIA Irrigation Land Data reports.[2] No documentation is available for the BIA data to explain how the total project acres, crop acres, net irrigated acres or acres presently irrigated were determined each year. Table 5 also shows the amount of irrigated acres for tributary irrigation projects and for scattered

[1] The reporting format for the Irrigation Land Data reports changed over time. The reports for 1963 and 1964 list acres used and acres idle for each Navajo irrigation project, and indicated that the total project acreage including used lands and idle lands were all assessed as presently irrigated land (with no lands assessed as dry farmed). The reports for 1965 and 1966 explicitly listed the acres presently irrigated, acres dry farmed and acres idle for each Navajo irrigation project, and indicated that the project lands were assessed as such. The report for 1967 listed the amounts of acres used and acres idle for each Navajo irrigation project, but did not list the amounts of land assessed as either presently irrigated or dry farmed. An undated table believed to be from the report for 1968 based on its similar format to the Irrigation Land Data report for 1967 and its place following the year 1967 among these documents, which were produced in the Zuni River Adjudication along with a letter of instruction for compiling irrigation census data for 1969, also listed acres used and acres idle for each Navajo irrigation project during the year; except, that while the acres used in 1968 by the Navajo tributary irrigation projects in the portion of the San Juan River Basin in New Mexico north of Sheep Springs were listed as equal to 6 percent or less of their total assessable project acres and appear to be consistent with patterns of reported irrigated acres in other years and with the reported total crop values for each of these projects for the year, the acres used in 1968 by the Navajo tributary irrigation projects in the portion of the basin in New Mexico south of Sheep Springs (namely, the Choiska, Crystal, Naschitti Drolet, Northern Naschitti, Southern Naschitti, Well 14A-79 and Well 14Mile-1 projects) were listed as equal to the total assessable project acres even though assumed full irrigation of the entire project acres would not be consistent with patterns of reported irrigated acres in other years or for other projects, other information relating to histories of irrigation use or dry farming on several of these projects, or the extremely little total crop values for each of these projects listed for the year. Thus, different reporting criteria appear to have been used by BIA personnel for two different geographic regions within the basin in New Mexico, such that some of the data believed to be for 1968 appear to represent acres of land assessed as irrigated lands or lands that could be irrigated within a project, as opposed to acres of land actually irrigated during the year. For this reason, only data that appear to reasonably represent acres irrigated in 1968 by Navajo tributary irrigation projects in the northern portion of the basin were considered in the analysis presented herein.

[2] Data for the Mulholland Well Project are included in table 5 as evidence of historic use by tributary irrigation projects even though the US Survey did not include a claim for historic uses for the project and it is not included in the Proposed Supplemental Decree. The BIA annual crop report data indicated that a maximum of 30 acres was irrigated on the Mulholland Well Project in 1943, and that no project lands were irrigated after 1949. The BIA crop reports for the Mulholland Well Project for 1951 and 1952 noted that the project land is heavily alkalied and too costly to reclaim.

The Northern Naschitti and Southern Naschitti projects reported by the BIA were named the Naschitti Northern and Naschitti Southern projects, respectively, by the US Survey. The Juan's Lake Project reported by the BIA constituted, in part, the Lake Valley Project identified by the US Survey.

tributary non-project irrigation uses in the ephemeral tributary drainages in the San Juan River Basin in New Mexico found by crop field surveys conducted by the ISC in 1994, 2000 and 2003.[3]

The 1938 State Engineer Hydrographic Survey for irrigation uses within the Chaco River drainage determined irrigated acreage for several non-Navajo irrigation projects, but the amount of irrigated acreage determined by a hydrographic survey does not necessarily translate to acres actually irrigated during the year of the survey.[4] The US Survey claims that the non-Indian uses included in the 1938 State Engineer Hydrographic Survey were on lands now held by the United States in trust on behalf of the Navajo Nation or its members or held by the Navajo Nation in fee. Other estimates of irrigated acreage in the Chaco River and Chinle Wash drainages reported or used in past water use studies were based on nominal tributary irrigation project acreages.[5]

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[3] For the ISC field surveys, possible farmland in the ephemeral tributary drainages within Navajo country was delineated based on interpretation of potential fields from aerial imagery, and the identified possible farmlands within these drainages were field checked for crop and irrigation status. The ISC partially surveyed irrigated crops on only certain Navajo irrigation projects near Newcomb in 1994, in cooperation with the US Bureau of Reclamation (USBR), and 2000. The base maps used for the ISC's 2003 field survey were derived from, and the possible field parcels were delineated from, interpretation of 1996 black and white US Geological Survey digital orthophoto quadrangles (see Memorandum on "2003 San Juan River Basin Acreage Inventory," prepared by Patricia Turney and dated September 13, 2004, last revised December 7, 2004). Based on the delineated possible field acres, a total of about 7,829 acres of land were identified for field checking of any irrigation and crop status, including: (1) about 4,182 acres of possible fields under Navajo tributary irrigation projects and 2,820 acres of possible fields associated with miscellaneous or non-project lands in the Chaco River drainage (including lands supplied by spreader dams as described in the 1938 State Engineer Hydrographic Survey); and (2) about 411 acres of possible fields under Navajo tributary irrigation projects and 416 acres of possible fields associated with miscellaneous or non-project lands in the Chinle Wash drainage. Based on the field survey results, approximately 426 acres were irrigated in 2003 under Navajo tributary irrigation projects along the Chuska Mountains in the Chaco River drainage, about 31 acres were irrigated in 2003 on miscellaneous or non-project lands in the Chaco River drainage, and no acres were irrigated in 2003 in the Chinle Wash drainage. The 2003 field survey found that many of the possible field parcels identified by inspection of the aerial imagery were covered with wild native vegetation, indicative of the parcel not having been irrigated for a long period of time, if ever. The personnel conducting the field checks in 2003 also noted a lack of water for irrigation or adequate crop production in the Newcomb and Crystal areas, and a preponderance of dry land farming of natural grass in the Sheep Springs, Two Grey Hills, Sanostee, Mexican Springs, Naschitti, Tohatchi, Twin Lakes, Coyote Canyon, Crownpoint, Standing Rock, Lake Valley and Crystal areas (see "San Juan County Irrigated Field Survey Summary," prepared by Garda Stock and Thelma Yazzie, and dated October 15, 2003).

[4] Testimony of I.K. Westbrook in the Echo Ditch adjudication indicated for the Westbrook spreader dam irrigation uses from Indian Creek that: (1) the spreader dams were constructed over a period of time from 1928-1938; (2) the principal crop irrigated by the spreader dams was natural vega hay; (3) water for irrigation by the spreader dams was available seasonally from summer rains beginning July; (4) the water available for irrigation by the spreader dams in some years was sufficient to cover the full water right acreage and in other years was sufficient to cover only a few acres; and (5) upstream construction of a dam and reservoir on Indian Creek by the Indian Department for use to store water for livestock purposes in February 1935 diminished the water supply available to the spreader dams on this stream such that water was no longer available in many years until October when it was too late to use for irrigation (see transcripts of testimony in *The Echo Ditch Company, et al., v. The McDermott Ditch Company, et al.*, New Mexico District Court, San Juan County, Cause No. 01690, pages 1266-1271).

[5] The SCS in 1968 listed nominal irrigated acres by crop under normalized conditions for 1965 level of development for Indian and non-Indian lands in New Mexico within the Chaco River drainage and the Crystal area of the Chinle Wash drainage (see "Upper Colorado Region, Type I Survey, New Mexico, Water Resources, Present Water Use, Irrigated Acreage by Evaluation Areas, Crops, and Full and Short Water Supply," spreadsheet prepared by the SCS and dated August 20, 1968). The SCS' nominal irrigated acreage for 1965 for the Chaco River drainage was 4,200 acres, including 3,300 acres of Navajo irrigation and 900 acres of non-Indian irrigation, as compared to an irrigated acreage of about 840 acres in 1975 that was estimated by the OSE apparently based on information provided from the BIA (see Memorandum on "Irrigation in San

5. Potential Rehabilitation of Tributary Irrigation Projects. Table 6 attached hereto lists for the tributary irrigation projects included in the "Inventory of Navajo Indian Irrigation Projects," prepared by the SCS and dated August 1986 (1986 SCS Inventory), information contained in that report relating to the water supply available to the projects. In general, the 1986 SCS Inventory noted that water supplies for the surface water irrigation projects were not dependable during the summer and fall months, there was a lack of interest in farming under the ground water irrigation projects, and severe erosion in combination with questionable water supply led to abandonment of the Northern Naschitti, Naschitti Drolet and Southern Naschitti projects. Based on the 1986 SCS Inventory, the acreages farmed as of 1986 on Navajo tributary irrigation projects in New Mexico in the Chaco River and Chinle Wash drainages amounted to about 1,743 acres and 350 acres, respectively, for a total of about 2,093 acres. The amounts of acreage actually irrigated, on average, under present conditions are less.

The Northwestern New Mexico Rural Water Projects Act (Public Law 111-11, Title X, Subtitle B) in March 2009 approved the Settlement Agreement and authorized to be appropriated $50 million for deposit into a trust fund for expenditure by the Navajo Nation on costs associated with development of water resources projects for irrigation, municipal or domestic water supply, flood control, sediment control, recreation, fish and wildlife, and other beneficial purposes. Expenditures from the trust fund for investigation, development or rehabilitation of water resources projects may be made for projects within Arizona, New Mexico or Utah. To assess possible development or rehabilitation of local water infrastructure on small irrigation projects, the Navajo Nation has implemented an evaluation process that considers the following topics: farming history, agricultural economics, available water supplies, water conservation and water management practices (including system operation and overall irrigation efficiency), capacities for water users to form associations and pay water use assessments, environmental issues, capital and operation and maintenance budget requirements, education needs, and monitoring plans (see "Water Resource Development Strategy for the Navajo Nation," prepared by the Navajo Nation Department of Water Resources and dated July 17, 2000, pages 60-64). The 1986 SCS Inventory, which included Navajo irrigation projects in Arizona, New Mexico and Utah, identified a large number of historic irrigation projects that the SCS believed should be of high or medium priority for rehabilitation, including the Captain Tom, Grey Mesa and Sanostee projects in the Newcomb area, the Choiska Project (including Red Willow Ditch) located near Tohatchi, the Crystal Project in the Chinle Wash drainage, and a few other small triburary irrigation projects in New Mexico. Rehabilitation of these projects may result in a return to the level of peak irrigation use for these projects

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Juan County, 1965-1975," prepared by Earl Sorensen and dated October 6, 1976). The SCS' nominal irrigated acreage for 1965 for the Chinle Wash drainage near Crystal was 300 acres, as compared to an irrigated acreage of about 100 acres in 1975 that was estimated by the OSE apparently based on information provided from the BIA. Mapping data to support the SCS' assessment of irrigated lands and crops are not available. The SCS' nominal tributary project acres are not determinative of the amount of acres actually irrigated in 1965 or any other year, and the total nominal acreage was comparable to the total project acres under ditch as of 1946 that was reported by the Secretary of the Interior for Navajo projects in these geographic areas (see the 1948 Navajo Report, page 18). The BIA Irrigation Land Data report for 1965 indicates that the total acreage irrigated during that year on all Navajo irrigation projects in the San Juan River Basin in New Mexico combined was about 1,782 acres. Also, the 1948 Engineering Advisory Committee report included for the period 1914-1945 average irrigated crop acreages for lands irrigated in the Chaco River drainage in New Mexico based principally on the use of USBR land classification maps to determine areas of lands irrigated as of 1948 conditions or 1948 level of development, which acreages again are not determinative of the acres actually irrigated in any year (see Final Report of the Engineering Advisory Committee to Upper Colorado River Basin Compact Commission, dated November 29, 1948, pages 34 and 44).

that was experienced in the 1940s or early 1950s, albeit not without years of substantial water supply shortages.

6. Types of Claimed Non-Project Irrigation Uses. The US Survey generally classified tributary non-project irrigation uses into the following types of use (see Ebert and Associates Report, at page 15): (1) diversion of natural surface water, spring flow or well water; (2) diversion of natural flows or well water, with reservoirs to regulate diversions or water deliveries; (3) diversion of storage water released from upstream reservoirs in addition to the diversion of natural flows; (4) planting of crops such as sparse-density corn or native grasses across the active channels of broad ephemeral stream channels whereby intermittent flows in the channel can pass over the planted areas (referred to as channel interception by the US Survey); and (5) planting of crops such as sparse-density corn or native grasses across floodplains where overbank flows can pass over the planted areas (referred to as floodwaters by the US Survey). The average density of corn on lands claimed to receive water by channel interception or floodwater overflow is about 9 feet between plants according to the Ebert and Associates Report (Appendix C, page C-6). Claimed channel interception and floodwater uses do not involve the diversion and control of water, and therefore, the historic agricultural practice of planting crops across broad ephemeral stream channels or overbank areas does not constitute the basis for a water right. A small amount of the acreage claimed by the US Survey for some Navajo tributary irrigation projects and a substantial amount of the acreage claimed by the US Survey for Navajo tributary non-project irrigation uses are claimed uses by channel interception or floodwater overflow.

Table 7 attached hereto provides a summary of the distribution of acres claimed by the US Survey for tributary irrigation non-project uses in the San Juan River Basin by type of irrigation use and quadrangle. The claimed tributary irrigation non-project fields and acres were determined primarily by interpretation of land use from aerial imagery with few site visits. In comparison to the large amount of acreage claimed for Navajo tributary irrigation non-project uses, the ISC in 2003 surveyed about 2,820 acres of possible fields associated with miscellaneous or non-project lands in the Chaco River drainage and 416 acres of possible fields associated with miscellaneous or non-project lands in the Chinle Wash drainage, most of which were covered with wild native vegetation and only about 31 acres of which were found to be irrigated in the whole basin (see Memorandum on "2003 San Juan River Basin Acreage Inventory," prepared by Patricia Turney and dated September 13, 2004, last revised December 7, 2004).

C. Annual Depletions

1. Tributary Irrigation Project Depletion Claims. The US Survey at pages 11-12 claims reserved water rights for Navajo tributary irrigation projects in the total amount of 15,528 acre-feet per year of depletion at the sites of use (at-site depletion) associated with the irrigation of 8,426 acres of land held by the United States in trust for the Navajo Nation. Adjusting this depletion amount for an apparent error in tabulating the depletion associated with a parcel of land (field number 718) under the Long Lake Project, the claim for reserved rights for Navajo tributary irrigation projects totals to about 15,539 acre-feet per year of at-site depletion (see tables 1 and 3). Of this amount, about 434 acre-feet of depletion is associated with about 257 acres of irrigation on lands that were once associated with private irrigation development on the Westbrook, Pitt, Farris or Tanner ranches, which lands were acquired by the United States in trust for the Navajo Nation. Therefore, the federal reserved water right claims for tributary irrigation projects can be reduced to about 15,105 acre-feet per year of at-site depletion on about 8,169

acres of Navajo Nation trust lands. The US Survey did not specify the quantities of depletions that it may claim in association with tributary irrigation project uses on about 98 acres of Navajo allotment lands, or the quantity of depletions and the priority dates that the Navajo Nation could claim in association with tributary irrigation project uses on about 1,431 acres of Navajo Nation fee lands.

2. Tributary Irrigation Non-Project Lands Depletion Claims. The US Survey at page 13 claims federal reserved water rights for Navajo tributary irrigation non-project lands in the total amount of 6,273 acre-feet per year of at-site depletion associated with the irrigation of 3,734 acres of land held by the United States in trust for the Navajo Nation (see tables 2 and 3). The US Survey did not specify the quantities of depletions that it may claim in association with irrigation uses for tributary irrigation non-project lands on about 209 acres of Navajo allotment lands, or the quantity of depletions and the priority dates that the Navajo Nation could claim in association with irrigation uses for tributary irrigation non-project lands on about 26 acres of Navajo Nation fee lands.

3. General Discussion of Historic Irrigation Depletion Claims. The US Survey at pages 11 and 13 states that the irrigation water requirements for both tributary irrigation projects and tributary irrigation non-project lands were calculated based on a crop mix appropriate for the elevation and precipitation of the irrigated fields. The "Inventory of Navajo Lands within the San Juan River Basin in New Mexico Irrigated by Groundwater and Tributaries of the San Juan River," prepared by Ebert and Associates, Inc., with Christopher D. Banet, Bureau of Indian Affairs, and dated January 2012 (Ebert and Associates Report), at Appendix C, page C-7, further states that for the US Survey the consumptive irrigation requirement (CIR) for each tract of land for which water rights are claimed were computed using the Lowry-Johnson method.[6] Paragraph 4.2.2 of the Settlement Agreement provides that the depletion and diversion rights for the Navajo Nation's historic and existing irrigation uses from ephemeral tributaries to the San Juan River, including for federal reserved and any state law irrigation rights that are to be included in the Proposed Supplemental Decree, shall be determined consistent with the approach or methodology for irrigation water requirements adopted by the Court in the Adjudication for determining water rights for other irrigation uses in the San Juan River Basin. Until otherwise determined, it is assumed that the Court will rely on the irrigation water requirements computed by the 1938 State Engineer Hydrographic Survey using the Lowry-Johnson method and approved by the Echo Ditch Decree for determining non-Indian irrigation rights in the basin that are based on historic use of previously decreed rights.[7]

Table 8 attached hereto provides a comparison for each tributary irrigation project of the average annual depletion rate claimed by the US Survey and the CIR for each project estimated by simple extrapolation of the 1938 State Engineer Hydrographic Survey CIRs to each project location. The claimed depletion

[6] For the US Claims, the CIRs for each tract of land for which water rights are claimed were computed using the Hargreaves method (see Ebert and Associates Report, page C-7). The Hargreaves method generally results in greater estimates of CIRs and irrigation depletions than does the Lowry-Johnson method. Descriptions of the CIR calculations prepared using both methods, and of the data used in said calculations, were provided in more detail in "Navajo San Juan Tributary Consumptive Irrigation Requirements," prepared by Keller-Bliesner Engineering, LLC, and dated January 12, 2012.

[7] The Proposed Decree also includes depletion, farm delivery and diversion right amounts for the Fruitland-Cambridge and Hogback-Cudei irrigation projects on the San Juan River mainstream based on extrapolation of the 1938 State Engineer Hydrographic Survey water requirement information (see "Responses to Public Comments Received on Drafts of the San Juan River Basin in New Mexico Navajo Nation Water Rights Settlement," prepared by John Whipple, and dated December 10, 2010, pages 42-46).

rates for tributary irrigation projects in the Chaco River drainage generally exceed the extrapolated CIRs by about 2 to 6 percent, with the difference approaching about 15 percent for a few projects. The differences may be interpreted as appropriate to reflect incidental irrigation depletions on the projects. The OSE Water Use and Conservation Bureau in the past has assumed that incidental depletions, including evaporation and evapotranspiration losses along canals, on-farm incidental depletions and below-farm incidental depletions by non-crop vegetation, for flood irrigation from ditches in the Chaco River drainage average about 15.4 percent of crop consumptive use, including about 4.4 percent for incidental depletions from canals (see "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 2000," State Engineer Technical Report 51, prepared by Brian Wilson, et al., and dated February 2003). The Navajo tributary irrigation projects generally have little non-crop vegetation that is supported by irrigation on the farms, and the projects supplied by wells or spreader dams do not have extensive ditch delivery systems. The US Survey to compute irrigation depletions on tributary irrigation projects generally increased its estimated CIRs by 5 percent to account only for evaporation losses and phreatophyte evapotranspiration losses associated with storage reservoirs and ditch systems (see Ebert and Associates Report, Appendix C, pages C-7 and C-8). The claimed depletion rates for tributary irrigation projects in the Chinle Wash drainage generally are less than the extrapolated CIRs by about 5 to 15 percent, possibly due to taking relatively high elevations and orographic precipitation effects into account.

4. Historic Tributary Irrigation Depletions. Table 9 attached hereto provides estimates of historic annual irrigation depletion demands for Navajo tributary irrigation uses for 1936-1959, 1963-1968, 1994, 2000 and 2003 based on the available irrigated acres data shown in table 5, the average annual depletion rates for tributary irrigation uses claimed by the US Survey, and assuming a full water supply for the acres irrigated.[8] Table 10 attached hereto provides estimates of historic annual irrigation depletions for Navajo tributary irrigation uses assuming an average water supply shortage of 50 percent for all surface water uses and no shortages for ground water uses. The 1986 SCS Inventory notes a lack of dependable summer water supply for most Navajo projects in New Mexico on ephemeral tributaries to the San Juan River (see table 6). Based on crop consumptive use computations provided by the SCS in 1968, the average annual crop consumptive uses, after accounting for water supply cutoff dates for short-supply alfalfa, grass hay and pasture acreage, for the Chaco River drainage total to approximately 47 percent of the annual crop-weighted CIR for the drainage and for the Crystal area in the Chinle Wash drainage total to approximately 32 percent of the annual crop-weighted CIR for the area (see "Upper Colorado Region, Type I Survey, New Mexico, Water Resources, Present Water Use, Irrigated Acreage

[8] The estimates of historic full-supply irrigation depletion demands by Navajo tributary irrigation projects provided in table 9 were made for the purpose of determining the terms and administrative conditions of the Navajo Nation's water rights described by the Proposed Supplemental Decree using CIR assumptions that are consistent with the irrigation water requirements computed by the 1938 State Engineer Hydrographic Survey using the Lowry-Johnson method. These estimates, and subsequent computations of shorted irrigation depletions and depletions of San Juan River flow that rely on these estimates, should not be construed as the State of New Mexico's agreement that actual irrigation depletions in the San Juan River Basin should be computed using this methodology for any other purpose, including for determining its consumptive uses as against its water apportionment pursuant to the Upper Colorado River Basin Compact. Natural flows of the Colorado River at Lee Ferry used by the USBR for preparing the "Hydrologic Determination, 2007, Water Availability from Navajo Reservoir and the Upper Colorado River Basin for Use in New Mexico," dated April 2007 (2007 Hydrologic Determination), were computed using historic irrigation depletions in the Upper Basin estimated based on the modified Blaney-Criddle method and yearly irrigated acreage, cropping pattern and climate data. The modified Blaney-Criddle method generally results in greater estimates of CIRs and irrigation depletions than does the Lowry-Johnson method. The estimates of historic irrigation depletions shown in table 9 do not consider annual variability in crop consumptive use resulting from annual variations in cropping patterns and climate.

by Evaluation Areas, Crops, and Full and Short Water Supply," spreadsheet prepared by the SCS and dated August 20, 1968 (1968 SCS Type I Study)). The 1968 SCS Type I Study results thus suggest an average water supply shortage of about 53 percent for irrigation uses in the Chaco River drainage and 68 percent for irrigation uses in the Crystal-Whiskey Creek area.[9] The use of water supply cutoff dates to estimate average annual shortages, however, neglects the lack of significant spring snowmelt runoff from the Chuska Mountains in some years and some amount of possible irrigation diversions from summer rainfall runoff. Also, even if the Captain Tom Project is rehabilitated, the total water storage in Captain Tom Reservoir if full equates to less than 1 acre-foot of supply per acre for the maximum historic irrigated acreage of about 1,184 acres. Therefore, it was generally assumed for this analysis that irrigation uses in New Mexico made from surface water on ephemeral tributaries to the San Juan River experience an overall water supply shortage of approximately 50 percent on an average annual basis.[10]

5. Historic Depletions of San Juan River Flow by Tributary Irrigation Uses. Depletions of San Juan River flow by irrigation uses on ephemeral tributaries are less than the depletions of tributary water at the places of use because if the water had been left in the ephemeral stream channel instead of being used, some of that water would have been lost to evaporation or evapotranspiration from the stream channels and would not have reached the San Juan River. Thus, by using water from ephemeral tributaries to the San Juan River at places of use that are a great distance from the river, downstream channel losses on the ephemeral tributaries are salvaged as a result of using the water upstream. The net depletion impact on flow of the San Juan River is the at-site depletion (that is, the depletion at the place of use), less the amount of water salvaged by the use (that is, the amount of reduction in channel losses from ephemeral stream channels resulting from the use). An analysis by the ISC staff of channel losses on Morgan Lake discharges in the Chaco River drainage indicates that for a constant discharge at a rate

[9] The 1968 SCS study did not segregate irrigation projects in the Chaco River drainage into those with reservoir storage and those without storage, and it is not clear if the difference between the indicated water supply shortages for the Chaco River drainage and the Crystal area reflect average water supplies considering also reservoir storage. Also, the effectiveness and use of reservoir storage facilities for irrigation purposes over time is not known; except, that remarks in the 1986 SCS Inventory indicate that some of the reservoirs associated with Navajo irrigation projects at present are not effective in storing and regulating flows for use, and that some of the diversion works for Navajo irrigation projects were ineffective in capturing water for use. No information is available regarding the operation or effectiveness of a few of the larger reservoirs.

[10] For irrigation by spreading of floodwaters with dams across ephemeral stream channels, depletions were assumed to be limited by the availability of floodwaters. For example, State Engineer Permit No. 2831 allows the Bureau of Land Management to divert floodwater as available at diversion dikes near Pueblo Pintado, and states that the use of water under the permit would result in two inches of water being spread across the permitted irrigated acreage three times per year. The total of 6 inches of water applied would increase forage of natural grasses for livestock. This compares to a total annual water application on Conservation Reserve Program acreage within the NIIP of approximately 8 inches per year, on average, to maintain natural grass ground cover (see "Navajo Indian Irrigation Project 2006 Irrigation and Drainage Analysis," prepared by Bureau of Indian Affairs and Keller-Bliesner Engineering, LLC, and dated September 12, 2008, page 49, table 4.1). Based on this information and the reliance of spreader dams and diversion dikes on summer flooding resulting from thunderstorm activity to irrigate native grasses, it was assumed that the amount of water applied to the acres irrigated by spreader dams amounts to about 6 inches per year, on average, in years when floodwaters are available, and that the amount of water applied by spreaders would be fully consumed. Also, testimony of I.K. Westbrook in the Echo Ditch adjudication indicated that the water available for irrigation by the spreader dams along Indian Creek in some years was sufficient to cover only a few acres and that upstream construction in February 1935 of a dam and reservoir on Indian Creek by the Indian Department for use to store water for livestock purposes had diminished the water supply available to the spreader dams on this stream such that water was no longer available in many years until October when it was too late to use for irrigation (see transcripts of testimony in *The Echo Ditch Company, et al., v. The McDermott Ditch Company, et al.*, New Mexico District Court, San Juan County, Cause No. 01690, pages 1266-1271). Based on this testimony, it was assumed that floodwaters are available for effective irrigation use by spreader dams in only about 50 percent of the years or less.

of about 22 cubic-feet-per-second (cfs), about 30 percent of the discharge amount, or about 7 cfs, is lost in transit, on average, in the 16.5-mile river channel reach between the point of discharge and the San Juan River, such that only about 70 percent of the discharge contributes to flow in the river (see Memorandum on "Historic Depletions from the San Juan River in New Mexico for Power Generation," prepared by Pat Turney and John Whipple, revision dated August 8, 2003, pages 4-9). This analysis suggests that incremental channel losses in the ephemeral tributaries average approximately 0.4 cfs per mile at a constant flow rate of about 22 cfs. Based on this channel loss rate information, the generally small sizes of Navajo tributary water uses, and ephemeral channel distances between points of diversion or places of use and the San Juan River, this analysis makes assumptions regarding the extent to which a given water use depletion at the site of use may impact stream flow in the San Juan River. Figure 1 attached hereto shows the assumed percentage depletion impact on river flow of Navajo Nation tributary surface water uses by location or map quadrangle.

Table 11 attached hereto shows tributary irrigation project information regarding project location and size (including project acreages, diversion rates and storage capacities), and indicating the assumed percentage depletion impact on San Juan River flow for each listed project based on figure 1. The percentage depletion impact on river flow by irrigation uses on the Captain Tom Project was assumed to average approximately 45 percent of at-site irrigation depletions based on: (1) weighting the river depletion impacts from figure 1 for the Upper Captain Tom project unit located in the Newcomb quadrangle area and the Lower Captain Tom project unit located mostly in the Newcomb SE quadrangle area by the amounts of acres for each project unit claimed by the US Survey (32 percent); and (2) adding over 10 percent to the resulting weighted river depletion impact in recognition that Captain Tom Reservoir during the irrigation season may supply a relatively small but significant amount of the project diversion demand each year from storage water that was diverted from Captain Tom Wash during periods of spring snowmelt runoff from the Chuska Mountains when flows were reaching the river and prior to the irrigation season.[11] For the Beclabito Project, the river depletion impact was assumed to average approximately 90 percent of at-site irrigation depletions based on its location near the corner of the Sallies Spring and Beclabito quadrangles. Table 12 attached hereto provides for 1936-1959, 1963-1968, 1994, 2000 and 2003 estimates of historic annual depletions of San Juan River flow resulting from the shorted at-site irrigation depletions shown in table 10 after reductions for channel losses on the ephemeral tributaries that were estimated to be salvaged by use. Based on this analysis, the historic maximum annual depletion of San Juan River flow by irrigation uses in ephemeral tributary drainages within Navajo country in New Mexico is estimated to have been about 978 acre-feet in 1941, excluding any small amount of river flow depletion that may have resulted from irrigation uses on scattered non-project lands in that year.

D. Annual Diversions

1. Tributary Irrigation Projects. The US Survey at pages 11-12 claims reserved water rights for Navajo tributary irrigation projects in the total amount of 57,922 acre-feet per year of diversion associated with the irrigation of 8,426 acres of land held by the United States in trust for the Navajo Nation. Adjusting

[11] Stream flow data are available for a limited period of years from the US Geological Survey for gaging stations on the Chaco River near Burnham and near Waterflow. Flow statistics for these gages indicate several periods of one to two weeks of runoff in the Chaco River at these gaging station locations, on average, during the winter and early spring months before the growing season begins in earnest. Flow statistics also indicate periods of runoff in the Chaco River occur during the monsoon season from short-duration thunderstorm runoff events.

this diversion amount for an apparent error in tabulating the depletion associated with a parcel of land (field number 718) under the Long Lake Project, the claim for reserved rights for Navajo tributary irrigation projects totals to about 57,944 acre-feet per year of diversion (see tables 1 and 3). Of this amount, about 726 acre-feet of diversion is associated with about 257 acres of irrigation on lands that were once associated with private irrigation development on the Westbrook, Pitt, Farris or Tanner ranches, which lands were acquired by the United States in trust for the Navajo Nation. Therefore, the federal reserved water right claims for tributary irrigation projects can be reduced to about 57,218 acre-feet per year of diversion on about 8,169 acres of Navajo Nation trust lands. The US Survey did not specify the quantities of diversions that it may claim in association with tributary irrigation project uses on about 98 acres of Navajo allotment lands, or the quantity of diversions and the priority dates that the Navajo Nation could claim in association with tributary irrigation project uses on about 1,431 acres of Navajo Nation fee lands.

2. Tributary Irrigation Non-Project Lands. The US Survey at page 13 claims federal reserved water rights for Navajo tributary irrigation non-project lands in the total amount of 10,465 acre-feet per year of diversion associated with the irrigation of 3,734 acres of land held by the United States in trust for the Navajo Nation (see tables 2 and 3). The US Survey did not specify the quantities of diversions that it may claim in association with irrigation uses for tributary irrigation non-project lands on about 209 acres of Navajo allotment lands, or the quantity of diversions and the priority dates that the Navajo Nation could claim in association with irrigation uses for tributary irrigation non-project lands on about 26 acres of Navajo Nation fee lands.

3. Discussion of Historic Irrigation Diversion Claims. As described above, it is assumed that the Court in the Adjudication will rely on the irrigation water requirements computed by the 1938 State Engineer Hydrographic Survey and approved by the Echo Ditch Decree for determining non-Indian irrigation rights in the basin that are based on historic use of previously decreed rights. Therefore, pursuant to paragraph 4.2.2 of the Settlement Agreement, table 8 provides a comparison for each tributary irrigation project of the average annual diversion rate claimed by the US Survey and the project diversion requirement (PDR) estimated consistent with extrapolation of the 1938 State Engineer Hydrographic Survey water requirements to the project location. The PDRs were computed using the CIRs determined by simple extrapolation of the 1938 State Engineer Hydrographic Survey CIRs to each project location, an on-farm flood irrigation efficiency of 63 percent, and a canal delivery efficiency for surface water diversion and irrigation ditch distribution systems of 60 percent as determined by the 1938 State Engineer Hydrographic Survey.[12] Spreader dam uses and ground water irrigation uses do not utilize extensive ditches to bring water to the field.

With a few notable exceptions, the annual irrigation diversion rates claimed by the US Survey for tributary irrigation projects are generally less than or similar to the PDRs determined for each project consistent with the 1938 State Engineer Hydrographic Survey. Annual irrigation diversion rates claimed by the US Survey for the Toadlena, Upper Captain Tom, Grey Mesa, Long Lake and Choiska projects

[12] The US Survey to compute irrigation diversion requirements used the CIRs estimated based on the Lowry-Johnson method, an on-farm irrigation efficiency of 60 percent for all claimed irrigation uses, and different canal system delivery efficiencies for each tributary irrigation project or non-project use based on water conveyance efficiencies for well and poorly maintained earthen and concrete lined ditches and for natural channels, and on interpretations of ditch and natural channel lengths used to convey water as interpreted from aerial imagery by Ebert and Associates (see Ebert and Associates Report, Appendix C, pages C-8 through C-11).

are significantly greater than the PDR determined consistent with the 1938 State Engineer Hydrographic Survey. The Toadlena and Grey Mesa projects have relatively long earthen ditches for the amount of acreage served, with the Grey Mesa project apparently being supplied diversions from Captain Tom Wash that are conveyed through a combination of man-made and natural channels. Higher annual diversion rates claimed for the Upper Captain Tom, Long Lake and Choiska projects may be interpreted to reflect diversion requirements to refill project water supply reservoirs after ditch and reservoir seepage losses or to reflect the use of reservoir storage to maintain flow in canals throughout the irrigation season. Still, for full project utilization, the available water supplies do not appear to be adequate for sustaining annual diversions of about 15 acre-feet per acre or more for the Grey Mesa and Choiska projects, about 9 acre-feet per acre or more for the Upper Captain Tom project unit, or up to 6 acre-feet per acre for the Toadlena Project and for portions of the Long Lake Project. Such annual diversion rates for these projects are considered to be in excess of the diversion rate required for reasonably efficient crop irrigation based on the PDRs for other ditches listed in the 1938 State Engineer Hydrographic Survey report. Water rights for filling and refilling of Captain Tom Reservoir, Long Lake and Chuska Lake are provided separately in the Proposed Supplemental Decree. No data are available on actual historic diversions by Navajo tributary irrigation uses.

E. Proposed Water Rights for Tributary Irrigation Uses

1. General. The Proposed Supplemental Decree at paragraphs 3 and 4 includes water rights for historic and existing irrigation uses on Navajo Nation trust lands and Navajo Nation fee lands, respectively, from ephemeral tributaries to the San Juan River, which rights include: (1) amounts of water right acres that effectively provide project areas within which lands can be irrigated based on the US Survey; and (2) limits on depletions and diversions determined based on historic use indicated from evidence of the historic maximum amount of acres irrigated in any one year within the indicated project area. The Proposed Supplemental Decree allows for realignments of water conveyance system layouts and fields within a described irrigation project or area that can be supplied irrigation water consistent with apparent historic irrigation development and use, and for rotations between irrigated fields within a described irrigation project or area, without procedurally changing places of use. In addition, the Proposed Supplemental Decree provides that irrigation diversions may be used also for livestock watering purposes. No water rights are included in the Proposed Supplemental Decree for claimed watering of crops in broad ephemeral stream channels or overbank areas by channel interception or floodwater overflow. The Proposed Supplemental Decree explicitly does not, however, prohibit members of the Navajo Nation from continuing traditional agricultural practices of planting crops such as sparse-density corn or native pasture across the active channel of broad ephemeral streams in the San Juan River Basin so long as these practices do not divert and control water.

2. Reserved Water Rights for Navajo Nation Tributary Irrigation Projects. Table 13 attached hereto provides a listing of the proposed federal reserved water rights for tributary irrigation projects on lands held by the United States in trust on behalf of the Navajo Nation in the San Juan River Basin in New Mexico. These proposed reserved water rights for tributary irrigation project uses on Navajo Nation trust lands are based on: (1) water right acres based on the irrigated acres for the project claimed by the US Survey; (2) limits on the annual at-site irrigation depletion for the project determined based on the historic maximum acres irrigated within the project in any year and the average depletion rates claimed by the US Survey for the project as shown in table 8; and (3) limits on the annual irrigation diversion for the project determined based on the historic maximum acres irrigated within the project in any year and

the average diversion rates claimed by the US Survey as shown in table 8, with the exception that the annual diversion rates for the Toadlena, Captain Tom, Grey Mesa and Choiska projects are limited to 5.30 acre-feet per acre to reflect a reasonable project water use efficiency similar to that included in the 1938 State Engineer Hydrographic Survey for non-Indian irrigation ditches in the basin.[13] The irrigation diversions for the Captain Tom and Choiska projects are to be measured below Captain Tom Reservoir and Chuska Lake, respectively, because the Proposed Supplemental Decree recognizes the Navajo Nation's rights to fill and refill each reservoir as water is available. The proposed water right acres do not include lands claimed by the US Survey to be watered by channel interception or floodwater overflow. For those historic tributary irrigation projects on lands held by the United States in trust on behalf of the Navajo Nation, exclusive of the projects included in the 1938 State Engineer Hydrographic Survey, and on which irrigation was attempted for short periods of time decades ago, water rights are proposed based on evidence of historic use; except, that water rights for the Naschitti Northern, Naschitti Drolet and Beclabito projects are limited to the amounts of acres for these projects claimed by the US Survey that are significantly less than the historic maximum acres irrigated in these projects as determined from BIA irrigated acres data. In addition, the Proposed Supplemental Decree provides that the diversion and depletion amounts for an irrigation project may be exercised on another project within the same drainage regardless of the source of water so long as the total of the acres irrigated in a project does not exceed the project area described by the Proposed Supplemental Decree. These irrigation rights are otherwise transferable only to the extent of average historic use and subject to no change in water supply and no increase in depletions over and above historic average depletions.

The maximum acres irrigated within each project in any year were estimated based on the maximum amount of acres irrigated in any one year historically as determined from BIA annual crop report net irrigated acres data and annual irrigated acres summaries generally available for the periods 1936-1959 and 1963-1968, which apparently cover the years of peak irrigation development and use for each of the projects for which data are available (see tables 4-6). To reconcile differences between BIA project irrigated acreage reporting and project designations described by the US Survey, the following projects described by the US Survey were combined for inclusion in the Proposed Supplemental Decree: (1) the Crystal Project for which BIA irrigated acres data appear to have covered most, if not all, of the Crystal, Lower Crystal and Sonsela project areas described by the US Survey, which project areas the Ebert and Associates Report renamed the Crystal, Coyote Wash and Lower Crystal projects, respectively; (2) the Captain Tom Project for which BIA irrigated acres data appear to have covered both the Upper Captain Tom and Lower Captain Tom project areas described by the US Survey; (3) the Grey Mesa Project for which BIA irrigated acres data are available appear to have covered the Grey Mesa and Two Grey Hills project areas described by the US Survey; and (4) the Toadlena Project for which BIA irrigated acres data are available appear to have covered the Toadlena and Toadlena NE project areas described by the US Survey.[14]

[13] The proposed depletion rights for tributary irrigation projects shown in table 13 and for tributary irrigation non-project lands shown in table 14 do not include any depletion rights for livestock uses, including livestock storage reservoirs and livestock watering, that may be supplied from irrigation diversions. Depletion rights for livestock reservoirs and livestock watering uses are described separately in the Proposed Supplemental Decree.

[14] Until the US Survey was prepared, the United States had not identified by name separate irrigation units within the Captain Tom, Grey Mesa or Toadlena project areas, or a Sonsela Project in New Mexico. The United States also had not identified by name a Coyote Wash Project near Crystal until it released the Ebert and Associates Report. Table 13 and the Proposed Supplemental Decree refer to the Lower Crystal and Sonsela projects described by the US Survey as the Coyote Wash and

The Crystal and Sonsela (renamed Lower Crystal) projects divert water from Crystal Creek, with the diversion for the uppermost ditch in the Sonsela (renamed Lower Crystal) unit located about 2000 feet downstream of the lowermost parcel of land in the Crystal unit. The Lower Crystal (renamed Coyote Wash) project unit diverts water from a tributary to Crystal Creek, but the lowermost parcels of land in the Lower Crystal (renamed Coyote Wash) unit area within the project boundaries claimed by the US Survey and totaling about 45.0 acres are shown in a U.S. Indian Service map of the Crystal Project, dated 1939, as being irrigated from the Crystal Project ditch system (see figure A-35 of the Ebert and Associates Report). In addition to changing project names, the irrigated acreage claims shown in table D-1 of the Ebert and Associates Report indicate that the report also changed project boundaries for the Crystal and Lower Crystal (renamed Coyote Wash) projects as compared to the project boundaries used in the US Survey, such that these 45.0 acres were reassigned from the Lower Crystal (renamed Coyote Wash) Project to the Crystal Project. Excluding claimed channel interception and floodwater uses, the total irrigated acreage claimed by the US Survey for all three project units combined is about 560.7 acres (distributed by the Ebert and Associates Report as 243.5 acres on the Crystal Project, 107.1 acres on the Coyote Wash Project, and 210.1 acres on the Lower Crystal Project).[15]

Separate BIA crop reports for the Crystal and Lower Crystal projects for 1941 indicate total project acreages (net acres irrigated plus irrigable but idle acres) of about 183 acres for the Crystal Project and 158 acres for the Lower Crystal Project, or about 341 acres for both projects combined. The BIA crop reports for subsequent years are not available separately for the Lower Crystal Project, and for the Crystal Project indicate a total project area of up to 351 acres. The BIA crop reports for 1943-1945 explicitly state that the crop acres data are for the Crystal and Lower Crystal projects combined. The subsequent BIA crop reports for the Crystal Project thus cover both the Crystal and Lower Crystal projects as those projects were originally defined by the BIA. In addition, the 1948 Navajo Report indicates for the Crystal Project a planned ultimate size of 600 acres, with 408 acres under ditch as of 1946. The BIA Irrigation Land Data reports for 1963-1968 and a 1970 BIA letter indicated that the Crystal Project totaled 480 acres of irrigated plus idle lands (see table 4). A review of the US Survey ArcGIS shapefiles to determine the amount of project lands identified by the US Survey from each set of available aerial imagery as being used for agricultural purposes indicates that the maximum possible agricultural acreage existing at any one time for all three project units combined was about 400 acres in 1952, which is approximately equal to the 408 acres under ditch as of 1946 that was reported for the Crystal Project in the 1948 Navajo Report.[16] However, although the US Survey claims that all the

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Lower Crystal projects, respectively, consistent with the more recent project names adopted by the Ebert and Associates Report, which report was prepared in support of the US Claims and the US Survey.

[15] The total claimed acreage was distributed by the US Survey as 198.5 acres on the Crystal Project, 152.1 acres on the Lower Crystal (renamed Coyote Wash) Project, and 210.1 acres on the Sonsela (renamed Lower Crystal) Project.

[16] The following is a summary of the acres of agricultural land estimated by the US Survey to exist in the Crystal area at the time the aerial imagery was taken and claimed by the US Survey to have been irrigated at or prior to the date of the imagery (excluding lands claimed to receive water from channel interception or floodwater overflow, and excluding adjustments to claimed acres by project for the realignment of the Crystal and Lower Crystal (renamed Coyote Wash) project boundaries by the Ebert and Associates Report):

agricultural lands so identified were historically irrigated, the identification of claimed agricultural lands on aerial imagery available for select years does not necessarily mean that all lands identified on the various images were irrigated in any particular year. Such agricultural lands may have been dry farmed, cleared for grazing, or fenced or used for other non-irrigation purposes. The BIA crop reports for the Crystal Project for 1947 and 1950 make note that gardens and vegetables in the Crystal area are grown primarily on dry land patches, and the 2003 ISC crop field survey found substantial amounts of dry farming in the Crystal area including dry farming of pasture crops. Thus, the identification of agricultural lands on aerial imagery available for select years also does not necessarily mean expansion of the irrigation area for the Crystal area projects, as opposed to possible changes over time as to which lands may receive water from project ditches.

The BIA crop reports for the Crystal Project indicate a maximum irrigated acreage of 286 acres in 1941, and an irrigated acreage of 219 acres in 1948, 211 acres in 1949, 203 acres in 1950, 96 acres in 1951, and 219 acres in 1952. The amount of total (irrigated or idle) land reported for the Crystal Project was 351 acres developed for irrigation as of the early 1950s, as compared to the maximum amount of agricultural land, including dry farmed and idle lands, within the combined project area of about 400 acres identified by the US Survey from the 1952 aerial imagery and about 349 acres identified by the US Survey from the 1997 aerial imagery. Assuming that the difference in claimed developed agricultural acreage of 49 acres as of 1952 between the US Survey and the BIA crop reports were all irrigated at one time during the five-year period 1948-1952, the maximum amount of acres irrigated during this time span would have been no more than 268 acres. It is not clear when the additional acreage identified by the US Survey from the 1952 aerial imagery may have been developed for agricultural use or if portions of the agricultural lands that may not have been included in the BIA crop reports for the Crystal Project were possibly irrigated prior to 1948. The 1968 SCS Type I Study reported a nominal irrigated acreage for 1965 conditions for the Chinle Wash drainage near Crystal of 300 acres, including the Crystal area projects and the Whiskey Creek Project. The BIA map of Navajo Reservation Miscellaneous Irrigation Projects dated May 1952 that is shown in figure A-1 of the Ebert and Associates Report shows only one project, named the Crystal Project, in the Crystal area. Based on this information, it was assumed that the historic maximum acres irrigated for all three Crystal area projects combined was 286 acres, which when added to the maximum of 37 acres irrigated for the Whiskey Creek Project gives a total maximum irrigated acres in any one year for projects in the Chinle Wash drainage of 323 acres.

The Upper Captain Tom and Lower Captain Tom projects described by the US Survey divert water from Captain Tom Wash, with the Lower Captain Tom unit diversion located about 2 miles downstream of the lowermost parcel of land in the Upper Captain Tom unit. Excluding claimed channel interception and floodwater uses (see table D-1 of the Ebert and Associates Report), the total irrigated area claimed by the US Survey for both project units combined is about 2,008.8 acres (1,422.4 acres on the Upper Captain Tom Project and 586.4 acres on the Lower Captain Tom Project). A tabulation on Irrigation Resources and Cost Estimates, New Mexico, attached to a letter from Firman H. Brown of the Navajo

Year of Imagery	Crystal Project	Lower Crystal (Coyote Wash) Project	Sonsela (Lower Crystal) Project	Total
1935	101.84	25.41	34.74	161.99
1952	148.57	124.20	127.19	399.96
1975	123.01	73.24	82.39	278.64
1997	88.95	103.47	156.71	349.13
2005-09	125.29	61.50	89.42	276.21

Service to B.R. Fryer dated May 28, 1937, reported for the Captain Tom Project an ultimate irrigable area of 3,700 acres (1,000 acres for an Upper Captain Tom Project and 2,700 acres for a Captain Tom Wash Project), of which 2,100 acres were under constructed works as of 1937 (400 acres for an Upper Captain Tom Project and 1,700 acres for a Captain Tom Wash Project) and about 1,100 acres were irrigated in 1937 (300 acres for an Upper Captain Tom Project and 800 acres for a Captain Tom Wash Project). The BIA crop report for the Captain Tom Project for 1937 indicates that 1,037 acres were irrigated on the project in that year. The US Indian Service map of the Captain Tom area dated December 1938 that is shown in figure A-2 of the Ebert and Associates Report indicates that the Captain Tom Wash irrigation unit encompasses both the Upper Captain Tom and Lower Captain Tom project areas described by the US Survey combined. The geographic area of the Upper Captain Tom Project referenced by the 1937 tabulation on Irrigation Resources and Cost Estimates was not described. The US Indian Service maps for the Captain Tom Project dated December 1938 and September 1947 that are shown in figures A-9 and A-10, respectively, of the Ebert and Associates Report include only the Upper Captain Tom project unit area described by the US Survey.

The 1948 Navajo Report indicates for the Captain Tom Project a planned ultimate size of 3,700 acres, with 1,930 acres under ditch as of 1946. The first BIA crop report for the Captain Tom Project to give both the area irrigated and the irrigable but idle area was the report for 1939 that indicated a total developed project area of 1,726 acres as of that time. Subsequent BIA crop reports for the Captain Tom Project indicate a total project area (irrigated or idle lands) of about 1,573 acres during the 1940s and about 1,412 acres during the 1950s. Thus, the peak levels of irrigation use on the Captain Tom Project from the late 1930s to the early 1950s as reported by the BIA may have been associated with an irrigable area exceeding the US Survey claims for the Upper Captain Tom Project area alone by as much as about 304 acres. A review of the US Survey ArcGIS shapefiles to determine the amount of project lands identified by the US Survey from each set of available aerial imagery as being used for agricultural purposes indicates that the maximum possible agricultural acreage existing at any one time for both project units combined was about 1,393 acres in 1935, which amounts to about 333 acres less than the developed Captain Tom Project acreage of 1,726 acres indicated by the 1939 BIA crop report for the project.[17] The possible agricultural acreage for both project units combined was about 1,003 acres in 2005-09 and approximately 900 acres, plus or minus, in intervening years of imagery. The maximum possible agricultural acreage existing at any one time for the Upper Captain Tom Project area alone was about 896 acres in 1935 based on the US Survey, which is about 288 acres less than the maximum irrigated acreage of 1,184 acres for the Captain Tom Project reported by the BIA crop report for 1949. Again, the identification of agricultural lands on aerial imagery available for select years does not necessarily mean the lands were irrigated in any one year, or mean expansion of the irrigation area for the Captain Tom area projects as opposed to changes over time as to which lands may receive water from project ditches. Based on this information, it was assumed that the historic maximum acres

[17] The following is a summary of the acres of agricultural land estimated by the US Survey to exist in the Captain Tom area at the time the aerial imagery was taken and claimed by the US Survey to have been irrigated at or prior to the date of the imagery (excluding lands claimed to receive water from channel interception or floodwater overflow):

Year of Imagery	Upper Captain Tom Project	Lower Captain Tom Project	Total
1935	895.83	497.13	1,392.96
1965	789.52	99.03	888.55
1997	799.28	108.38	907.66
2005-09	889.99	112.61	1,002.60

irrigated for the Captain Tom area projects combined was 1,184 acres based on the BIA annual crop reports for the Captain Tom Project.

The Grey Mesa and Two Grey Hills projects described by the US Survey share a common point of diversion from Captain Tom Wash, with one ditch serving portions of the Two Grey Hills Project on the northwest side of the wash and a second ditch serving portions of the Two Grey Hills Project on the southeast side of the wash plus the Grey Mesa Project. The US Survey claims a total of about 878.3 acres of historic irrigated lands within the two project units combined (297.8 acres on the Two Grey Hills Project and 580.5 acres on the Grey Mesa Project). The BIA crop reports for the Grey Mesa Project and BIA Irrigation Land Data reports indicate development of a total farmland acreage on the project, including irrigated and idle lands, of about 905 acres during the period 1941-1946, declining to about 813 acres after 1947 and to about 800 acres after 1953, and increasing to about 856 acres during the period 1957-1959 and to 905 acres during the period 1963-1968. In addition, the BIA Shiprock Agency for 1976 reported a total project area of 905 acres for the "Grey Mesa (Two Grey Hills)" Project. The 1948 Navajo Report states that the Grey Mesa Project had about 1,000 acres under ditch as of 1946. The BIA crop report for the Grey Mesa Project for 1941 gives a maximum net acres irrigated on the project of about 709 acres, which amount is significantly greater than the claimed acreage of about 580.5 acres for the Grey Mesa Project described by the US Survey alone. The US Indian Service map of the Captain Tom area dated December 1938 that is shown in figure A-2 of the Ebert and Associates Report indicates that the Grey Mesa irrigation unit encompasses the Grey Mesa and Two Grey Hills project areas combined. Based on this information, it was assumed that the historic maximum acres irrigated for the Grey Mesa and Two Grey Hills project areas combined was 709 acres.

The Toadlena and Toadlena NE projects divert water from To-dil-hil Wash, with the Toadlena NE unit diversion located about 1 mile downstream of the lowermost parcel of land in the Toadlena unit. The US Survey claims a total of about 222.6 acres of historic irrigated lands within the two project units combined (174.6 acres on the Toadlena Project and 48.0 acres on the Toadlena NE Project). The 1948 Navajo Report indicates for the Toadlena Project a planned ultimate size of 300 acres, with 275 acres under ditch as of 1946. The BIA crop reports for the Toadlena Project indicate development of a total of 261.5 acres including irrigated and idle farmland during the mid-1940s to mid-1950s, and the BIA crop report for the Toadlena Project for 1942 gives a maximum net acres irrigated on the project of 228 acres, which amount is slightly in excess of the aggregate claimed total acreage of about 222.6 acres for the Toadlena and Toadlena NE project units combined. The net acres irrigated on the Toadlena Project according to BIA records exceeded the claimed acreage for the Toadlena Project unit described by the US Survey alone during each year 1940-1945 and in 1952. While the BIA maps for the Toadlena Project dated September 1933 and December 1938 that are shown in figures A-31 and A-32, respectively, of the Ebert and Associates Report include only the Toadlena project unit area described by the US Survey, the US Indian Service map of the Captain Tom area dated December 1938 that is shown in figure A-2 of the Ebert and Associates Report appears to suggest that the Toadlena irrigation unit encompasses the Toadlena and Toadlena NE project areas combined. Based on this information, it was assumed that the historic maximum acres irrigated for the Toadlena area projects combined was 222.6 acres.

For Navajo Nation tributary irrigation projects described by the US Survey for which no BIA irrigated acreage data are available, the annual depletion and diversion limits were determined based on the following assumed historic maximum acres irrigated in any year: 38 acres for the Tocito Lake Project,

30 acres for the Tocito Springs Project, 40 acres for the Sheep Dip Reservoir Project, 158 acres for the Red Rock Canyon Projects, 3.3 acres for the Porcupine Canyon Project, 30 acres for the Long Lake Project, 4.6 acres for the Sand Springs Project, 20 acres for the White Rock Project, 30 acres for the Red Wash Project, and 40 acres for that portion of the Lake Valley Project that is on Navajo Nation trust lands. These maximum acres irrigated assumptions were based on a review of the US Survey ArcGIS shapefiles to determine the amount of project lands identified by the US Survey from each set of available aerial imagery as being used for agricultural purposes.[18]

Although the identification of agricultural lands on aerial imagery available for select years does not necessarily mean that all lands identified on the various images were irrigated in any particular year, the maximum amounts of agricultural acres identified by the US Survey from any one year of aerial imagery for the following projects were used as the basis of quantifying proposed irrigation water rights for the Navajo Nation: (1) the Tocito Lake Project, which consists of two separate and distinct irrigation areas with different water sources; (2) the Tocito Springs Project, for which the maximum amount of agricultural acres were identified from two years of aerial imagery; (3) the Long Lake Project; and (4) the Sand Springs Project, based on the most recent imagery. For the Sheep Dip Reservoir Project, the historic maximum acres irrigated was assumed considering the amount of agricultural land identified by the US Survey from the 1951 aerial imagery, which was a subset of the agricultural land for the project identified by the US Survey from the 1935 aerial imagery, plus an additional 1-acre field identified from the 1997 aerial imagery (the available imagery suggests that not all of the agricultural lands interpreted by the US Survey from the 1935 aerial imagery were ever irrigated). For the Red Rock Canyon Projects, about 158 acres of the 170 acres of agricultural land identified by the US Survey from the 1951 aerial imagery were identified as agricultural land on other years of imagery also. The historic maximum acres irrigated for the White Rock Project was assumed to be about 20 acres considering the amount of agricultural land identified on the project by the US Survey from the 1965 aerial imagery (13.6 acres), which was a subset of the agricultural land for the project identified by the US Survey from the 1935 aerial imagery, plus a 2.3 acre field identified from the 1935 aerial imagery that appears in the imagery to have been largely irrigated in that year, plus an additional 4 acres of possibly irrigated land interpreted from the aerial imagery. For the Red Wash Project, the historic maximum acres irrigated was assumed based on inspection of the 1935 aerial imagery that appears to show at least approximately 30 acres may have been irrigated in that year. Recent aerial imagery suggests that no irrigation uses have been made on the Red Wash Project for decades (see Appendix E, map E-5, of the US Survey). The Lake Valley Project identified by the US Survey consists of two distinct areas: (1) the northern project area adjacent to Juan's Lake for which the US Survey claims irrigation uses on Navajo allotments; and (2) the southern project area a few miles south of Juan's Lake for which the US Survey

[18] The following is a summary of the acres of agricultural land estimated by the US Survey to exist at the time the aerial imagery was taken and claimed by the US Survey to have been irrigated at or prior to the date of the imagery (excluding lands claimed to receive water from channel interception or floodwater overflow):

Year of Imagery	Tocito Lake	Tocito Springs	Sheep Dip Reservoir	Red Rock Canyon	Porcupine Canyon	Long Lake	Sand Springs	White Rock	Red Wash	Lake Valley (trust)
1935	12.32	30.03	64.15	100.41	4.10	30.12	3.40	40.12	39.91	17.20
1951	38.11	29.51	39.40	170.14	3.27					
1965							4.27	13.61		44.47
1969						26.63				
1975	27.66	15.24		154.99	3.27	27.41				
1997	28.09	7.54	17.13	94.51	3.27	22.52				38.48
2005-09	31.85	0.00	17.26	86.43	3.27	23.59	4.59			18.83

claims irrigation uses on Navajo Nation trust lands and on Navajo allotments. It is assumed that the BIA irrigated acres data for the Juan's Lake Project, which data indicate a maximum of 30 acres irrigated on the project in 1942, applies to the northern area of the Lake Valley Project adjacent to Juan's Lake, for which the US Survey claims 33.75 acres of irrigation uses on Navajo allotments based on interpretation of agricultural lands from the 1935 aerial imagery (excluding lands claimed to receive water from channel interception or floodwater overflow).[19]

Based on the proposed federal reserved irrigation rights in the Proposed Supplemental Decree for Navajo Nation tributary irrigation projects, the annual depletion of San Juan River flow resulting from irrigation uses on these projects may be anticipated to be about 1,180 acre-feet assuming that all of these rights are fully exercised and average water supply conditions (see table 13). This compares to a maximum historic annual depletion of San Juan River flow by irrigation uses in the ephemeral tributary drainages within Navajo country in New Mexico of about 978 acre-feet in 1941 (see table 12).[20] History suggests that the proposed irrigation rights for the Navajo Nation that are in the Proposed Supplemental Decree are not likely to all be fully exercised in any given year.

3. State Law Water Rights for Tributary Irrigation Projects. Water rights previously adjudicated, licensed or permitted under state law for spreader dams or other irrigation uses in the Chaco River drainage are considered water rights acquired under state law, as opposed to federal reserved rights, regardless of whether the lands appurtenant to these uses are now held in trust by the United States for the benefit of the Navajo Nation or held in fee by the Navajo Nation. The US Survey claimed water rights for the Navajo Nation for the following tributary irrigation projects that were included in the 1938 State Engineer Hydrographic Survey: (1) I.K. Westbrook spreader dams along Indian Creek on what is now claimed as Navajo Nation trust lands (140.90 acres) or Navajo Nation fee lands (578.83 acres); (2) I.K. Westbrook spreader dams along Kin Klizhin Wash on what is now claimed as Navajo Nation trust lands (40.47 acres) or Navajo Nation fee lands (443.61 acres); (3) Pitt Ranch spreader dams on what is now claimed as Navajo Nation fee lands (239.96 acres); (4) J.B. Tanner irrigation uses on what is now

[19] A tabulation on "Irrigation Resources and Cost Estimates, New Mexico," attached to a letter from Firman H. Brown of the Navajo Service to B.R. Fryer dated May 28, 1937, reported for the Kimenola-Juan's Lake Project an ultimate irrigable area of 600 acres, of which 400 acres were under constructed works as of 1937 and no acres were irrigated in 1937. A letter from Billie D. Smith of the BIA to Earl F. Sorensen of the OSE, dated June 19, 1970, states that the Juan's Lake Project had been dropped from BIA records.

[20] The historic annual depletions of San Juan River flow by Navajo tributary irrigation uses provided in table 12 were made using CIR assumptions that are consistent with the irrigation water requirements computed by the 1938 State Engineer Hydrographic Survey using the Lowry-Johnson method. The US Survey for the US Claims computed CIRs for each tract of land for which water rights are claimed using the Hargreaves method (see Ebert and Associates Report, page C-7). The total amount of Navajo tributary irrigation project annual depletion reported in the US Claims at table DD-1 and computed using the Hargreaves method is about 18,766 acre-feet, which is about 21 percent greater than the total amount of tributary irrigation project annual depletion claimed for the same irrigated acreage in the US Survey at table I-1 and computed using the Lowry-Johnson method of about 15,528 acre-feet. If the estimated actual historic annual depletions of San Juan River flow by Navajo tributary irrigation uses were increased by about 21 percent for a change in CIR methodology, the maximum historic annual river flow depletion by Navajo tributary irrigation uses would be estimated to have been about 1,183 acre-feet in 1941. Again, reliance on the Lowry-Johnson method as a basis for quantifying the Navajo Nation's irrigation water rights consistent with the quantification of irrigation rights adjudicated by the 1948 Echo Ditch Decree should not be construed as the State of New Mexico's agreement that irrigation depletions in the San Juan River Basin should be computed using the Lowry-Johnson method for any other purpose. Nor does the State of New Mexico agree that the Hargreaves method should be used to estimate its irrigation consumptive uses as against its water apportionment pursuant to the Upper Colorado River Basin Compact.

claimed as Navajo Nation trust lands (0.18 acre) or Navajo Nation fee lands (45.41 acres); (5) J.B. Farris Ranch irrigation uses on what was claimed by the US Survey as Navajo Nation trust lands (75.51 acres); and (6) R.L. Tanner irrigation uses on what is now claimed as Navajo Nation fee lands (122.70 acres).[21] The lands associated with the J.B. Farris Ranch irrigation uses in the Seven Lakes Draw sub-drainage are not on lands held by the United States in trust on behalf of the Navajo Nation, and no water rights are recognized for these uses in the Proposed Supplemental Decree.[22] The 1948 Echo Ditch Decree adjudicated water rights for the I.K. Westbrook spreader dams on Indian Creek, but did not include water rights for the other tributary irrigation projects described by the 1938 State Engineer Hydrographic Survey.

Water rights for the irrigation of 716.7 acres by I.K. Westbrook via spreader dams on Indian Creek were adjudicated a water right with a priority date of March 3, 1934, by the 1948 Echo Ditch Decree (see the Echo Ditch Decree, page 376, and the 1938 State Engineer Hydrographic Survey, Map Sheets 85-87). The United States in December 1965 purchased about 140.90 acres of land associated with the I.K. Westbrook-Indian Creek Project to be held in trust on behalf of the Navajo Tribe. The Navajo Nation has not provided documentation as to when it acquired in fee the remainder of the project lands, or evidence as to how much irrigation use has been made on the project lands since the 1938 Hydrographic Survey was conducted or the 1948 Echo Ditch Decree was entered. Testimony of I.K. Westbrook in the Echo Ditch adjudication indicates that upstream construction in February 1935 of a dam and reservoir on Indian Creek by the Indian Department for use to store water for livestock purposes diminished the water supply available to the spreader dams on this stream such that water was no longer available in many years until October when it was too late to use for irrigation (see transcripts of testimony in *The Echo Ditch Company, et al., v. The McDermott Ditch Company, et al.*, New Mexico District Court, San Juan County, Cause No. 01690, pages 1266-1271). Image A-1 of Appendix A attached hereto shows aerial imagery dated 1969 that covers approximately two-thirds of the I.K. Westbrook-Indian Creek Project area, including those portions of the project area that are located on land that in 1965 was deeded to the United States in trust for the Navajo Nation. Visual inspection of image A-1 appears to indicate that by the late 1960s: (1) substantial amounts of project lands may have been severely eroded, or possibly infested with phreatophytes or other native non-crop vegetation; and (2) the spreader dams on Indian Creek may not all have been effective for supporting irrigation uses. While it does not appear that the spreader dams and associated irrigated lands on the project were always well maintained for optimizing the irrigation of natural grass pasture (vega), irrigation by spreader dams is a passive activity that can occur to the extent that floodwaters are available and the dams still spread them.[23]

[21] The US Survey also identifies small amounts of acreage under the I.K. Westbrook-Indian Creek (0.60 acre), the J.B. Farris (1.76 acres) and the R.L. Tanner (4.53 acres) irrigation projects as being on lands now claimed as Navajo allotments.

[22] Land associated with the J.B. Farris Ranch irrigation uses was the subject of an Executive Order which in 1913 reserved the land for the benefit of the Navajo Nation subject to prior claims, and a prior claim was resolved in the 1990s.

[23] The US Survey claims that one or more of the spreader dams on the I.K. Westbrook-Indian Creek Project are stock water storage reservoirs (see image A-1(b)). It is reported in "San Juan Stream System Navajo Water Use Report on Impoundments, Wells, and Springs," prepared by Keller-Bliesner Engineering, LLC, and dated January 12, 2012 (Keller-Bliesner Report), at page 4, that any storage reservoirs that appear to have been used or to have the potential to be used for irrigation of nearby field crops were classified as irrigation reservoirs by the US Survey. The amount of acres of overlapping claims is relatively small.

The I.K. Westbrook spreader dam irrigation uses on Kin Klizhin Wash were not adjudicated a water right by the 1948 Echo Ditch Decree. The United States in July 1931 purchased about 40.47 acres of land associated with the Westbrook-Kin Klizhin Wash Project to be held in trust on behalf of the Navajo Tribe. The Navajo Nation has not provided documentation as to when it acquired in fee the remainder of the project lands, or evidence as to how much irrigation use has been made on the project lands since the land was deeded to the United States in 1931 or since the 1938 Hydrographic Survey was conducted.

The Navajo Nation also has not provided documentation as to when lands associated with the other irrigation projects included in the 1938 State Engineer Hydrographic Survey were acquired in fee, or as to whether any irrigation uses have been made on these other projects after the 1938 State Engineer Hydrographic Survey was conducted, or either prior to or after the Navajo Nation acquired said project lands. The lands associated with the R.L. Tanner irrigation uses were located below an irrigation reservoir referred to as Tanner Lake (see figure B-1 of the Ebert and Associates Report). The dam forming Tanner Lake, which was developed in 1935 for irrigation purposes based on the 1938 State Engineer Hydrographic Survey, appeared to have been breached based on aerial imagery dated 1998 and is claimed as a stock water reservoir by the US Survey because it was not apparent in the preparation of the US Survey storage reservoir claims that the lake provided water storage for any nearby irrigation project or use (see Keller-Bliesner Report, page 4). Based on the 2003 ISC crop field survey, it appeared that no irrigation uses had been made on the R.L. Tanner project lands for many years as they were covered by wild native vegetation. The J.B. Farris irrigation project also was associated with an irrigation reservoir, and the J.B. Tanner project may have been irrigated with well water though the US Survey does not appear to include an irrigation well at the project site.

Water rights under state law are included in the Proposed Supplemental Decree for irrigation by spreading of floodwaters as available on: (1) 716.1 acres of Navajo Nation trust lands and Navajo Nation fee lands within the I.K. Westbrook-Indian Creek Project area, based on irrigation rights previously adjudicated by the Echo Ditch Decree; and (2) 40.5 acres of Navajo Nation trust lands within the I.K. Westbrook-Kin Klizhin Wash Project area, based on the amount of land within the project area that the United States acquired in trust for the Navajo Nation in 1931. No water rights are proposed for the Navajo Nation for the other tributary irrigation projects that were described by the 1938 State Engineer Hydrographic Survey.

4. Reserved Water Rights for Navajo Tributary Non-Project Irrigation Uses. For Navajo tributary non-project irrigation uses claimed by the US Survey, no irrigated acres data are available to determine historic irrigation use. Therefore, no water right analysis is made for individual water right claims for each non-project irrigated field claimed by the US Survey. Rather, claims by the US Survey for non-project irrigation uses (excluding claimed uses by channel interception or floodwater overflow) are evaluated in the aggregate based on a review of the US Survey ArcGIS shapefiles to determine the amount of non-project lands identified by the US Survey from each set of available aerial imagery as being used for agricultural purposes.[24] Again, although the US Survey claims that all lands so identified

[24] The following is a summary of the acres of agricultural land estimated by the US Survey to exist at the time the aerial imagery was taken and claimed by the US Survey to have been irrigated at or prior to the date of the imagery (excluding lands claimed to receive water from channel interception or floodwater overflow, and excluding acres of agricultural land identified by the US Survey from the aerial imagery dated 1975):

were historically irrigated, the identification of agricultural lands on aerial imagery available for select years does not necessarily mean that all lands identified on the various images were irrigated by diversions in the recent past or in any particular year, or that some of the lands identified were not simply cleared for grazing range animals, used for dry farming, fenced or used for other non-irrigation purposes, or received water by channel interception or floodwater overflow. Images A-2 through A-10 of Appendix A attached hereto provide examples of fields on Navajo Nation trust lands that are claimed by the US Survey as Navajo tributary non-project irrigation use lands served by diversions, which examples indicate some amount of uncertainty in the identification from aerial imagery alone of tracts of land that have been irrigated.[25] The US Survey primarily relied on photo-interpretation alone to identify claimed non-project agricultural fields and irrigation facilities, with few site visits to verify likely historic irrigation use. The aerial imagery shown in figures 26, 30, 35, 36, 38 and 39 of the Ebert and Associates Report provide examples of fields claimed by the US Survey that appear to have possibly been irrigated, in part, during the year the imagery was taken.

The aerial imagery for 1935, 1997 and 2005-2009 covered the entire US Survey irrigation use study area, and the imagery available for other years covered only portions of the study area. Based on this review, the maximum possible agricultural acreage existing at any one time was about 419 acres in 1935 (including about 355 acres on Navajo Nation trust lands), as compared to about 329 acres in 1997 (including about 318 acres on Navajo Nation trust lands) and 309 acres during 2005-2009 (including about 294 acres on Navajo Nation trust lands). However, only about 173 agricultural acres interpreted by the US Survey from inspection of the 1935 imagery were confirmed or found in subsequent aerial images based on tables E-10 and D-2 of the Ebert and Associates Report. A composite coverage of nearly the entire US Survey irrigation use study area can be approximated by adding the claimed acres from the 1951, 1952, 1965 and 1969 imagery, with reductions to eliminate field duplication between years for overlapping portions of imagery coverage (see the Ebert and Associates Report, table 2). Using this approach, the possible agricultural acreage during the 1950s to mid-1960s totaled as much as about 856 acres total (907 acres total is reduced to 856 acres with adjustments to avoid duplication of identified agricultural fields for overlapping coverage between years), or about 831 acres on Navajo Nation trust lands. However, lands identified from one image as possibly being used for agricultural

	Claimed Irrigated Acres			Acres Found Only in the Year Indicated		
Year of Imagery	Total Acres	Trust Lands	Navajo Allotments	Total Acres	Trust Lands	Navajo Allotments
1935	418.5	355.2	63.4	245.4	196.0	49.4
1951	123.5	123.5	0.0	53.4	53.4	0.0
1952	564.6	541.5	23.1	265.5	246.7	18.8
1965	92.5	92.5	0.0	4.0	4.0	0.0
1969	126.1	124.8	1.3	12.0	11.0	0.9
1997	328.8	317.8	11.0	12.5	12.5	0.0
2005-09	308.5	294.5	14.0	8.4	8.4	0.0

[25] Image 2(b) also illustrates another possible problem with the US Survey's methodology to quantify irrigated acres claims. Based on the "union analysis" approach described by the Ebert and Associates Report at pages 17-18, the amount of acres for Field No. 178 claimed by the US Survey appears to include all of the area encompassed by the field boundary delineated from the 1935 aerial imagery plus the additional area encompassed by the field boundary delineated from the 1997 aerial imagery, even though it is clear that a significant portion of the land within the field boundary identified from the 1935 imagery is shown in the 1997 imagery to now have a road and buildings on it. Of the total amount of field acres claimed by the US Survey as non-project irrigation lands (other than lands receiving water from channel interception or floodwater overflow), it has not been determined how many claimed acres have been developed for other purposes and are not now irrigable as a result.

purposes may not be recognizable as possible agricultural land in a subsequent image taken years later. Only about 521 acres of agricultural fields (including about 516 acres on Navajo Nation trust lands) interpreted by the US Survey from inspection of the subject imagery for 1951-1969 were confirmed or found in aerial images from more than one of the eight available sets of imagery from the period 1935-2009. Again, identification of these lands from the aerial imagery does not necessarily imply that all of the lands were actually irrigated historically, let alone all irrigated during any one year. For example, aerial imagery dated September 1952 that is shown in figures 26, 30 and 44 of the Ebert and Associates Report illustrates that irrigation cannot be assumed to have occurred in that year on all of the agricultural land identified from the 1952 imagery. The photo-interpretation of possible agricultural lands for a given year is not an evaluation of the amount of acres irrigated in that year or any other year.

The OSE Hydrographic Survey and Mapping Bureau's interpretation of the aerial imagery to evaluate possible irrigated acreage in the ephemeral tributary drainages indicates a more conservatively low estimate of the amount of tributary non-project lands that may have been historically irrigated than was mapped by the US Survey. The OSE Hydrographic Survey and Mapping Bureau has reservations about the use of the aerial imagery provided by the United States as the sole piece of data used to make such interpretations, particularly because some of the older imagery appears to be of relatively poor quality. Based solely on its review and interpretation of the historic aerial imagery provided by the United States and without any other supporting data or field inspections, the OSE Hydrographic Survey and Mapping Bureau estimated that there may be as little as 100 acres of the 1,425 acres of tributary non-project irrigation lands claimed by the US Survey (excluding lands claimed to receive water from channel interception or floodwater overflow) that could be confidently interpreted from the aerial imagery alone as irrigated tracts or tracts that have been historically irrigated. Still, it is possible that interest in developing scattered small non-project irrigation uses on Navajo lands may have peaked during the 1940s to early 1950s, coincident with the peak of historic irrigation development and use on Navajo tributary irrigation projects.

Based on this information, the Proposed Supplemental Decree recognizes federal reserved water rights for all Navajo tributary non-project irrigation uses combined based on: (1) a total of 1,425 water right acres for irrigation of non-project lands in the San Juan River Basin in New Mexico, which is the total amount of non-project irrigation acreage on Navajo Nation trust land claimed by the US Survey (excluding lands claimed to receive water from channel interception or floodwater overflow); and (2) total diversion and depletion rights for irrigation of non-project lands in the basin computed based on irrigation of up to 516 acres in any one year by Navajo tributary non-project irrigation uses. The Proposed Supplemental Decree also provides that the exercise of these diversion and depletion rights may be made for irrigation uses from any water source other than the San Juan River on any Navajo Nation trust lands in the San Juan River Basin in New Mexico, and that up to 300 acres of irrigation water rights proposed for Navajo tributary irrigation projects may be exercised off tributary project lands for irrigation uses from any water source other than the San Juan River on any Navajo Nation trust lands in the basin. This limited flexibility to replace a tributary non-project irrigation use in one location on Navajo Nation trust lands in the basin with one at another location allows for scattered irrigation uses to come and go over time consistent with historic patterns of land use illustrated by the aerial imagery used by the US Survey, and also allows for any Navajo tributary non-project irrigation uses that may have been omitted from the US Survey to continue without increasing the total diversion and depletion rights for all Navajo tributary irrigation uses combined.

To determine the total diversion and depletion rights for all Navajo tributary non-project irrigation uses combined, the assumed historic maximum acres irrigated by non-project irrigation uses was distributed to surface water uses and ground water uses in the Chaco River and Chinle Wash drainages based on an evaluation of the amounts of agricultural acres identified by the US Survey from the available aerial imagery for 1935, 1997 and 2005-2009, which each cover the entire US Survey study area. For these three years, the average distribution of identified agricultural non-project acres by water source and drainage was about 92.4 percent surface water use claims (including from springs) in the Chaco River drainage, about 1.0 percent surface water use claims in the Chinle Wash drainage, and about 6.6 percent ground water use claims in the Chaco River drainage. The amounts of acres distributed to surface water uses in the Chaco River and Chinle Wash drainages and to ground water uses in the Chaco River drainage were then further distributed by quadrangle based on the quadrangle distributions of the pertinent acres of non-project irrigation uses claimed by the US Survey. Table 14 attached hereto provides by quadrangle and drainage the resultant distribution of the assumed historic maximum acres irrigated that was used to determine annual at-site irrigation depletions and diversion requirements for tributary non-project irrigation uses on Navajo Nation trust lands in the San Juan River Basin in New Mexico. The annual depletion demands and diversions shown in table 14 were determined using the average annual depletion and diversion rates per acre, respectively, for claimed tributary non-project uses in each quadrangle computed from the US Survey claims as shown in table 2. The shorted irrigation depletions assume an average water supply shortage of 50 percent for all tributary non-project surface water irrigation uses, and no shortage for ground water irrigation uses. To estimate annual depletions of San Juan River flow that could result from Navajo tributary non-project irrigation uses included in the Proposed Supplemental Decree, the percentage depletion impact on river flows of Navajo Nation tributary non-project surface water irrigation depletions in each quadrangle were assumed from figure 1. Based on this analysis, the potential annual depletions of San Juan River flow by Navajo tributary non-project irrigation uses in the basin may be anticipated to be about 23 acre-feet.

Table 15 attached hereto provides a summary of the proposed federal reserved water rights for the Navajo Nation for all tributary non-project irrigation uses in the basin combined, including: (1) water right acres; (2) limits on the combined total annual at-site irrigation depletion based on the assumed historic maximum acres irrigated and the depletion rates for these uses claimed by the US Survey; and (3) limits on the combined total annual diversion based on the assumed historic maximum acres irrigated and the diversion rates for these uses claimed by the US Survey. The annual depletion of San Juan River flow resulting from the use of water under these proposed irrigation rights for tributary non-project uses is anticipated to be small due to the geographic locations and small sizes of individual non-project irrigation uses.

III. TRIBUTARY WATER STORAGE RESERVOIRS

A. US Survey Methodology for Estimating Reservoir Sizes

1. General. The US Survey includes maximum surface area and storage capacity claims for historic and existing water storage reservoirs on Navajo lands in the San Juan River Basin in New Mexico supplied from water sources other than the San Juan River within the drainages of ephemeral tributaries to the river. The methodology used to survey areas and capacities for the reservoirs is not described by the US Survey, but is described in the Keller-Bliesner Report.

2. Maximum Reservoir Surface Areas at Spillway Crest. The methodology used for the US Survey to estimate maximum surface areas for reservoirs at spillway crest as described in the Keller-Bliesner Report generally relied on: (1) surface areas for 415 reservoirs physically surveyed in the field using Global Positioning System (GPS) equipment at the identified spillway crest or overflow outlet pipe elevation; and (2) surface areas for 1,806 reservoirs estimated by stereographically viewing 2005 digital orthophotos to remotely interpret spillway crest locations and elevations and associated surface areas at spillway crest, including for 290 reservoirs for which the surface areas at spillway crest were measured in the field.[26] To verify the US Survey stereo analysis interpretations of maximum reservoir surface areas, the Keller-Bliesner Report states that the surface areas interpreted by stereo analysis were compared to GPS field measured surface areas for the 290 reservoir sites for which overlapping data were collected. However, the verification data for the Keller-Bliesner Report provided to the State of New Mexico indicated that only 275 reservoir sites, almost all of which were either stock water or irrigation reservoirs, were included in the verification analysis. Figure B-1(a) of Appendix B attached hereto shows the relationship of field measured reservoir area at spillway crest to stereo analysis interpreted maximum surface area based on the 275 reservoir sites used to verify the US Survey methodology for remotely estimating reservoir areas. Although the linear regression analysis shown in figure B-1(a) indicates that the GPS field measured surface areas at spillway crest are about 5 percent less, on average, than the stereo analysis interpreted areas, the US Survey made no adjustments to reduce the stereo analysis interpreted surface areas for reservoirs for which no field data were collected.

Figures B-1(b) and B-1(c) of Appendix B attached hereto provide the same verification data as shown in figure B-1(a); except, that these two figures display the verification data at different scales to better illustrate the scatter in the data and relative errors in reservoir areas interpreted from stereo analysis. Figures B-2(a) and B-2(b) illustrate the errors in the maximum surface areas determined by stereo analysis interpretation. The OSE Hydrographic Survey and Mapping Bureau reviewed US Survey backup data for storage reservoirs and found an additional 13 reservoir sites for which both GPS field measurements and stereo analysis interpretation estimates of maximum surface area were available, but that were omitted from the reservoir sites used for the US Survey verification analysis. Comparison of the surface area data for the additional 13 reservoir sites is shown in figures B-3(a) and B-3(b). Addition of only the omitted data for reservoirs less than a few acres in size does not significantly affect the overall average relationship between field measured and stereo analysis interpreted maximum surface areas as determined by linear regression analysis even though: (1) all of the omitted data exhibit greater error in the stereo analysis interpreted surface areas than do most of the reservoirs of the same

[26] The reservoirs included in the US Survey include reservoirs used for irrigation, stock water, sewer settling or industrial purposes. The Proposed Supplemental Decree includes water rights for irrigation and stock water reservoirs, but does not include storage rights for sewer settling or industrial reservoirs.

size included in the US Survey verification analysis; and (2) the stereo analysis interpreted areas for 12 of the 13 reservoirs excluded from the verification analysis substantially overstate the surface areas at spillway crest measured in the field. However, the addition of the omitted data for reservoirs greater than a few acres in size casts doubt as to whether stereo analysis interpreted surface areas greater than about 8-10 acres reasonably represent, on average, actual surface areas at spillway crest. Figure B-4(a) shows the correlation of field measured reservoir area at spillway crest to stereo analysis interpreted maximum surface area based on the available data for reservoirs less than 8 acres in size. The available data by reservoir type described by the US Survey as shown in figure B-4(b) appear to indicate that the ranges of variation in the data for well reservoirs and for diversion reservoirs are within the range of variation in the data for in-channel reservoirs.[27]

For reservoir sites for which GPS field measurements of maximum surface area at spillway crest are available, the US Survey surface area claims are based on the field measurements. However, for reservoir sites for which GPS field measurements of maximum surface area were not made, there is no check as to whether the stereo analysis accurately interpreted the surface area at spillway crest. Stereo analysis interpretation of maximum surface areas at some reservoir sites, such as at sites with flat topography near the spillway crest elevation, can be difficult. Also, the methodology used by the United States in many instances may result in estimates of surface area that better reflect the area at dam crest rather than at spillway crest, particularly in instances where an ungated outlet pipe or culvert serves as an effective spillway in lieu of providing a notch in an earthen reservoir that could otherwise be eroded by overflow. The OSE Hydrographic Survey and Mapping Bureau performed an expedited review of US Survey backup data that was provided by the United States to the State of New Mexico for some of the livestock reservoirs that were visited in the field. As part of the data, the United States provided photographs of the reservoirs that were taken during the field inspections that show ungated outlet pipes or culverts serving as apparent spillways or overflow pipes. For examples of ungated outlet pipes or culverts, see pictures C-1 through C-5 of Appendix C attached hereto for Impoundment Nos. P-5033, P-5215, P-5075, P-5002 and P-5201, respectively. The orthophotos that were viewed stereographically are not of sufficient quality and detail to be able to locate pipes and determine their upstream elevation, and therefore, the maximum surface areas for such reservoirs can be expected to be overstated and to more nearly reflect the lowest elevation along the crest of the dam using the stereo analysis methodology.[28] Of all the reservoirs claimed by the US Survey, including the 1,516 reservoirs that the Keller-Bliesner Report indicates were not surveyed in the field, it is not known how many reservoirs have ungated outlet pipes or culverts serving the function of a spillway.

[27] The US Survey classified reservoirs constructed on stream channels as in-channel reservoirs or as diversion reservoirs if filled via a diversion from another watercourse, reservoirs constructed outside of defined stream channels and filled by diversions of surface water from streams as off-channel reservoirs, reservoirs filled solely from ground water as well reservoirs, and reservoirs filled by diversion from an improved spring as improved spring reservoirs.

[28] The maximum surface area at spillway crest for Impoundment No. 5033, which is one of the 13 reservoirs that was omitted by the US Survey verification analysis, was determined by GPS field measurement to be about 18.4 acres and was interpreted by stereo analysis to be about 118.0 acres (a 540 percent error). The maximum surface area at spillway crest for Impoundment No. 5215, which also was omitted from the verification analysis, was determined by field measurement to be about 0.48 acre and was interpreted by stereo analysis to be about 1.07 acres (a 122 percent error). The maximum surface area at spillway crest for Impoundment No. 5075, which was included in the verification analysis, was determined by field measurement to be about 1.21 acres and was interpreted by stereo analysis to be about 1.87 acres (a 55 percent error). The surface areas for Impoundment Nos. P-5002 and P-5201 were not estimated using the stereo analysis method.

In addition, although the Keller-Bliesner Report indicates that the stereo analysis may have considered visual cues in interpreting the maximum surface areas for some reservoirs, it appears from an expedited review of available aerial imagery for some livestock reservoirs that the claimed reservoir boundary interpreted by stereo analysis is in some instances significantly greater than the maximum surface area for the reservoir that can be determined based on either field survey or the appearance of soils and vegetation within and outside of the claimed reservoir area and downstream of the dam (see, for example, aerial imagery shown in pictures C-6 through C-14 for Impoundment Nos. P-0445, P-1059, P-0033, P-0234, P-0470, P-0740, P-1325, P-1345 and P-1396, respectively). Picture C-14 for Impoundment No. P-1396 shows an example where the entire reservoir appears to be misidentified by the US Survey stereo analysis, with visual inspection of the aerial imagery indicating that the actual reservoir covers only the center of the claimed area and that both the dam forming the reservoir and the reservoir outlet are located to the southwest of the center of the lake rather than across land covered with native vegetation in the northwest corner of the image. Pictures C-6 through C-14, plus the aerial imagery shown in pictures C-15 through C-17 for Impoundment Nos. P-0103, P-5345 and P-0809, respectively, also indicate that the spillway elevations and surface areas at spillway crest claimed by the US Survey cannot be assumed to be indicative of historic use as may be measured by a demonstrable high water mark. The reservoir areas and storage volumes at high water mark can be equal to or less than the areas and capacities estimated for the spillway crest. Pictures C-18 and C-19 for claimed livestock Impoundment Nos. P-5408 and P-5413, respectively, show what appear to be new coarsely constructed berms of dirt that may not be associated with previous water storage. Also, as is illustrated in the aerial imagery shown in picture C-11 for Impoundment No. P-0740, some of the livestock reservoirs claimed by the US Survey may consist, at least in part, of catchment dikes that do not store water but rather divert water from channels into a smaller storage reservoir (such as may be the case along road right-of-ways for flood and drainage control).

The OSE Hydrographic Survey and Mapping Bureau used available aerial imagery for 1996, 2005 and 2009, digital versions of the US Geological Survey quadrangle maps, and some years of the historic imagery provided by the United States to the State of New Mexico to interpret the historic maximum surface areas based on high water mark for all 163 livestock and irrigation reservoirs claimed by the US Survey to be greater than 6 acres in size and for 146, or about 9 percent, of the livestock and irrigation reservoirs claimed by the US Survey to be less than 6 acres in size (see Appendix D attached hereto). Figures B-5(a) and B-5(b) of Appendix B show the resultant relationship of OSE photo-interpreted high water mark area to US Survey field measured surface area at spillway crest for livestock reservoirs claimed by the US Survey that were field surveyed. Figures B-6(a) through B-6(d) show the resultant relationship of OSE photo-interpreted high water mark area to US Survey stereo analysis interpretations of surface area at spillway crest for livestock and irrigation reservoirs claimed by the US Survey that were not surveyed in the field, including four reservoirs that were breached on all available imagery. On average, the OSE photo-interpreted high water mark area tends to be significantly less than the surface area at spillway crest claimed by the US Survey. The available data by reservoir type described by the US Survey as shown in figure B-5(c) and B-6(e) indicate that the ranges of variation in the data for well reservoirs, diversion reservoirs and improved spring reservoirs are within the range of variation in the data for in-channel reservoirs.

Thus, it appears that the US Survey methodology is not sufficient by itself to accurately determine the actual maximum surface area at spillway crest, or the surface area at high water mark, for many of the reservoirs included in the US Survey. Overall, the total maximum surface area claimed for all of the

reservoirs on Navajo lands in the San Juan River Basin in New Mexico identified by the US Survey combined appears to overstate both the combined existing total area at spillway crest and total area at high water mark, which would include water surface area and area of apparent exposed shoreline as may be interpreted based on visual inspection of aerial imagery. However, it is possible that in some instances reservoir surface areas at spillway crest under present conditions could be smaller than original total areas at spillway crest if a sediment delta formed within the original reservoir pool area.

The average maximum surface area for the 1,729 tributary livestock reservoirs claimed by the US Survey is about 3.0 acres; however, there are several rather large reservoirs identified by the US Survey that have a substantial impact on the average of the maximum surface areas claimed by the US Survey for livestock reservoirs (see table M-3 of the US Survey). By comparison, the average maximum surface areas for active (not breached or silted) stock ponds in the San Juan River Basin in New Mexico as of 1963 were 0.5 acre for stock ponds on Navajo lands as reported by the BIA and 1.0 acre for stock ponds on private lands as reported by the SCS (see OSE Memorandum dated February 27, 1964, from E.F. Sorensen to J.C. Yates on "Active Stock Ponds in New Mexico as of June 30, 1963"). Reasons for the differences in average stock pond sizes on Navajo lands in the basin between those reported by the BIA for 1963 conditions and those claimed by the US Survey may be due to a combination of factors, including: (1) the United States or the Navajo Nation since 1963 acquiring lands that had stock water reservoirs that were larger than those existing on Navajo lands as of 1963; (2) the Navajo Nation or its members, or the BIA for the benefit of the Navajo Nation or Navajo allottees, constructing larger stock ponds on Navajo lands since 1963; (3) the abandonment of smaller stock ponds that were active in 1963 but were since silted or breached; (4) the inclusion of larger reservoirs that were once used or accounted for irrigation, industrial, flood control or other purposes as stock water reservoirs in the US Survey (for example, Juan's Lake, Long Lake, Little White Cone Lake and Tanner Lake); (5) the inclusion in the US Survey of large inactive (breached or silted) livestock reservoirs, some of which may have already been breached prior to 1963 and not considered in reporting an average area for active stock ponds; or (6) overstated estimates of livestock reservoir surface areas as discussed above.[29] No information is available explaining how the federal agencies determined the amount of active stock ponds and associated average maximum surface areas as of 1963 for Navajo lands or private lands in the basin, and it is possible that the federal agencies in reporting average sizes for stock ponds were more nearly indicating a median or typical reservoir size for stock ponds that were active at the time.

3. Maximum Reservoir Depths. The average maximum depth for the 1,729 tributary livestock reservoirs claimed by the US Survey is about 5.2 feet. While there are several relatively deep reservoirs identified by the US Survey that have a significant impact on the average of the maximum depths claimed by the US Survey for livestock reservoirs, most of the reservoirs are claimed to be in the range of about 1 foot to 12 feet in depth at spillway crest. However, interpretation of maximum reservoir

[29] Pictures C-6 (for Impoundment No. P-0445), C-8 (for Impoundment No. P-0033), C-9 (for Impoundment No. P-0234), C-12 (for Impoundment No. P-1325), C-15 (for Impoundment Nos. P-5425, P-0103 and P-0104), C-16 (for Impoundment No. P-5345), C-17 (for Impoundment Nos. P-1414 and P-0378) and C-20 (for Impoundment Nos. P-1367, P-1368, P-1407 and P-1408) show several examples of claimed storage reservoirs that are breached and appear to have been breached for some time. Picture C-6 for Impoundment No. P-5388 also shows a small reservoir that: (1) was approximately 600 feet upstream from Impoundment No. P-5388; (2) may have had a surface area of an acre or so at one time but appeared to be silted and incapable of storing water; and (3) was not claimed by the US Survey. The US Survey does not document the condition (active, silted or breached) of each claimed storage reservoir. Also, the aerial imagery shown in picture C-21 for Impoundment No. P-0287 provides an example where the spillway location at the west edge of the reservoir appears to be misidentified by the stereo analyst, resulting in an overestimated maximum reservoir surface area.

depths by stereographically viewing digital orthophotos appears to be of limited precision or accuracy when attempting to interpret spillway and dam toe locations and elevations, and consequently, reservoir depths at spillway crest for shallow reservoirs. No general data are available for reservoir depths for stock ponds on Navajo lands in the San Juan River Basin in New Mexico from sources other than the US Survey.

The methodology used for the US Survey to estimate maximum depths for reservoirs at spillway crest as described in the Keller-Bliesner Report generally relied on: (1) measured depths for 415 reservoirs physically surveyed in the field at the identified spillway crest or overflow pipe elevation based on the maximum of the depths measured with respect to the elevation at the downstream toe of the dam or to the invert elevation (that is, the lowest elevation within the reservoir pool area); and (2) depths for 1,806 reservoirs estimated by stereographically viewing 2005 digital orthophotos to remotely interpret the locations and elevations of the spillway crest, the downstream toe of the dam and the invert including for 290 reservoirs for which the depths at spillway crest were measured in the field. Figure B-7 of Appendix B attached hereto shows a comparison of field measured depth at spillway crest determined from the reservoir invert elevation to field measured depth at spillway crest determined from the downstream dam toe elevation by reservoir type, excluding two NIIP off-channel livestock reservoirs that are supplied water from the San Juan River via the NIIP Canal. The available data seem to suggest that very shallow ponds, including water storage pits used to store pumped well water, may tend to have lower invert elevations than downstream dam toe elevations, perhaps as a result of excavation of material within the reservoir pool area to construct the dam. For reservoirs greater than a few feet deep at spillway crest, the downstream toe may tend to have lower elevations than invert elevations, on average. The US Survey to calculate storage volumes for the claimed reservoirs used the maximum of the depth determined with reference to the invert elevation or the depth determined with reference to the downstream toe elevation (whether those depths were the measured depths for those reservoirs surveyed in the field or were interpreted by stereo analysis for those reservoirs that were not surveyed in the field). Thus, the maximum depths based on either field measurements or stereo analysis interpretations may be overstated by using the elevations at the downstream toe of the dam, as opposed to at the upstream toe of the dam within the reservoir pool area, as a measure of the lowest elevation at the bottom of the reservoir. In some instances, however, current depth based on the invert elevation may not be representative of the original maximum reservoir depth due to sediment deposition within the reservoir pool area. Also, the maximum depths based on stereo analysis interpretations may be overstated by using the elevations along the dam crest to estimate spillway elevations for reservoirs for which ungated outlet pipes or culverts function as spillways and cannot be detected by stereo analysis interpretation, or for which small narrow or shallow spillways along the dam crest or at the edge of the dam may not be readily identified at the elevation scale of the orthophotos.

According to the Keller-Bliesner Report, no analysis was performed to verify the US Survey stereo analysis interpretations of maximum reservoir depths. The United States has not provided an analysis documenting a correlation between field measured reservoir depths and depths interpreted by stereo analysis. Thus, the maximum depths interpreted using stereo analysis cannot be assumed to reliably represent actual or relative depths at spillway crest or high water mark for many storage reservoirs on Navajo lands in the San Juan River Basin. Errors in using stereo analysis to interpret elevations at spillways or around the perimeters of reservoirs can also translate to errors in surface areas at spillway crest using the stereo analysis methodology.

Figures B-8(a) and B-8(b) show the relationship by reservoir type of US Survey field measured depths at spillway crest, measured as the maximum of the depths with respect to invert elevation or downstream dam toe elevation, to US Survey field measured area at spillway crest for 413 livestock and irrigation reservoirs that were field surveyed (excluding two NIIP off-channel reservoirs). The available data shown in figures B-8(a) and B-8(b) suggest that there is no correlation between field measured reservoir depths and field measured areas at spillway crest. A review of the available field survey data indicates that the average of the maximum depths at spillway crest for: (1) in-channel reservoirs outside the NIIP is about 4.87 feet based on measurements made at 292 reservoir sites, or at about 20 percent of the 1,447 total amount of claimed livestock and irrigation in-channel reservoirs outside the NIIP; (2) in-channel reservoirs within the NIIP is about 6.26 feet based on measurements made at 52 reservoir sites, or at about 63 percent of the 83 total amount of claimed livestock and irrigation in-channel reservoirs within the NIIP; (3) diversion reservoirs is about 5.53 feet based on measurements made at 18 reservoir sites, or at about 78 percent of the 23 total amount of claimed livestock and irrigation diversion reservoirs; and (4) well reservoirs is about 3.88 feet based on measurements made at 51 reservoir sites, or at about 22 percent of the 234 total amount of claimed livestock and irrigation well reservoirs. No field measurements were taken at any of the 26 livestock or irrigation reservoir sites with claimed off-channel reservoirs or at any of the 8 livestock or irrigation reservoir sites with claimed improved spring reservoirs. Overall, for all 413 of the reservoirs that were surveyed in the field, the average maximum depth measured by the US Survey was about 4.96 feet.

4. Reservoir Capacities at Spillway Crest. The methodology used for the US Survey to estimate capacities for reservoirs at spillway crest as described in the Keller-Bliesner Report generally relied on: (1) surface areas and maximum depths at spillway crest for 415 reservoirs physically surveyed in the field; (2) surface areas and maximum depths at spillway crest for 1,806 reservoirs interpreted remotely by stereographically viewing 2005 digital orthophotos, including for 290 reservoirs for which the surface areas at spillway crest were measured in the field; and (3) reservoir capacities at spillway crest computed as the maximum surface area at spillway crest, times the maximum depth at spillway crest, times an assumed average reservoir pool geometric shape factor of 0.6. According to the Keller-Bliesner Report, no field measurements were made of reservoir capacity at spillway crest for any of the reservoirs visited in the field, and no analyses were performed to calibrate or verify the average reservoir pool shape factor assumed by the US Survey or the reservoir capacity computations. A reservoir geometric shape factor of 0.6 could be representative of bowl-shaped reservoirs such as may exist for some on-farm irrigation ponds, shallow off-channel reservoirs, or ponds or pits filled from ground water wells. However, for reservoirs which are nearly wedge-shaped, such as many of the reservoirs located in stream channels, geometric shape factors may generally range from less than about 0.35 to about 0.45 or more depending upon the physical reservoir setting and reservoir bottom and side slopes. Most of the irrigation and livestock reservoirs claimed by the US Survey are in-channel storage reservoirs. The US Survey does not describe the pond geometry for each storage reservoir, and it can be expected that there is variation in shapes and geometry for irrigation and livestock reservoir pools on Navajo lands in the San Juan River Basin in New Mexico. Due to the large amount of storage reservoirs claimed by the US Survey and the large aerial extent of Navajo lands on which they are located, making measurements in the field of storage capacities for each storage reservoir claimed by the US Survey or negotiating a technically appropriate reservoir shape factor for each claimed reservoir based on field geometry at each site is not feasible in the short term.

The average storage capacity for the 1,729 tributary livestock reservoirs claimed by the US Survey is about 12.2 acre-feet; however, there are several rather large reservoirs identified by the US Survey that have a substantial impact on the average of the capacities claimed by the US Survey for livestock reservoirs (see table M-3 of the US Survey). By comparison, the average capacities for active stock ponds in the San Juan River Basin in New Mexico as of 1963 were 2.77 acre-feet for stock ponds on Navajo lands as reported by the BIA and 3.00 acre-feet for stock ponds on private lands as reported by the SCS (see OSE Memorandum dated February 27, 1964, from E.F. Sorensen to J.C. Yates on "Active Stock Ponds in New Mexico as of June 30, 1963"). Reasons for the differences in average stock pond capacities on Navajo lands in the basin between those reported by the BIA for 1963 conditions and those claimed by the US Survey may be due to a combination of factors, including: (1) the same factors creating differences in average surface areas for stock ponds on Navajo lands in the basin between those reported by the federal agencies for active stock ponds as of 1963 and those claimed by the US Survey as discussed above; (2) the factors that tend to create overestimates of maximum reservoir depths by the US Survey as described above; and (3) the US Survey's use of a conservatively high reservoir geometric shape factor of 0.6 to compute the storage capacities for each of the reservoirs claimed by the US Survey, which shape factor is likely to result in an overestimate of the total amount of storage capacity for all of the claimed reservoirs combined.

B. Summary of Tributary Livestock Reservoir Claims

1. General Description of US Survey Claims for Tributary Livestock Reservoirs. The US Survey includes historic and existing livestock reservoirs in New Mexico supplied from water sources other than the San Juan River within the drainages of ephemeral tributaries to the San Juan River. The US Survey at Appendix B and table M-3 of Appendix M identifies the claimed locations, maximum surface areas and spillway crest capacities for 1,729 livestock reservoirs on Navajo lands in the basin in New Mexico. Water rights for the stock water reservoirs or ponds identified in table M-3 of the US Survey are included in the Proposed Supplemental Decree; except, that rights for storage of water in Impoundment Nos. P-5346 and P-5350, which are off-channel reservoirs filled from the NIIP Canal system, are not included in the Proposed Supplemental Decree because they are filled via diversions from the San Juan River. The evaporation depletions from Impoundment Nos. P-5346 and P-5350 are included within the depletion rights for the NIIP that are provided pursuant to paragraph 3(a) of the Proposed Decree.

Tables 16-18 attached hereto provide drainage and county summaries of the information provided in table M-3 of the US Survey for the livestock reservoirs by topographic quadrangle and water source classification for lands held in trust by the United States on behalf of the Navajo Nation, for lands held in fee by the Navajo Nation, and for lands allotted by the United States to members of the Navajo Nation, respectively. All of the identified livestock reservoirs are claimed for primary stock water uses, and Impoundment Nos. P-5092 (Berland Lake), P-5081 (Todacheene Lake) and P-0042 (Long Lake) are listed with recreation as a secondary use. The US Survey describes most of the livestock reservoirs as in-channel reservoirs, but several of the reservoirs are listed as off-channel reservoirs or reservoirs filled by diversions and many are listed as being supplied by wells. Evaporation from small steel tanks and troughs that are filled by developed springs or ground water withdrawals are not separated in the Proposed Supplemental Decree from: (1) the water rights proposed for livestock watering uses as described below; or (2) the ground water rights for domestic uses provided by paragraph 7 or the *de minimis* domestic use rights provided by paragraph 10 of the Proposed Decree.

2. Tributary Livestock Reservoir Surface Area Claims. The US Survey at table M-3 claims a combined total surface area at spillway crest of approximately 5,168 acres for 1,729 tributary livestock reservoirs, including reservoirs on the NIIP. Of this surface area, about 3,271 acres for 1,138 reservoirs are located on lands held by the United States in trust for the Navajo Nation, about 514 acres for 301 reservoirs are located on lands held by the Navajo Nation in fee, and about 1,383 acres for 290 reservoirs are located on lands allotted by the United States to individual members of the Navajo Nation (see tables 16-18).

3. Tributary Livestock Reservoir Storage Capacity Claims. The US Survey at table M-3 claims a combined total storage capacity at spillway crest of approximately 21,081 acre-feet for 1,729 tributary livestock reservoirs. Of this storage capacity, about 12,692 acre-feet for 1,138 reservoirs are located on lands held by the United States in trust for the Navajo Nation, about 1,794 acre-feet for 301 reservoirs are located on lands held by the Navajo Nation in fee, and about 6,594 acre-feet for 290 reservoirs are located on lands allotted by the United States to individual members of the Navajo Nation (see tables 16-18).

4. General Discussion of Livestock Reservoir Claims. The US Survey identified as historic uses a total of 1,657 stock ponds on Navajo lands, including on Navajo Nation trust lands, Navajo Nation fee lands and Navajo allotments, in the San Juan River Basin in San Juan and McKinley counties combined. The BIA reported that 1,625 stock ponds were active in 1980 on Navajo lands in San Juan County, of which an estimated 1,618 would be in the San Juan River Basin.[30] Active stock ponds are those reservoirs that are capable of storing most of the water for which it was constructed, and whose usefulness had not been lost due to the dam being breached or due to siltation of the storage capacity of the pond. The BIA also reported that 597 stock ponds were active in 1980 on Navajo lands in the basin in McKinley County. Thus, based on BIA records, about 2,215 stock ponds were active in 1980 on Navajo lands in the basin in San Juan and McKinley counties combined.[31] The US Survey does not indicate the current physical condition (active, breached or silted) of each of the claimed livestock reservoirs, and it is apparent from

[30] Based on a spreadsheet entitled "1980 Stockpond Evaporation," prepared by Brian Wilson and dated August 31, 1981 (OSE backup data to Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1980, Technical Report 44). The BIA reported that there were 1,640 active stock ponds on Indian lands in San Juan County in 1980, including 15 stock ponds on Ute Mountain Ute lands. About 0.5 percent of Indian lands in the county are in the Little Colorado River Basin, of which about 80 percent is Navajo grazing land (see "County Profile, San Juan County, New Mexico, Water Resources Assessment for Planning Purposes," prepared by the ISC and OSE, and dated 1975, tables 1 and 2). For this analysis, it was assumed that 99.6 percent of the stock ponds in San Juan County that were reported by the BIA were in the San Juan River Basin. Therefore, the number of BIA stock ponds in San Juan County that were in the San Juan River Basin and active as of 1980 was estimated at 1,633 ponds, of which 1,618 ponds were on Navajo lands.

[31] An earlier compilation of active stock ponds in the basin as of 1963 indicated that based on stock pond counts provided by the BIA and mapping of pond locations, there were a total of 725 active stock ponds on Indian lands in the San Juan River Basin at that time, including on Navajo lands, Jicarilla lands and Ute Mountain Ute lands in San Juan, McKinley, Rio Arriba and Sandoval counties combined (see OSE Memorandum dated February 27, 1964, from E.F. Sorensen to J.C. Yates on "Active Stock Ponds in New Mexico as of June 30, 1963"). Also, a tabulation on Irrigation Resources and Cost Estimates, New Mexico, attached to a letter from Firman H. Brown of the Navajo Service to B.R. Fryer dated May 28, 1937, reported for 1937 a total of 204 dirt tanks or stock ponds and a total of 184 tanks and troughs on Navajo lands in New Mexico. This information indicates substantial increases in active stock ponds on Indian lands in the basin between 1937 and 1963 and between 1963 and 1980, but the amounts of the increases that are due to acquisition of private lands with stock ponds either by the Navajo Nation or by the United States in trust on behalf of the Navajo Nation or Navajo allottees or that are due to construction of new ponds after 1937 or 1963 are not known.

available aerial imagery that some of the historic livestock reservoirs claimed by the US Survey have been breached and rendered ineffective for storing much water for periods of time historically.

Most of the tributary livestock reservoirs claimed by the US Survey are less than a few acres of maximum surface area estimated at spillway crest. Based on the note at the end of table M-3 of the US Survey, the claimed areas and capacities of the livestock reservoirs were surveyed by the United States using the methodology described by the Keller-Bliesner Report; except, that the capacity for Long Lake (Impoundment No. P-0042) was based on previously available documentation which is not described by the US Survey. Other than the area and capacity estimates presented in the US Survey for claimed historic tributary livestock reservoirs, little such information is available for livestock reservoirs on Navajo lands. Part A of table 21 provides a summary from tables 16-18 of the total surface area at spillway crest for Navajo livestock reservoirs claimed by the US Survey by land ownership status and county. Also shown in part A of table 21 for this discussion are total surface areas by land ownership status and county that are revised to exclude the claimed surface acres for specific reservoirs that the OSE for reporting water use has in the past included under small lake evaporation in the San Juan River Basin, as opposed to under stock pond evaporation (see, for example, "Water Surface Evaporation for 1985, Small New Mexico Reservoirs, Upper Colorado River Basin," backup data for New Mexico State Engineer Technical Report 46). Based on the revised total livestock reservoir surface areas for each county (excluding the small lakes specified), table 21 indicates that the overall average of the maximum surface areas at spillway crest for stock ponds on Navajo lands claimed by the US Survey is about 2.41 acres. By comparison, average maximum surface areas for stock ponds used by the OSE to account stock pond evaporation in the basin in New Mexico are 0.50 acre for active stock ponds on Navajo lands as reported by the BIA and 1.00 acre for active stock ponds on private lands as reported by the SCS (see OSE Memorandum dated February 27, 1964, from E.F. Sorensen to J.C. Yates on "Active Stock Ponds in New Mexico as of June 30, 1963").

Similarly, part A of table 22 attached hereto provides a summary from tables 16-18 of the total storage capacity at spillway crest for Navajo livestock reservoirs claimed by the US Survey by land ownership status and county. Also shown in part A of table 22 for this discussion are total capacities by land ownership status and county that are revised to exclude the claimed capacities for specific reservoirs that the OSE for reporting water use has in the past included under small lake evaporation in the San Juan River Basin, as opposed to under stock pond evaporation (see, for example, "Water Surface Evaporation for 1985, Small New Mexico Reservoirs, Upper Colorado River Basin," backup data for New Mexico State Engineer Technical Report 46). Based on the revised total livestock reservoir capacities for each county (excluding the small lakes specified), table 22 indicates that the overall average of the storage capacities at spillway crest for stock ponds on Navajo lands claimed by the US Survey is about 9.12 acre-feet. By comparison, average storage capacities for stock ponds in New Mexico previously reported by federal agencies include 2.77 acre-feet for active stock ponds on Navajo lands as reported by the BIA and 3.00 acre-feet for active stock ponds on private lands as reported by the SCS (see OSE Memorandum dated February 27, 1964, from E.F. Sorensen to J.C. Yates on "Active Stock Ponds in New Mexico as of June 30, 1963"). Both the surface areas and the capacities for livestock reservoirs on Navajo lands in the basin claimed by the US Survey exceed the average stock pond sizes previously reported by the BIA for Navajo lands and by the SCS for private lands in New Mexico by a factor of about three, plus or minus.

C. Summary of Tributary Irrigation Reservoir Claims

1. General Description of US Survey Claims for Tributary Irrigation Reservoirs. The US Survey includes historic and existing irrigation reservoirs in New Mexico supplied from water sources other than the San Juan River within the drainages of ephemeral tributaries to the river, principally within the Chaco River and Chinle Wash drainages. The US Survey at Appendix B and table F-3 of Appendix F identifies the claimed locations, maximum surface areas and spillway crest capacities for 95 irrigation reservoirs on Navajo lands in the basin in New Mexico. Water rights for the irrigation reservoirs or ponds identified in table F-3 of the US Survey are included in the Proposed Supplemental Decree; except, that a right for storage of water in Impoundment No. P-1380, which is part of the Hogback Canal delivery system, is not included in the Proposed Supplemental Decree because it is filled via diversions from the San Juan River. The evaporation losses from Impoundment No. P-1380 are included within the depletion rights for the Hogback-Cudei Irrigation Project that are provided pursuant to paragraph 3(e) of the Proposed Decree.[32]

Tables 27 and 28 attached hereto provide drainage and county summaries of the information provided in table F-3 of the US Survey for the other 94 irrigation reservoirs by topographic quadrangle and water source classification for lands held in trust by the United States on behalf of the Navajo Nation and for lands allotted by the United States to members of the Navajo Nation, respectively. The US Survey does not claim any irrigation reservoirs for lands held in fee by the Navajo Nation. All of the identified irrigation reservoirs are claimed for primary irrigation uses and secondary stock water uses, and Impoundment Nos. P-1162 (Chuska Lake) and P-0043 (Whiskey Lake) are listed with recreation as an additional secondary use. The US Survey describes many of the irrigation reservoirs as in-channel reservoirs, but several of the reservoirs are listed as off-channel reservoirs or reservoirs filled by diversions and several are listed as being supplied by wells. Several of the smaller reservoirs are on-farm ponds.

2. Tributary Irrigation Reservoir Surface Area Claims. The US Survey at table F-3 claims a combined total surface area at spillway crest of approximately 725 acres for 95 tributary irrigation reservoirs. Excluding Impoundment No. P-1380 because it is supplied water from the San Juan River via the Hogback-Cudei Irrigation Project, the adjusted claim for tributary irrigation projects amounts to a combined total surface area at spillway crest of approximately 709 acres for 94 tributary irrigation reservoirs in the drainages of ephemeral tributaries to the San Juan River. Of this surface area, about 592 acres for 83 reservoirs are located on lands held by the United States in trust for the Navajo Nation and about 117 acres for 11 reservoirs are located on lands allotted by the United States to individual members of the Navajo Nation (see tables 27 and 28). No tributary irrigation reservoirs are claimed for lands held by the Navajo Nation in fee.

3. Tributary Irrigation Reservoir Storage Capacity Claims. The US Survey at table F-3 claims a combined total storage capacity at spillway crest of approximately 11,742 acre-feet for 95 tributary irrigation reservoirs. Excluding Impoundment No. P-1380 because it is supplied water from the San Juan River via the Hogback-Cudei Irrigation Project, the adjusted claims for tributary irrigation

[32] Cutter Reservoir, a storage facility on the NIIP Canal that re-regulates diversions from Navajo Reservoir for deliveries on the NIIP and the authorized Navajo-Gallup Water Supply Project (NGWSP), is not identified as an irrigation reservoir in the US Survey. The storage rights for Cutter Reservoir are included within the diversion and depletion rights for the NIIP and the NGWSP that are provided pursuant to paragraphs 3(a) and 3(b), respectively, of the Proposed Decree.

reservoirs amount to a combined total storage capacity at spillway crest of approximately 11,392 acre-feet for 94 tributary irrigation reservoirs in the drainages of ephemeral tributaries to the San Juan River. Of this storage capacity, about 11,015 acre-feet for 83 reservoirs are located on lands held by the United States in trust for the Navajo Nation and about 377 acre-feet for 11 reservoirs are located on lands allotted by the United States to individual members of the Navajo Nation (see tables 27 and 28). No tributary irrigation reservoirs are claimed for lands held by the Navajo Nation in fee.

4. General Discussion of Irrigation Reservoir Claims. Only a few of the tributary irrigation reservoirs claimed by the US Survey are of significant capacity to supply much irrigation use, namely Impoundment Nos. P-1162 (Chuska Lake), P-0043 (Whiskey Lake) and P-0036 (Captain Tom Reservoir). Based on the note at the end of table F-3 of the US Survey, the claimed areas and capacities of the irrigation reservoirs were estimated by the United States using the methodology described by the Keller-Bliesner Report; except, that the capacities for Chuska Lake (Impoundment No. P-1162) and Whiskey Lake (Impoundment No. P-0043) were based on previously available documentation which is not described by the US Survey. Other than the data for area and capacity at spillway crest presented in the US Survey for claimed historic tributary irrigation reservoirs, little data is available for irrigation reservoirs on Navajo lands. However, significantly different reservoir statistics have been reported for Chuska Lake, Whiskey Lake and Captain Tom Reservoir by various sources.[33]

Some of the tributary irrigation reservoirs claimed by the US Survey may have been breached or seldom utilized to capacity historically. No data are available for the tributary irrigation reservoirs documenting actual historic storage conditions; except, that BIA annual crop reports for several of the tributary irrigation projects available for the period 1936-1959 noted for some projects and years that there was insufficient water in storage to provide irrigation water or that little or no spring snowmelt runoff from the Chuska Mountains was available to store in reservoirs. Also, little information is available regarding the operation or effectiveness of a few of the larger irrigation reservoirs, though the ability to capture water for storage in Captain Tom Reservoir is limited based on the availability of stream flow in, and the diversion capacity of a canal from, Captain Tom Wash for diversion to the reservoir (the reservoir from an operational standpoint appears to be primarily an off-stream storage facility even though the US Survey lists it as an in-channel reservoir).

D. Proposed Storage Rights for Tributary Reservoirs

1. General Description of Proposed Storage Rights. The Proposed Supplemental Decree at paragraphs 3 and 4 includes rights for the Navajo Nation to fill and refill each tributary livestock or irrigation

[33] Reported reservoir statistics (at spillway crest) for Chuska Lake, Whiskey Lake and Captain Tom Reservoir vary as follows:

	US Survey		Navajo Nation DWR*		1986 SCS Inventory	
Reservoir	Maximum Area (acres)	Capacity (acre-feet)	Maximum Area (acres)	Capacity (acre-feet)	Original Capacity (acre-feet)	Capacity as of 1986 (acre-feet)
Chuska Lake	101	1,200	83	3,345	1,500	1,200
Whiskey Lake	224	8,000	100	7,458	1,000	900
Captain Tom Reservoir	98	1,056	75	1,170	1,020	800

* "Draft Water Resource Development Strategy for the Navajo Nation," prepared by the Navajo Nation Department of Water Resources and dated April 6, 2008 (table 3.2).

storage reservoir claimed by the US Survey on Navajo Nation trust lands and Navajo Nation fee lands, respectively, to the existing capacity, or if breached to the capacity that would exist if the dam breach was repaired, as often as water is available from the historic water source.[34] However, based on the review of the US Survey storage reservoir claims described above, it is evident that the claimed surface areas and capacities at spillway crest for livestock and irrigation reservoirs on Navajo lands in the San Juan River Basin in New Mexico cannot be assumed to accurately reflect actual reservoir conditions at any given reservoir site, and therefore, additional analyses were needed to describe the elements of the reservoir storage rights for the Proposed Supplemental Decree. Also, the US Survey did not address evaporation rates or amounts for claimed tributary storage reservoirs.

The Proposed Supplemental Decree recognizes the reservoir sites identified by the US Survey as locations where reservoirs may store water but does not quantify a storage volume limit at any individual reservoir site. Instead, the Proposed Supplemental Decree includes the following conditions for storage of water diverted by the Navajo Nation from sources other than the San Juan River in the ephemeral tributary drainages to the river. First, the Proposed Supplemental Decree at paragraphs 3 and 4 includes total annual evaporation depletion limits for all livestock reservoirs combined on Navajo Nation trust lands, for all livestock reservoirs combined on Navajo Nation fee lands, and for all irrigation reservoirs combined on Navajo Nation trust lands, each stated separately as to tributary drainage as specified therein. The proposed total annual evaporation depletion limits for storage reservoirs were determined as described below based on the adjusted reservoir maximum surface areas and storage volumes computed for livestock and irrigation reservoirs in tables E-2 and E-5, respectively, and summarized in tables 19 and 20 for livestock reservoirs and table 29 for irrigation reservoirs. To describe the bases for the reservoir storage evaporation depletion limits in terms of water storage, the adjusted reservoir storage volume computations were made for each claimed reservoir, and the results summed to derive the total storage volume amounts by drainage for both stock ponds and irrigation reservoirs.

Second, the Proposed Supplemental Decree at paragraph 12 includes a provision that would only allow a change in place of use or point of diversion for stock ponds if such change is within 1000 feet of the original place of use or point of diversion, respectively, as described by the US Survey and does not relocate the dam to a point below the confluence of the original water course with another water course. The Proposed Supplemental Decree would ensure that the purpose of use for Navajo tributary stock ponds shall not be changed, and that the stock ponds can only be reconstructed at or near their current locations without any opportunity to increase the amount of water supply available for filling them. Third, the Proposed Supplemental Decree at paragraph 5 includes, based on historic water supply availability, average annual depletion limits for all Navajo tributary water uses combined, exclusive of livestock watering uses, within each drainage area and a limit on the average annual depletion of San Juan River flow resulting from all uses described in the Proposed Supplemental Decree. These depletion limits, which consider for the reservoir storage uses on Navajo Nation lands the amounts of

[34] The Proposed Supplemental Decree includes tributary livestock or irrigation reservoir storage rights as federal reserved rights for those reservoirs located on land that is currently held by the United States in trust on behalf of the Navajo Nation. No attempt was made to determine which of the tributary livestock reservoirs on Navajo Nation trust lands may have been associated with state law rights developed before the land was acquired and placed into trust. State law storage rights are included in the Proposed Supplemental Decree for livestock reservoirs on lands currently held by the Navajo Nation in fee. The US Survey did not include any claims for irrigation reservoirs on lands held by the Navajo Nation in fee.

depletion associated with the historic high water mark area and average water storage levels within the high water mark area, are described below.

2. Methodology for Determining Reservoir Sizes. To compute adjusted reservoir storage volumes, the maximum surface areas for livestock and irrigation reservoirs were generally adjusted as follows: (1) the surface area at spillway crest measured in the field by the US Survey was used without adjustment for reservoirs that were surveyed in the field; (2) the OSE photo-interpreted high water mark area was used for reservoirs claimed by the US Survey to be greater than 8 acres and that were not surveyed in the field; and (3) the US Survey maximum surface area interpreted by stereo analysis was reduced by 5 percent for reservoirs claimed by the US Survey to be less than 8 acres and that were not surveyed in the field, based on the relationship of field measured reservoir area at spillway crest to stereo analysis interpreted maximum surface area for reservoirs claimed to be less than 8 acres shown in figure B-4(a) of Appendix B. These adjustments were made without regard to physical reservoir classifications such as in-channel, off-channel, diversion or well reservoirs. Also, the maximum reservoir depths were generally adjusted as follows: (1) the maximum depth at spillway crest measured in the field by the US Survey (based on the maximum of the depths measured with reference to the reservoir invert elevation and the downstream dam toe elevation) was used without adjustment for reservoirs that were surveyed in the field; and (2) the averages of the maximum depths by reservoir type for reservoirs that were surveyed in the field were used for reservoirs that were not surveyed in the field (4.9 feet for in-channel reservoirs outside the NIIP, 6.3 feet for in-channel reservoirs within the NIIP, 5.5 feet for diversion reservoirs and off-channel reservoirs, and 3.9 feet for well reservoirs and improved spring reservoirs). A reservoir shape factor of 0.4 was used to compute adjusted storage volumes for reservoirs classified by the US Survey as in-channel reservoirs, including in-channel reservoirs outside and within the NIIP area, and a reservoir shape factor of 0.6 was used to compute adjusted storage volumes for all other reservoirs claimed by the US Survey.[35] Exceptions to this approach were made for the few reservoirs claimed by the US Survey for which area-capacity tables or other data are available from the BIA, the US Bureau of Reclamation (USBR) or other sources.

The US Survey reservoir storage areas and capacities for each claimed livestock and irrigation reservoir are shown in tables E-1 and E-5 of Appendix E attached hereto, respectively. The computations of adjusted reservoir volumes for the claimed livestock and irrigation reservoirs are shown in tables E-2 and E-6 of Appendix E, respectively. In making these adjustments, the following claimed livestock reservoirs were tabulated as irrigation reservoirs because they historically supported irrigation uses in addition to stock uses: Naschitti Reservoir, Little White Cone Lake, Long Lake, Sheep Dip Reservoir, Bass Lake, and the White Rock Project reservoir. The area-capacity data available from the BIA or the USBR for select irrigation reservoirs are included in table E-6 and reviewed as needed in the notes at the end of table E-6. Tables E-3 and E-7 provide statistical summaries for livestock and irrigation reservoirs, respectively, comparing reservoir sizes claimed by the US Survey and the adjusted reservoir sizes estimated by the analysis described herein. Figures E-1 through E-3 show cumulative frequency distributions of claimed and adjusted values for maximum reservoir area, maximum depth and storage volume, respectively, for livestock reservoirs on Navajo lands in the San Juan River Basin. Figures E-4 through E-6 show cumulative frequency distributions of claimed and adjusted values for maximum reservoir area, maximum depth and storage volume, respectively, for irrigation reservoirs on Navajo lands in the basin.

[35] The Jicarilla Partial Final Decree includes storage volumes for reservoirs on the Jicarilla Apache Indian Reservation that were calculated based on an average reservoir shape factor of 0.40.

Parts B of tables 21 and 22 provide summaries from table E-2 of Appendix E of the averages of the adjusted maximum reservoir surface areas and adjusted maximum storage volumes, respectively, for Navajo livestock reservoirs claimed by the US Survey by land ownership status and county. Excluding the small lakes specified, parts B of tables 21 and 22 indicate that the overall averages of the adjusted maximum surface areas and volumes for stock ponds on Navajo lands claimed by the US Survey are about 1.73 acres and 3.61 acre-feet, respectively. The cumulative frequency distribution for the adjusted maximum reservoir surface areas that is shown in figure E-1 indicates that the median adjusted maximum surface area for the tributary livestock reservoirs claimed by the US Survey is about 0.85 acre, and that about 76 percent of the reservoirs are 2.0 acres or less in size. The cumulative frequency distribution for the adjusted maximum storage volumes that is shown in figure E-3 indicates that the median adjusted maximum volume for the tributary livestock reservoirs claimed by the US Survey is about 1.71 acre-feet, and that about 81 percent of the reservoirs are 5.0 acre-feet or less in size at spillway crest. The average and median adjusted maximum reservoir depths for claimed livestock reservoirs are 4.8 feet and 4.9 feet, respectively, with 95 percent of the reservoirs assumed to have a maximum depth of less than 7 feet at spillway crest (see table E-3 and figure E-2).

3. Storage Volumes for Tributary Livestock Reservoirs. Tables 19 and 20 attached hereto provide summaries of adjusted maximum storage volumes computed in table E-2 of Appendix E for the livestock reservoirs on lands held by the United States in trust on behalf of the Navajo Nation and on lands held in fee by the Navajo Nation, respectively, that are claimed by the US Survey, excluding two off-channel livestock reservoirs (Impoundment Nos. P-5346 and P-5350) that are assumed to be supplied water from the San Juan River via the NIIP Canal and six claimed livestock reservoirs that were instead included under irrigation reservoirs for purposes of the Proposed Supplemental Decree. Based on these computations, table 26 attached hereto shows by drainage the total storage volumes described in the Proposed Supplemental Decree as the bases for tributary livestock reservoir evaporation depletion rights: (1) on Navajo Nation trust lands within the San Juan River drainage above the Chaco River confluence, the Chaco River drainage, the San Juan River drainage below Chaco River the Chaco River confluence to Four Corners, and the Chinle Wash drainage; and (2) on Navajo Nation fee lands for the San Juan River drainage above the Chaco River confluence and the Chaco River drainage.

4. Storage Volumes for Tributary Irrigation Reservoirs. Table 29 attached hereto provides a summary of adjusted maximum storage volumes computed in table E-6 for the irrigation reservoirs on lands held by the United States in trust on behalf of the Navajo Nation that are claimed by the US Survey, excluding an irrigation reservoir (Impoundment No. P-1380) that is supplied water from the San Juan River via the Hogback Canal and including six claimed livestock reservoirs that were instead included under irrigation reservoirs for purposes of the Proposed Supplemental Decree. Based on these computations, table 31 attached hereto shows by drainage the total storage volumes described in the Proposed Supplemental Decree as the bases for tributary irrigation reservoir evaporation depletion rights on lands held by the United States in trust on behalf of the Navajo Nation within the Chaco River drainage, the San Juan River drainage below the Chaco River confluence to Four Corners, and the Chinle Wash drainage. The US Survey did not claim any irrigation reservoirs for lands held by the Navajo Nation in fee.

E. Proposed Evaporation Depletion Rights for Tributary Reservoirs

1. General. The total maximum annual reservoir evaporation depletion rights by drainage described in paragraphs 3 and 4 of the Proposed Supplemental Decree were derived assuming that all the tributary storage reservoirs claimed by the US Survey, including claimed reservoirs that presently are silted, breached or otherwise rendered ineffective in storing water, are actively storing water for livestock watering, irrigation or both; except, that two off-channel livestock reservoirs supplied from the NIIP Canal and one irrigation reservoir supplied from the Hogback Canal were excluded.[36] Further, it was assumed that water in storage in all livestock and irrigation reservoirs in the basin identified by the US Survey is maintained throughout the year at the levels of the adjusted maximum surface area and adjusted maximum storage volume for each reservoir determined in tables E-2 and E-6, respectively, of Appendix E. These assumptions take into account the proposed rights of the Navajo Nation to fill and maintain reservoir storage to capacity if sufficient water is available from existing sources to do so at each claimed reservoir site. However, the proposed total maximum annual evaporation depletion rights, including assumptions regarding maximum evaporative loss areas and annual evaporation rates used to calculate reservoir evaporation, should not be construed to in any way imply that all livestock or irrigation reservoirs in the basin identified by the US Survey actually do contain water in storage at the level of the spillway crest or high water mark at all times throughout the year, or that any particular reservoir on Navajo lands is operational or effective in storing water at present or at any other time. Based on historic surface water hydrology in the drainages of ephemeral tributaries to the San Juan River, local water supplies for livestock and irrigation reservoirs on Navajo lands in the San Juan River Basin in New Mexico are not sufficient to maintain full storage levels at each reservoir.

2. Tributary Reservoir Evaporation Rates. The SCS, in cooperation with the OSE and for the 1976 New Mexico Water Resources Assessment, prepared maps of New Mexico showing lines of equal annual gross lake evaporation for small reservoirs and of normal annual precipitation based on available climatological data and adjustments for physiographic factors (see figures 2 and 3 attached hereto). All of the Navajo tributary livestock and irrigation reservoirs claimed by the US Survey are considered small or shallow reservoirs. For evaluating evaporation from tributary reservoirs claimed by the US Survey, average gross annual lake evaporation and normal annual precipitation rates were estimated from the SCS maps shown in figures 2 and 3, respectively, for each map quadrangle identified in map B-1 of Appendix B to the US Survey. The gross lake evaporation rates were then reduced by normal annual precipitation to estimate net evaporation rates for small or shallow lakes and ponds on Navajo lands in the basin in each quadrangle. The resultant net reservoir evaporation rates for each quadrangle shown in table 23 attached hereto were used to estimate evaporation from tributary irrigation reservoirs in each quadrangle; except, that the net evaporation rates for Chuska Lake, Whiskey Lake, Captain Tom Reservoir and Long Lake were determined based on their specific locations rather than using the average net evaporation rates for their respective quadrangles.[37]

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[36] The proposed total annual evaporation depletion limits for tributary storage reservoirs for each drainage are solely for reservoir evaporation and do not include any depletion rights for livestock water consumption that could be supplied from the reservoirs. Depletion rights for livestock watering uses are described separately in the Proposed Supplemental Decree.

[37] Shallow reservoirs at high elevations in the Chuska Mountains (for example, Whiskey Lake at elevation 8895 feet) typically freeze over during all or part of the winter months of December-February, and thus the annual evaporation rates for free water surfaces may be reduced by up to a few percent for ice cover during the winter to estimate evaporation from a few high elevation reservoirs on Navajo lands in the basin. However, minor adjustments to evaporation rates for Navajo tributary lakes or ponds for winter ice cover are not included in this analysis.

3. Maximum Annual Evaporation Depletions for Livestock Reservoirs. Tables 24 and 25 attached hereto provide calculations of the maximum annual evaporation depletions for the livestock reservoirs on lands held by the United States in trust on behalf of the Navajo Nation and on lands held by the Navajo Nation in fee, respectively, that are claimed by the US Survey assuming each reservoir is full throughout the year to the level of the adjusted maximum reservoir surface area determined in table E-2 of Appendix E. The maximum annual evaporation losses were calculated by map quadrangle for livestock reservoirs filled from surface water, ground water or combined water sources, with livestock reservoirs within the NIIP area being segregated from reservoirs outside the NIIP area. The maximum annual reservoir evaporation depletion rights for livestock reservoirs on Navajo Nation trust lands in the San Juan River drainage above the Chaco River confluence, the Chaco River drainage, the San Juan River drainage below the Chaco River confluence to Four Corners, and the Chinle Wash drainage, and for livestock reservoirs on Navajo Nation fee lands in the San Juan River drainage above the Chaco River confluence and the Chaco River drainage, that are included in the Proposed Supplemental Decree are based on the appropriate total evaporation amounts for all livestock reservoirs in each drainage combined from tables 24 and 25, respectively, as shown in summary form in table 26.

4. Maximum Annual Evaporation Depletions for Irrigation Reservoirs. Table 30 attached hereto provides calculations of the maximum annual evaporation depletions for the irrigation reservoirs on lands held by the United States in trust on behalf of the Navajo Nation that are claimed by the US Survey assuming each reservoir is full throughout the year to the level of the adjusted maximum reservoir surface area determined in table E-6 of Appendix E. The maximum annual evaporation losses were calculated by map quadrangle for irrigation reservoirs filled from surface water, ground water or combined water sources. The maximum annual reservoir evaporation depletion rights for irrigation reservoirs on Navajo Nation trust lands in the Chaco River drainage, the San Juan River drainage below the Chaco River confluence to Four Corners, and the Chinle Wash drainage that are included in the Proposed Supplemental Decree are based on the appropriate total evaporation amounts for all irrigation reservoirs in each drainage combined from table 30 as shown in summary form in table 26.

F. Average Annual Reservoir Evaporation Depletions

1. General. The Proposed Supplemental Decree at paragraph 5 includes, based on historic water supply availability, ten-year average annual depletion limits for all Navajo tributary water uses combined, exclusive of livestock watering uses, within each drainage area and a limit on the average annual depletion of San Juan River flow resulting from all uses described in the Proposed Supplemental Decree. These depletion limits were determined, in part, based on estimates of average annual reservoir evaporation depletions associated with the livestock and irrigation reservoir storage rights described in paragraphs 3 and 4 of the Proposed Supplemental Decree after consideration of historic water supply availability to fill and refill reservoir storage. The calculations of average annual reservoir evaporation used to derive the depletion limits described in paragraph 5 of the Proposed Supplemental Decree assume that all the tributary storage reservoirs included by reference in paragraphs 3 and 4 are actively storing water for livestock watering, irrigation or both.[38]

[38] No attempt was made to identify any periods of time over which each claimed reservoir may have been inactive due to dam breaches or siltation. Also, this analysis should not be construed to imply that storage in all livestock or irrigation reservoirs on Navajo lands identified by the US Survey reaches the historic high water mark every year, or that any particular reservoir on Navajo lands is operational or effective in storing water at present or at any other time.

2. Average Reservoir Water Surface Areas. The OSE Hydrographic Survey and Mapping Bureau's review of maximum historic water surface areas based on photo-interpretation of high water mark for livestock and irrigation reservoirs claimed by the US Survey indicates that the reservoir areas at high water mark are significantly lower, on average, than the claimed spillway crest areas, and that the actual amount of water in storage at any time historically can be substantially less than either spillway crest capacity or volume at high water mark (see Appendix D).[39] For the purpose of calculating average annual reservoir evaporation based on historic water supply conditions, the maximum historic surface areas, or high water mark areas, for livestock and irrigation reservoirs were generally estimated as follows: (1) the OSE photo-interpreted high water mark area was used for the reservoirs for which high water mark area was interpreted by the OSE Hydrographic Survey and Mapping Bureau (see Appendix D); (2) the surface area at spillway crest measured in the field by the US Survey was reduced by approximately 60 percent overall for reservoirs that were surveyed in the field but not photo-interpreted by the OSE, based on the relationship of OSE photo-interpreted high water mark area to US Survey field measured area at spillway crest shown in figure B-5(b) of Appendix B; and (3) the US Survey surface area at spillway crest interpreted by stereo analysis was reduced by about 62 percent overall for reservoirs that were not surveyed in the field and were not photo-interpreted by the OSE, based on the relationship of OSE photo-interpreted high water mark area to US Survey stereo analysis area at spillway crest shown in figure B-6(d) of Appendix B. The computations of historic maximum surface areas used to estimate average annual reservoir evaporation for claimed livestock and irrigation reservoirs are shown in tables E-4 and E-8, respectively, of Appendix E.

To determine average reservoir water surface areas under normal water supply and normal operating conditions, the high water mark areas generally were adjusted by average fullness factors for stock ponds in each county that are used by the OSE to account stock pond evaporation, which fullness factors assume that water in storage typically ranges from about 30 percent to 40 percent full, on average.[40] Average surface areas for irrigation reservoirs, which primarily consist of small on-farm reservoirs or other small storage facilities used also for stock water purposes, generally were computed in the same manner as the surface areas for stock ponds. Pictures C-23 through C-25 of Appendix C, and photographs of Navajo tributary irrigation reservoirs shown in figures 11, 13, 16, 31 and 37 of the Ebert and Associates Report, indicate that, on average, small on-farm irrigation reservoirs also are likely dry or at relatively low storage levels as compared to high water mark much of the time. For reservoirs for which average or normal operating surface area data are available from the OSE or other sources (for example, for Long Lake shown in Picture C-26), the data from these sources were incorporated into the average water surface area estimates (see, for example, "Water Surface Evaporation for 1985, Small New Mexico Reservoirs, Upper Colorado River Basin," backup data for New Mexico State Engineer

[39] See also pictures C-1 through C-26 in Appendix C. Also, picture C-22 for Reservoir No. P-5147 illustrates a claimed reservoir site that for all appearances is probably dry most of the time even though a large tree or its shadow within the pond area could misleadingly appear on aerial imagery as a small round body of water.

[40] The OSE for past water use accounting of stock pond evaporation in the San Juan River Basin has applied these fullness factors to the average stock pond areas reported by the BIA and the SCS for 1963 (see "1980 Stockpond Evaporation," backup data for New Mexico State Engineer Technical Report 44, "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1980," prepared by Earl Sorensen in cooperation with the US Geological Survey, and dated May 1982). No information is available that would explain how the fullness factors were derived. No adjustments were made to the average fullness factors for their application herein to the maximum historic surface areas for stock ponds and irrigation reservoirs that are based on high water mark areas.

Technical Report 46). The computations of average water surface areas for the claimed livestock and irrigation reservoirs are shown in tables 24 and 25 for livestock reservoirs on Navajo Nation trust lands and Navajo Nation fee lands, respectively, and in table 30 for irrigation reservoirs on Navajo Nation trust lands.

3. Average Annual Livestock Reservoir Evaporation Depletions. Tables 24 and 25 provide calculations of average annual net evaporation losses for the livestock reservoirs on lands held by the United States in trust on behalf of the Navajo Nation and on lands held by the Navajo Nation in fee, respectively, based on the average water surface areas for the reservoirs and the net reservoir evaporation rates for each quadrangle as shown in table 23. The average annual net evaporation losses were estimated by quadrangle for livestock reservoirs filled from surface water, ground water or combined water sources, with livestock reservoirs within the NIIP area being segregated from reservoirs outside the NIIP area. The average annual net evaporation depletions resulting from the storage of water in these livestock reservoirs was included in determining the ten-year average at-site depletion limits for all Navajo tributary water uses on Navajo Nation trust lands and Navajo Nation fee lands in the San Juan River Basin in New Mexico combined, exclusive of livestock watering uses, described in paragraph 5(a) of the Proposed Supplemental Decree. To estimate the average annual depletion of San Juan River flow that could result from evaporation losses from Navajo livestock reservoirs on ephemeral tributaries to the river, the percentage depletion impact on river flow resulting from tributary reservoir evaporation in each quadrangle was assumed based on the distance of ephemeral channels between the reservoirs and the river (see figure 1). Based on this analysis, the average annual depletion of San Juan River flow resulting from evaporation losses that may occur from all claimed tributary livestock reservoirs on Navajo Nation trust lands and Navajo Nation fee lands combined is estimated at about 457 acre-feet (see table 26).

4. Average Annual Irrigation Reservoir Evaporation Depletions. Table 30 provides calculations of average annual net evaporation losses for the irrigation reservoirs on lands held by the United States in trust on behalf of the Navajo Nation based on the average water surface areas for the reservoirs and the net reservoir evaporation rates for each quadrangle as shown in table 23. The average annual net evaporation losses were estimated by quadrangle for irrigation reservoirs filled from surface water, ground water or combined water sources. The average annual net evaporation depletions resulting from the storage of water in these irrigation reservoirs was included in determining the ten-year average at-site depletion limits for all Navajo tributary water uses on Navajo Nation trust lands and Navajo Nation fee lands in the San Juan River Basin in New Mexico combined, exclusive of livestock watering uses, described in paragraph 5(a) of the Proposed Supplemental Decree. To estimate the average annual depletion of San Juan River flow that could result from evaporation losses from Navajo irrigation reservoirs on ephemeral tributaries to the river, the percentage depletion impact on river flow resulting from tributary reservoir evaporation in each quadrangle was assumed based on the distance of ephemeral channels between the reservoirs and the river (see figure 1); except, that the percentage depletion impact on river flow by evaporation from Captain Tom Reservoir was assumed to average approximately 35 percent, instead of 25 percent indicated by figure 1, because the reservoir may divert for storage a small but significant amount of water from Captain Tom Wash during periods of spring runoff from the Chuska Mountains when flows are reaching the river and prior to the irrigation season. Based on this analysis, the average annual depletion of San Juan River flow resulting from evaporation losses that may occur from all claimed tributary irrigation reservoirs on Navajo Nation trust lands combined is estimated at about 57 acre-feet (see table 31).

IV. LIVESTOCK WATER USE

A. United States' Description of Livestock Watering Uses on Navajo Lands

1. Water Right Claims for Livestock Watering. The US Claims at page 14 claims federal reserved water rights associated with historic, present and future livestock water consumption and associated water losses on lands in the San Juan River Basin in New Mexico held by the United States in trust for the Navajo Nation amounting to 1,173 acre-feet per year of diversion and 733 acre-feet per year of at-site depletion based on a maximum potential rangeland carrying capacity of 52,343 animal units (AU). An United States Government Memorandum on "NM vs. USA Potential Grazing Capacity," prepared by the Regional Rangeland Management Specialist and dated January 9, 2012, reported an updated maximum carrying capacity of 50,775 AU for rangeland within Navajo Nation trust lands in the basin. The US Survey at pages 16-17 states that: (1) the BIA estimates that 24,893 AU are currently engaged in grazing on 10 range units on Navajo lands within the San Juan River Basin in New Mexico (with sheep accounted as ¼ of an AU per head); (2) there are 650 wells, 138 springs, and surface water sources that serve livestock uses; and (3) the United States claims federal reserved water rights associated with historic and present livestock watering for livestock grazed on lands held by the United States in trust for the Navajo Nation amounting to 485 acre-feet per year of diversion and 304 acre-feet per year of at-site depletion (excluding the storage and evaporation of water from livestock reservoirs). The methodologies used by the United States to estimate livestock counts and livestock water use are described in "Navajo San Juan Livestock Water Requirements," prepared by Keller-Bliesner Engineering, LLC, and dated January 12, 2012 (Livestock Report). The United States' water claims for historic and existing livestock watering on Navajo Nation trust lands in the basin considered drinking water consumption by range animals, excluding livestock held at the cattle feedlot or sheep feedlot on the NIIP, and associated water losses from water trough evaporation and spills and from pipeline leaks (see Livestock Report, page 4).[41] Water rights for livestock water consumption on Navajo Nation trust lands and Navajo Nation fee lands in the basin in New Mexico from surface water sources other than the San Juan River or from ground water sources within the drainages of ephemeral tributaries to the San Juan River are included in the Proposed Supplemental Decree.[42]

2. Water Sources for Livestock Watering Uses. The sources of water for livestock watering on Navajo lands throughout the basin that are identified by the US Survey include: (1) ground water wells with stock water as the primary use listed in Appendix M, table M-1; (2) springs with stock water as the primary use listed in Appendix M, table M-2; (3) livestock reservoirs with stock water as the primary use listed in Appendix M, table M-3; (4) ground water irrigation wells listed in Appendix F, table F-1, for which stock water is claimed as a secondary use; (5) irrigation springs listed in Appendix F, table F-2, for which stock water is claimed as a secondary use; (6) irrigation reservoirs listed in Appendix F, table F-3, for which stock water is claimed as a secondary use; and (7) Morgan Lake (Impoundment No. P-0016) listed in Appendix K, table K-1, for which stock water is claimed as a secondary use. Morgan Lake is supplied water from the San Juan River via diversions under State Engineer Permit No. 2838 held by BHP-Billiton.

[41] Neither the United States nor the Navajo Nation quantified diversion or depletion claims for water rights under state law for livestock watering uses by range animals grazed on Navajo Nation lands held in fee.

[42] Small amounts of water use by domestic stock may be made under the ground water rights for domestic uses provided by paragraph 7 or the *de minimis* domestic use rights provided by paragraph 10 of the Proposed Decree.

B. Historic Head of Livestock

1. Sources of Livestock Head Count Data. Head counts for livestock in New Mexico by county are available periodically for census years from the "US Census of Agriculture" prepared by the US Department of Commerce through 1992 and the US Department of Agriculture (USDA) beginning 1997 (Census), and are available annually beginning 1960 from "New Mexico Agricultural Statistics" reports prepared by the New Mexico Department of Agriculture and New Mexico State University (Agricultural Statistics). The Census reports include data every four to five years beginning 1930 on numbers of cattle, milk cows, sheep and lambs, horses and mules, and other livestock by county, and the annual Agricultural Statistics reports include data on all cattle, milk cows, sheep and lambs, and other livestock by county.[43] For years for which the Census is published, the Agricultural Statistics for that year and for the following year for numbers of cattle, milk cows, and sheep and lambs by county may differ from those given in the Census, but it does not appear that the differences would significantly affect the calculation of livestock water consumption over time.

2. Head of Livestock in the San Juan River Basin by County. Table 32 attached hereto provides estimated numbers of head of beef cattle, sheep and horses in San Juan and McKinley counties for years of available data from the Census reports prior to 1960 and for each year beginning 1960 from the Agricultural Statistics reports. Rio Arriba and Sandoval counties are not included in this analysis of historic livestock numbers because there is relatively little Navajo grazing land in these two counties and the BIA reported that there were no stock ponds or tanks in service on Navajo lands in Rio Arriba or Sandoval counties as of 1980 (see "1980 Stockpond Evaporation," backup data for New Mexico State Engineer Technical Report 44, "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1980," prepared by Earl Sorensen in cooperation with the US Geological Survey, and dated May 1982).

It was assumed that 99.8 percent of all livestock in San Juan County, on average, were within the San Juan River Basin based on the percentages of grazing lands and total area in the county that are in the basin, as opposed to in the Little Colorado River drainage (see "County Profile, San Juan County, New Mexico, Water Resources Assessment for Planning Purposes," prepared by the ISC and the OSE, and dated 1975, table 1).[44] For McKinley County, it was assumed that 26.5 percent of beef cattle, 40.6 percent of sheep and 17.8 percent of horses in the county, on average, were within the basin based on the livestock distribution for 1970 developed by the OSE from available livestock data (see map of "Distribution of Livestock in Counties and River Basins in 1970," backup data for New Mexico State Engineer Technical Report 44, "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1980," prepared by Earl Sorensen in cooperation with the US Geological Survey, and dated May 1982). Table 32 shows the resultant estimated numbers of beef cattle, sheep and horses within each county that were in the basin historically.

[43] The Census was prepared decennially from 1840 to 1930. For purposes of this analysis, livestock data for years prior to 1930 were not included. The Agricultural Statistics data is for January 1, while some of the Census data for the latter census years appears to be for December 31.

[44] The OSE in its tabulations of livestock water uses in the San Juan River Basin assumes that all livestock in San Juan County are in the San Juan River Basin (see map of "Distribution of Livestock in Counties and River Basins in 1970," backup data to State Engineer Technical Report 44).

3. Head of Livestock on Navajo Lands. Direct data on historic livestock counts specifically for Navajo lands in the San Juan River Basin are not available to the OSE. For 1980 in San Juan County, the BIA reported that about 1,640 stock ponds and tanks were actively in service on Indian lands (1,625 on Navajo lands and 15 on Ute Mountain Ute lands), the Bureau of Land Management (BLM) reported that about 379 stock ponds and tanks were in service on lands that it manages, and the SCS reported that about 217 active stock ponds and tanks were in service on private lands (see "1980 Stockpond Evaporation," backup data for New Mexico State Engineer Technical Report 44, "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1980," prepared by Earl Sorensen in cooperation with the US Geological Survey, and dated May 1982). Thus, about 73 percent of all stock ponds and tanks in San Juan County that were reported to be in service in 1980 were on Navajo lands. For purposes of this analysis, it was assumed that the distribution of livestock grazing within the San Juan River Basin in San Juan County has historically been somewhat proportional to the distribution of active stock ponds within the basin and county, and that therefore, approximately 73 percent of beef cattle, sheep and horses within the basin and the county, on average, may have been on Navajo lands.

For 1980 in McKinley County, the BIA reported that about 597 stock ponds and tanks were actively in service on Indian lands (507 on Navajo lands, including some in the Little Colorado River drainage, and 90 on Zuni lands or Ramah Navajo lands in the Little Colorado River drainage), the US Forest Service reported that about 57 stock ponds and tanks were actively in service on forest service lands in the Little Colorado River drainage, the BLM reported that about 40 stock ponds and tanks were in service on lands that it manages in the San Juan or Little Colorado river drainages, and the SCS reported that about 1,035 active stock ponds and tanks were in service on private lands in the San Juan or Little Colorado river drainages (see "1980 Stockpond Evaporation," backup data for New Mexico State Engineer Technical Report 44, "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1980," prepared by Earl Sorensen in cooperation with the US Geological Survey, and dated May 1982). It was reported that of the 1,729 active stock ponds and tanks in McKinley County in 1980, about 771 of them were in the San Juan River Basin. Thus, less than 66 percent of all stock ponds and tanks in the basin in McKinley County that were reported to be in service in 1980 were on Navajo lands. For purposes of this analysis, it was assumed that the distribution of livestock grazing within the San Juan River Basin in McKinley County has historically been somewhat proportional to the distribution of active stock ponds within the basin and county, and that therefore, approximately 60 percent of beef cattle, sheep and horses within the basin and the county, on average, may have been on Navajo lands.

Table 32 shows the resultant estimates of historic numbers of head of beef cattle, sheep and horses on Navajo lands within the San Juan River Basin in San Juan and McKinley counties. Based on these estimates, about 63,000 AU may have been on Navajo lands in the basin as of 1930, about 38,000 AU to 47,000 AU may have been on Navajo lands in the basin during most years of the period 1959-2001, about 24,000 AU to 28,000 AU may have been on Navajo lands in the basin during the period 2003-2007, and about 30,000 AU may have been on Navajo lands in the basin during 2008 and 2009 (with each head of beef cattle and horses accounted as 1 AU and each head of sheep accounted as ¼ of an AU). The estimated historic numbers of head of livestock on Navajo lands in the basin were not segregated between Navajo Nation trust lands, Navajo Nation fee lands, or Navajo allotment lands.

4. Discussion of Historic Livestock Watering Animal Unit Claim. The US Survey claims that based on BIA estimates, a total of 24,893 AU are currently engaged in grazing on Navajo lands within the San Juan River Basin in New Mexico (with each head of beef cattle and horses, including also mules, burros and donkeys, accounted as 1 AU and each head of sheep, including also goats, accounted generally as ¼ of an AU). However, the Livestock Report at page 4 indicates that livestock grazed on Navajo Nation trust lands, Navajo Nation fee lands and Navajo allotments combined in 2009 amounted to 24,872 AU. These AU estimates for Navajo lands in the basin were derived from BIA Natural Resource Office data on the amount of permitted sheep units for Navajo lands in each of ten Navajo grazing districts in the basin in New Mexico for 2009, with the AU calculated for some grazing districts using a conversion factor of 4 sheep units to 1 AU and for other grazing districts using a conversion factor of 5 sheep units to 1 AU. By comparison, the historic head of livestock on Navajo lands within the basin in San Juan and McKinley counties combined for 2009 was estimated at about 30,224 AU based on the Agricultural Statistics data (see table 32). For the analysis of historic AU on Navajo lands in the basin provided in table 32, no adjustments were made to the historic total livestock head count data for San Juan County published in the Agricultural Statistics for the amount of livestock that were held at the cattle feedlot or the sheep feedlot on the NIIP.

C. Historic Livestock Water Use Depletions

1. Livestock Water Requirements. To account livestock watering depletions in New Mexico, the OSE currently uses average livestock water use rates of 10 gallons per capita per day (gpcd) for beef cattle, 2.2 gpcd for sheep and 13 gpcd for horses (see "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 2000," State Engineer Technical Report 51, prepared by Brian Wilson, et al., and dated February 2003, pages 46-53).[45] These water use rates include drinking water consumption and miscellaneous water losses relating to washing animals or equipment, controlling waste or dust, and evaporation or overflow from watering tanks and troughs.

The average water use rate for beef cattle in New Mexico of 10 gpcd used by the OSE was determined based on a study of metered water deliveries over a period of eleven months to a feedlot in Texas, at which the water use over the eleven months averaged about 7.0 gpcd and ranged from 4.2 gpcd during the winter months to 10.3 gpcd during the summer months. Based on this study, the OSE determined an average water requirement of 9.2 gpcd for drinking water for cattle in New Mexico based on an estimated amount of dry feed consumed and the average weight of a steer in New Mexico in 1990, plus an additional requirement for about 0.8 gpcd for trough water losses. Cattle grazing on range grasses or irrigated pasture may at times require less drinking water, on average, than feedlot cattle that are fed dried matter, and evaporative losses from stock ponds (excluding small steel tanks and troughs) are accounted under stock pond evaporation. Cattle may require more drinking water, however, than feedlot cattle when having to roam extensively in search of feed and water (see Livestock Report, page 2). The Navajo Nation Veterinary Program estimated the average drinking requirement for cattle on the Navajo Reservation to be about 2.5 gpcd during the winter months and 12 gpcd during the summer months, but

[45] The OSE for estimating water use by livestock in New Mexico in the past used water use rates of 10 gallons per capita per day (gpcd) for beef cattle and horses and 2 gpcd for sheep, which rates were general water use rates for most other states in the country obtained from a report entitled "Estimated Use of Water in the United States," US Geological Survey Circular 556, dated 1965 (see OSE Memorandum on "Water Requirements for Livestock in New Mexico in 1965," prepared by Earl Sorensen and dated January 1971, page 2; and see OSE Memorandum on "Water Requirements for Livestock and Stock Ponds in New Mexico in 1970 and Projected for 1980, 2000 and 2020," prepared by Earl Sorensen and dated August 1972, table 2).

notes also that more water is required when mineral blocks are available, when temperatures are extremely hot, to fatten livestock, and during growth, pregnancy and lactation (see undated slide from a presentation on "Livestock Management During Drought Conditions," prepared by the Navajo Nation Veterinary and Livestock Program). For purposes of this analysis, it was assumed that the per capita average annual water use rate for beef cattle on Navajo lands in the San Juan River Basin in New Mexico is about 10 gpcd.[46]

The average water use rate for sheep in New Mexico of 2.2 gpcd used by the OSE is based on information published by the SCS and the USDA. The Navajo Nation Veterinary Program estimates the average drinking requirement for sheep on the Navajo Reservation to be about 1 gpcd during the winter months and 2 gpcd during the summer months, but notes also that more water is required when temperatures are extremely hot, to fatten livestock, and during growth, pregnancy and lactation (see undated slide from a presentation on "Livestock Management During Drought Conditions," prepared by the Navajo Nation Veterinary and Livestock Program). For purposes of this analysis, it was assumed that the per capita average annual water use rate for sheep on Navajo lands in the San Juan River Basin in New Mexico is about 2 gpcd.[47]

The average water use rate for horses in New Mexico of 13 gpcd used by the OSE is based on general information indicating average per capita water requirements for horses of 12 gpcd for drinking water and 1 gpcd for miscellaneous cleaning and losses. The Navajo Nation Veterinary Program estimates the average drinking requirement for horses on the Navajo Reservation to range from 5 gpcd to 12 gpcd at any time of the year, but notes also that more water is required when temperatures are extremely hot, and during growth, pregnancy and lactation (see undated slide from a presentation on "Livestock Management During Drought Conditions," prepared by the Navajo Nation Veterinary and Livestock Program). For purposes of this analysis, it was assumed that the per capita average annual water use rate for horses on Navajo lands in the San Juan River Basin in New Mexico is about 12 gpcd.[48]

2. Consumptive Use of Water by Livestock on Navajo Lands. Table 32 provides estimates of historic water consumption by beef cattle, sheep and horses on Navajo lands in the San Juan River Basin in New Mexico, assuming that the entire annual livestock water requirement was consumptively used each year from sources in the basin. It also was assumed for purposes of this analysis that the total amount of incidental depletions associated with evaporation and spills from steel tanks and troughs and from pipe leaks at wells, windmills and developed springs (excluding stock pond evaporation) averages an amount equivalent to approximately 14 percent of the total amount of livestock water consumption on Navajo

[46] By comparison, the US Survey assumed that the average annual water use rate for cattle on Navajo Nation trust lands in the San Juan River Basin in New Mexico is 12.5 gpcd based on monthly water requirements reported by the North Dakota State University Extension Service ranging from about 8.5 gpcd during mid-winter to 20.2 gpcd during mid-summer for 1,000-pound beef cows (see Livestock Report, page 4 and Appendix B). The Jicarilla Partial Final Decree includes water rights for the Jicarilla Apache Tribe for livestock and wild game watering uses in the basin that were determined using an average water use rate of 15 gallons per AU per day.

[47] By comparison, the US Survey assumed that the average annual water use rate for sheep on Navajo Nation trust lands in the basin in New Mexico is 3 gpcd, or about ¼ the average annual water use rate assumed by the US Survey for cattle (see Livestock Report, page 4).

[48] By comparison, the US Survey, by applying its assumed average annual water use rate for cattle on Navajo Nation trust lands to each AU in the basin, implicitly assumed that the average annual water use rate for horses on trust lands in the basin in New Mexico is 12.5 gpcd.

lands in the basin.[49] This incidental depletion percentage is based on the following assumptions: (1) livestock watering uses are distributed in proportion to the distribution of potential stock water sources claimed by the US Survey; (2) the average incidental loss rate is equivalent to 40 percent of livestock water consumption for stock water uses at wells and developed springs on Navajo lands in the basin claimed by the US Survey with stock water as a primary or secondary purpose (a total of 839 wells and springs combined); and (3) there are no such incidental depletions for stock water uses at reservoirs on Navajo lands in the basin claimed by the US Survey with stock water as a primary or secondary purpose (a total of 1,568 reservoirs supplied solely from surface water sources, excluding springs and wells).[50] Based on this analysis, historic annual livestock watering depletions on Navajo lands in the basin may have amounted to about 690 acre-feet in 1930, ranged from about 450 acre-feet to 550 acre-feet during most years of the period 1959-2001, ranged from about 305 acre-feet to 360 acre-feet during the period 2003-2007, and was about 380 acre-feet during 2008 and 2009. These estimates of historic livestock watering depletions assume that sufficient water was historically available to fully supply all livestock watering demands over time even though the potential amount of water sources (reservoirs, stock wells and developed stock springs) per AU has increased substantially over time due to increased stock pond, well and spring development and decreased herd sizes since the 1930s. Also, these estimates of historic depletions are for livestock watering uses on all Navajo lands, including Navajo Nation trust lands, Navajo Nation fee lands and Navajo allotments; except, that small amounts of livestock watering uses on Navajo lands in the basin in Rio Arriba and Sandoval counties were omitted. No adjustments were made for livestock watering uses at the cattle feedlot or the sheep feedlot on the NIIP that were supplied from the San Juan River.

3. Discussion of Historic Livestock Water Use Depletion Claim. The US Survey based on 2009 forage allocation permits within Navajo Nation grazing districts estimated that 21,674 AU were engaged in grazing on lands held by the United States in trust for the Navajo Nation in the San Juan River Basin in New Mexico during 2009, and that the associated historic and present livestock watering for livestock grazed on Navajo Nation trust lands amounts to 485 acre-feet per year of diversion and 304 acre-feet per year of at-site depletion. The claimed depletion amount was based on an assumed average annual water consumption rate of 12.5 gallons per AU per day (see Livestock Report, page 4). Based on the US Survey claim that a total of 24,893 AU are presently grazed on Navajo lands in the basin, about 3,219

[49] The Livestock Report at page 4 claims that the water use efficiency of diversions for livestock watering for each AU is about 60 percent due to evaporation, spills and other losses. The Livestock Report does not indicate the basis for this water use efficiency value. Although the BIA reports that diversions from wells and developed springs into steel tanks and troughs may be primary water sources for livestock water consumption on Navajo lands in the basin, much of the drinking water for livestock on Navajo lands is supplied from stock ponds, irrigation reservoirs or natural surface water sources without diversions into steel tanks or troughs. Evaporation losses from stock ponds and irrigation reservoirs on Navajo lands in the basin are accounted separately. While incidental losses from diversions from wells or springs to reservoirs, tanks or troughs may average approximately 40 percent where they are used, it is not clear that this diversion efficiency applies to the full per-capita usage rate for every AU even though water may be maintained in some tanks when livestock in nearby areas are drinking water from stock ponds. Also, for purposes of this analysis, it was assumed that all livestock watering diversions, including spills from tanks and troughs and leaks from pipes onto the land surface, are fully depleted.

[50] The US Survey claims for all Navajo lands in the basin combined a total of 650 stock wells, 28 irrigation wells with stock water as a secondary use, 15 domestic water supply wells with stock water as a secondary use, 139 developed stock springs, and 7 developed irrigation springs with stock water as a secondary use (see US Survey, tables D-2, F-1, F-2, M-1 and M-2). The US Survey also claims for all Navajo lands in the basin combined a total of 1,488 livestock reservoirs and 80 irrigation reservoirs with stock water as a secondary use, excluding reservoirs supplied from wells, improved springs or combined water sources (see tables 16-17 and 22-24).

AU may be grazed at present on Navajo Nation fee lands or Navajo allotments in the basin with an associated annual at-site water consumption of about 45 acre-feet per year estimated using the US Survey average water consumption rate of 12.5 gallons per AU per day. This would give: (1) a total annual water consumption by livestock on Navajo lands in the basin of about 349 acre-feet per year, which is greater than the recent amount of depletion by livestock watering uses on all Navajo lands in the basin estimated by the historic livestock water use analysis presented herein that relied on more conservatively low water use rates for livestock as compared to the US Survey; and (2) a total average annual depletion under present grazing conditions of about 398 acre-feet per year for livestock watering uses including incidental depletions averaging about 14 percent of the annual water consumption demand on all Navajo lands in the basin, which is less than the average of the estimated historic annual at-site livestock watering depletion on Navajo lands in the basin prior to 2002.[51] The reduction in livestock counts in the basin in 2003 was likely a result of severe and prolonged drought in the basin beginning in 2002.

4. Depletions of San Juan River Flow by Livestock Watering Uses. Depletions of San Juan River flow by small amounts of livestock water consumption scattered throughout ephemeral tributary areas in the San Juan River Basin in New Mexico are less than the livestock watering depletions at the sites of use by the amounts of salvage of downstream channel losses on the ephemeral tributaries that result from the livestock watering uses. The following data were used to estimate the percentage depletion impact on San Juan River flows resulting from scattered livestock watering uses on Navajo lands in the basin. The Livestock Report at page 4, table 2, provides estimates of the AU on all Navajo lands in the basin in New Mexico, and of the AU on Navajo Nation trust lands in the basin, by Navajo grazing district for 2009, which estimates were derived from BIA Natural Resource Office data on the amount of permitted sheep units for Navajo lands in each district. A map showing the Navajo grazing districts within the basin in New Mexico is provided in the Livestock Report at page 3, and the grazing district boundaries were superimposed on figure 1 attached hereto that shows assumed percentage depletion impacts on San Juan River flows of surface water uses in each map quadrangle. To estimate weighted average percentage depletion impacts on San Juan River flows resulting from livestock watering uses on Navajo Nation trust lands within each grazing district, the permitted AU for Navajo Nation trust lands in each district were assumed to be geographically distributed by quadrangle in proportion to the number of potential stock water sources on trust lands within each quadrangle claimed by the US Survey (see Appendices D, F and M of the US Survey). Potential stock water sources include claimed livestock and irrigation reservoirs in the basin, claimed wells and developed springs in the basin that may supply stock water, and natural lakes or intermittent ponds along the Chuska Mountains. Wells supplying water to claimed livestock or irrigation reservoirs were not included so as to avoid double-counting of potential water sources, and no reductions to numbers of potential water sources were made for reservoirs or wells that may be inactive at present. To estimate weighted average percentage depletion impacts on river flows resulting from livestock watering uses on Navajo Nation fee lands and Navajo allotments, the remaining AU for Navajo lands in each district were generally assumed to be geographically distributed by land status and quadrangle in proportion to the number of stock water sources on fee lands

[51] For present livestock watering uses on Navajo Nation trust lands, the US Survey claimed water rights for livestock diversions totaling 485 acre-feet per year, or 181 acre-feet per year greater than the claimed total amount of livestock water consumption. This amount of diversion in excess of livestock consumptive use was claimed to cover evaporation and spills from steel tanks and troughs and from pipe leaks at wells, windmills and developed springs (see Livestock Report, page 4). However, the US Survey did not claim any depletion that may be associated with said evaporation, spills and leaks. The United States has not demonstrated that any livestock watering diversions in excess of drinking water requirements return to the water source or the San Juan River stream system.

or allotments, respectively, within each quadrangle claimed by the US Survey (see Appendices D, F and M of the US Survey).

The resulting estimates for the weighted average percentage depletions of river flow resulting from livestock watering uses in the basin on Navajo Nation trust lands, Navajo Nation fee lands and Navajo allotments are shown in table 33 attached hereto.[52] For all livestock watering uses on Navajo lands in the basin combined, it was assumed based on this analysis that the weighted average depletion of San Juan River flow is about 19 percent of at-site livestock watering depletions (see table 33). By applying this assumption to the estimated historic annual livestock watering depletions on Navajo lands in the basin, it was estimated that the historic annual depletions of San Juan River flow resulting from livestock watering uses on Navajo lands in the basin could have ranged from about 85 acre-feet to 105 acre-feet for the period 1959-2001, and from about 60 acre-feet to 70 acre-feet during the period 2003-2009.

D. Proposed Water Rights for Tributary Livestock Watering

1. General. The analysis of historic livestock watering uses on Navajo lands in the San Juan River Basin presented herein and shown in table 32 generally indicates that a total of about 41,200 AU (average) to 47,000 AU (maximum) may have been on Navajo lands in the basin during the period 1959-2001, with the numbers of sheep generally declining and the numbers of cattle generally increasing over time during this period. The associated total annual at-site livestock watering depletions on all Navajo lands in the basin combined during the period 1959-2001 was estimated at about 494 acre-feet (average) to 553 acre-feet (maximum). The peak annual amounts of AU and livestock watering depletions on Navajo lands in the basin estimated to have occurred during the period 1960-1975 prior to commencement of water deliveries to the NIIP are about the same as the peak amounts of AU and livestock watering depletions, respectively, on Navajo lands in the basin estimated to have occurred after 1975. Based on the forage allocation permits within Navajo Nation grazing districts for 2009, it was assumed that of the combined livestock watering use estimated to have historically occurred on Navajo lands in the basin, about 87.1 percent occurred on Navajo Nation trust lands, 6.4 percent occurred on Navajo Nation fee lands and 6.5 percent occurred on Navajo allotments (see table 33). Application of these grazing distributions suggests that: (1) historic livestock uses on Navajo Nation trust lands between 1959 and 2001 may have approached about 35,900 AU (average) to 40,900 AU (maximum), with associated annual at-site livestock watering depletions of about 430 acre-feet (average) to 482 acre-feet (maximum); and (2) historic livestock uses on Navajo Nation fee lands between 1959 and 2001 may have approached about 2,600 AU (average) to 3,000 AU (maximum), with associated annual at-site livestock watering depletions of about 32 acre-feet (average) to 35 acre-feet (maximum). Annual variations in range conditions and associated grazing capacities for Navajo lands in the basin contribute to annual variations in permitted AU and livestock watering uses on Navajo lands.

The Proposed Supplemental Decree includes water rights for historic livestock watering on rangelands within Navajo Nation trust lands and Navajo Nation fee lands in the basin from tributaries to the San Juan River, including from stock ponds within the NIIP, and from ground water sources based on this analysis. However, any livestock watering uses at the cattle feedlot or the sheep feedlot on the NIIP that

[52] Other than the water supply available for livestock from off-channel livestock or irrigation reservoirs filled by stream diversions, this analysis did not consider the availability of water from streams and canals from which water would be available also to meet livestock watering demands on Navajo lands in the basin.

are supplied water from the San Juan River via the NIIP Canal are accountable against the diversion and depletion rights for the NIIP under paragraph 3(a) of the Proposed Decree, any livestock watering uses supplied water from public water supply systems may be accounted against the Navajo Nation's domestic use water rights provided by paragraphs 3 or 7 of the Partial Final Decree, and any residential livestock watering uses supplied from residential domestic use wells may be accounted against the ground water rights for domestic uses provided by paragraph 7 or the *de minimis* domestic use rights provided by paragraph 10 of the Partial Final Decree. The Proposed Supplemental Decree does not include any water rights for the Navajo Nation for livestock watering on Navajo allotments.

2. Reserved Water Rights for Navajo Nation Livestock Watering. The Proposed Supplemental Decree includes federal reserved water rights for livestock watering for range animals on Navajo Nation trust lands in the San Juan River Basin totaling 482 acre-feet of annual diversion and depletion based on 40,900 AU. No attempt was made to determine which grazing areas on Navajo Nation trust lands may first have been developed for livestock watering under state law rights prior to the land being acquired and placed into trust. The annual depletion of San Juan River flow resulting from livestock watering on Navajo Nation trust lands may be anticipated to be about 101 acre-feet assuming that the depletion of river flow due to livestock watering on Navajo Nation trust lands in the basin averages about 21 percent of the total at-site depletions (see table 33).

3. State Law Water Rights for Navajo Nation Livestock Watering. The Proposed Supplemental Decree includes state law water rights for livestock watering for range animals on Navajo Nation fee lands totaling 3,000 AU with associated annual diversion and depletion rights of 35 acre-feet. All state law water rights of the Navajo Nation for livestock watering are proposed with a single priority date, and no attempt was made to determine individual priority dates for each tract of land acquired by the Navajo Nation in fee. The annual depletion of San Juan River flow resulting from livestock watering on Navajo Nation fee lands may be anticipated to be about 1 acre-foot assuming that the depletion of river flow due to livestock watering on Navajo Nation fee lands in the basin averages about 2 percent of the total at-site depletions (see table 33).

V. INDUSTRIAL WATER USES

The US Survey at Appendix L, table L-1 and maps L-1 through L-3, identified past and present heavy industrial water uses on Navajo lands in the San Juan River Basin in New Mexico. Of these claimed industrial water uses, the Proposed Supplemental Decree includes water rights for the Navajo Nation under state law for diversion and depletion of 86 acre-feet of ground water annually under OSE File Nos. SJ-43, SJ-44 and SJ-58 combined for uses at the Gallup Compressor Station. The El Paso Natural Gas Company (EPNG) when it filed with the Office of the State Engineer Declaration Nos. SJ-43, SJ-44 and SJ-58 for use of ground water to operate the Gallup Compressor Station listed the Navajo Tribe as the owner of the water rights. A letter from A.E. Viescas of the EPNG to J.L. Williams of the OSE dated January 20, 1959, reported that water use at the Gallup Compressor Station in 1958 amounted to about 86 acre-feet.

VI. DEPLETION LIMITS ON NAVAJO TRIBUTARY USES

A. Total Depletions for Navajo Nation Tributary Uses

Table 34 attached hereto provides a summary of the proposed federal reserved and state law water rights of the Navajo Nation for tributary water uses in the San Juan River Basin in New Mexico that are included in the Proposed Supplemental Decree. Although the maximum annual at-site depletion rights for the Navajo Nation described by the Proposed Supplemental Decree sum to about 25,145 acre-feet of depletion, the average annual at-site depletion by actual water uses made under these water rights may be anticipated to approach about 8,872 acre-feet annually assuming all rights are exercised and average hydrologic conditions taking into account shortages in the historically available water supply. The average annual depletion of San Juan River flow resulting from actual water uses made under these water rights may be anticipated to approach about 1,819 acre-feet after water supply shortages and salvage of ephemeral tributary losses by use, assuming all rights are exercised and average hydrologic conditions (see table 34).

B. Depletion Limits under the Proposed Supplemental Decree

1. Depletion Limits. Paragraph 5 of the Proposed Supplemental Decree includes depletion limits for average annual at-site depletions and average annual depletions of San Juan River flow by Navajo Nation tributary water uses for which water rights are included in the Proposed Supplemental Decree combined. Paragraph 5(a) of the Proposed Supplemental Decree provides that the Navajo Nation may not deplete at the sites of use an average of more than 8,355 acre-feet per year during any period of ten consecutive years pursuant to the proposed water rights described in paragraphs 3 and 4 of the Proposed Supplemental Decree, not including the livestock watering use rights included in subparagraphs 3.A.2 and 4.A.2 of the decree. This total depletion limit is also separated in paragraph 5(a) by tributary drainage. The livestock watering uses may move from drainage to drainage depending upon range forage conditions throughout Navajo Nation lands in the basin. Paragraph 5(b) of the Proposed Supplemental Decree provides that the Navajo Nation may not deplete from the flow of the San Juan River an average of more than 1,819 acre-feet per year during any period of ten consecutive years pursuant to the proposed water rights described in paragraphs 3 and 4 of the Proposed Supplemental Decree. These depletion limits are based on full utilization of the proposed water rights for Navajo Nation tributary water uses included in the Proposed Supplemental Decree and average historic hydrologic conditions.

Paragraph 5(c) of the Proposed Supplemental Decree further provides that if the Court in the Adjudication adopts a methodology to determine irrigation water requirements for non-Navajo water rights that differs from the methodology utilized for the Echo Ditch Decree and that would result in greater annual diversion and depletion quantities for the Navajo Nation's irrigation water rights than proposed by the decree, the Navajo Nation's water rights for tributary irrigation uses under paragraphs 3 and 4 of the decree and the depletion limits in subparagraph 5(a) and 5(b) of the decree may be recalculated accordingly. In addition, the depletion limit in paragraph 5(b) may be adjusted if the State Engineer adopts any change in methodology for calculating depletion effects on the flow of the San Juan River from the use of water pursuant to the water rights described in paragraphs 3 and 4 of the Proposed Supplemental Decree; provided, that the average annual total combined depletion limit on river flow is not adjusted below 1,819 acre-feet or above an amount that is equal to 50 percent of the at-site depletion

limit described in subparagraph 5(a) of the decree. This latter adjustment recognizes that better information may become available in the future regarding estimation of depletions of San Juan River flow resulting from at-site depletions for water uses made under the rights proposed by the Proposed Supplemental Decree, but also places an upper limit to the amount of any adjustments so as to protect the San Juan River and other water users in the event of actual or anticipated Upper Basin use curtailments pursuant to article IV of the Upper Colorado River Basin Compact.

2. Administration. Subparagraph 12(d) of the Proposed Supplemental Decree provides that if the average annual total combined at-site depletion in any of the drainages identified in paragraph 5(a) of the decree, excluding livestock watering uses, exceeds in any period of ten consecutive years the respective depletion limit for that drainage specified by subparagraph 5(a), the Navajo Nation may offset any excess depletion for the drainage in accordance with a replacement water plan approved by the State Engineer. Similarly, subparagraph 12(e) of the Proposed Supplemental Decree provides that if the average annual total combined depletion of San Juan River flow exceeds in any period of ten consecutive years the depletion limit described by subparagraph 5(b) of the decree, the Navajo Nation may offset any excess river flow depletion impact at the locations of impact in accordance with a replacement water plan approved by the State Engineer. Under both subparagraphs 12(d) and 12(e), such replacement plans would be required when the State Engineer determines that water is needed to meet the State of New Mexico's interstate compact obligations or when the State Engineer determines that a replacement plan is necessary to protect existing water uses in New Mexico.

TABLES

1 through 34

FIGURES

1 through 3

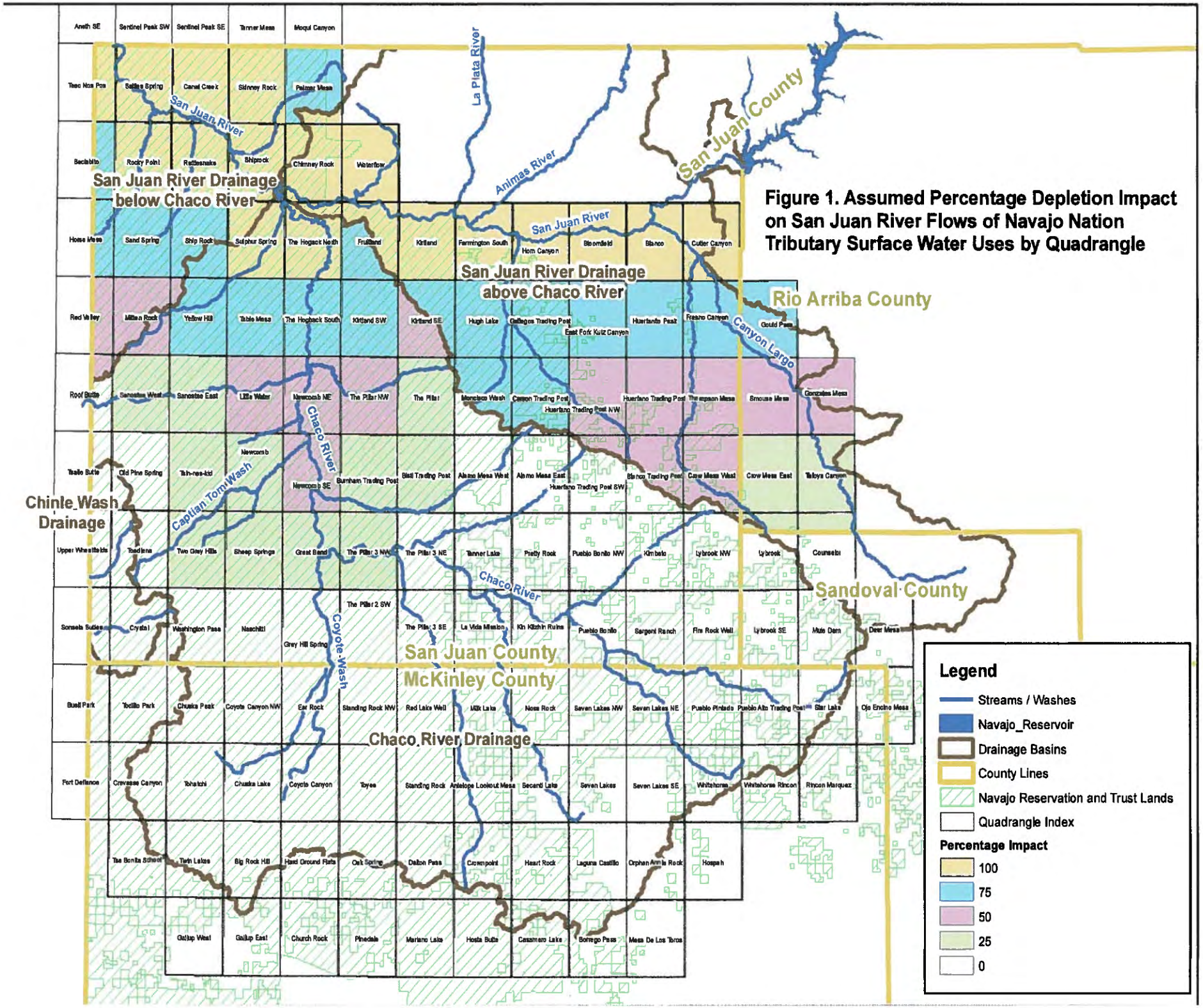
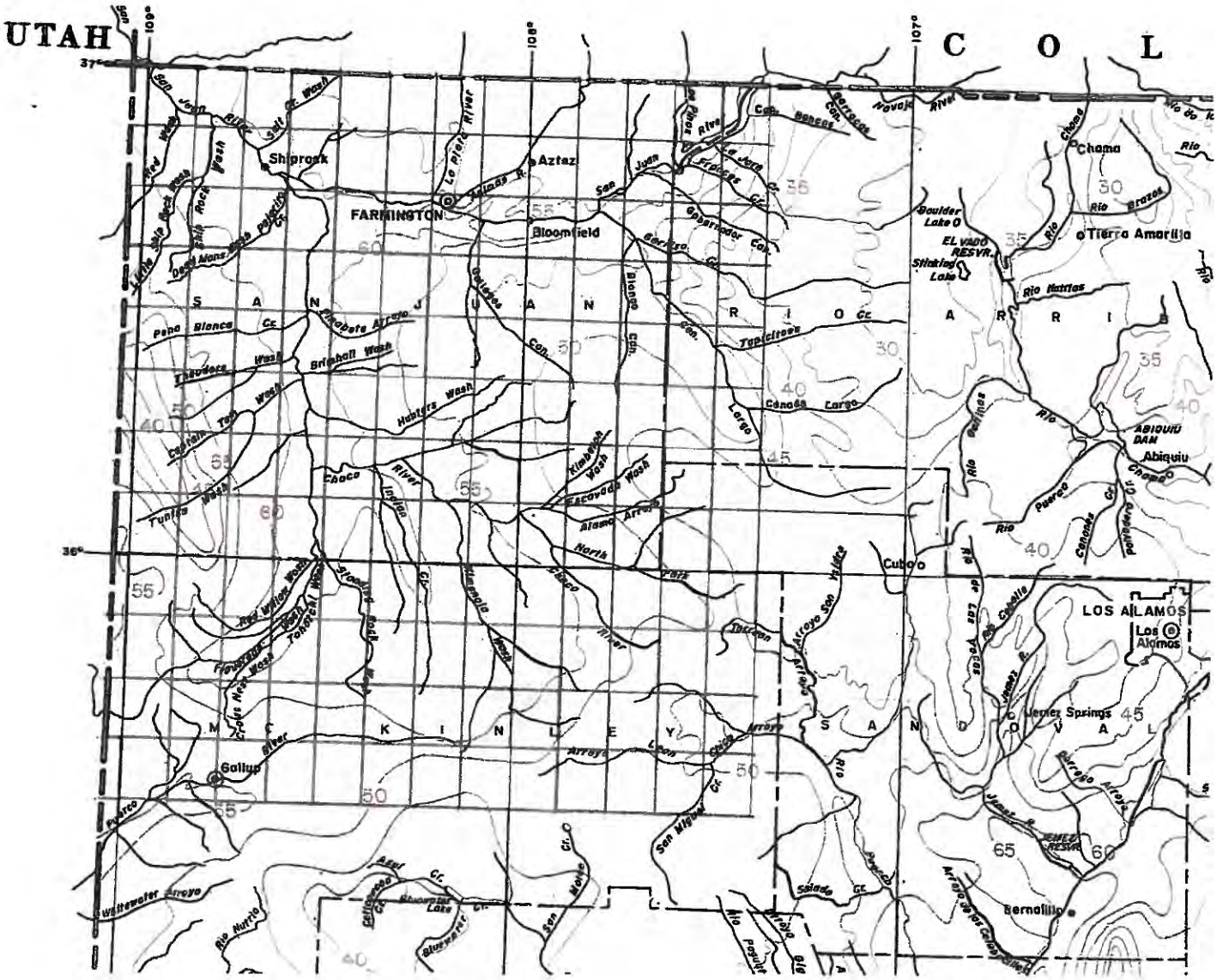


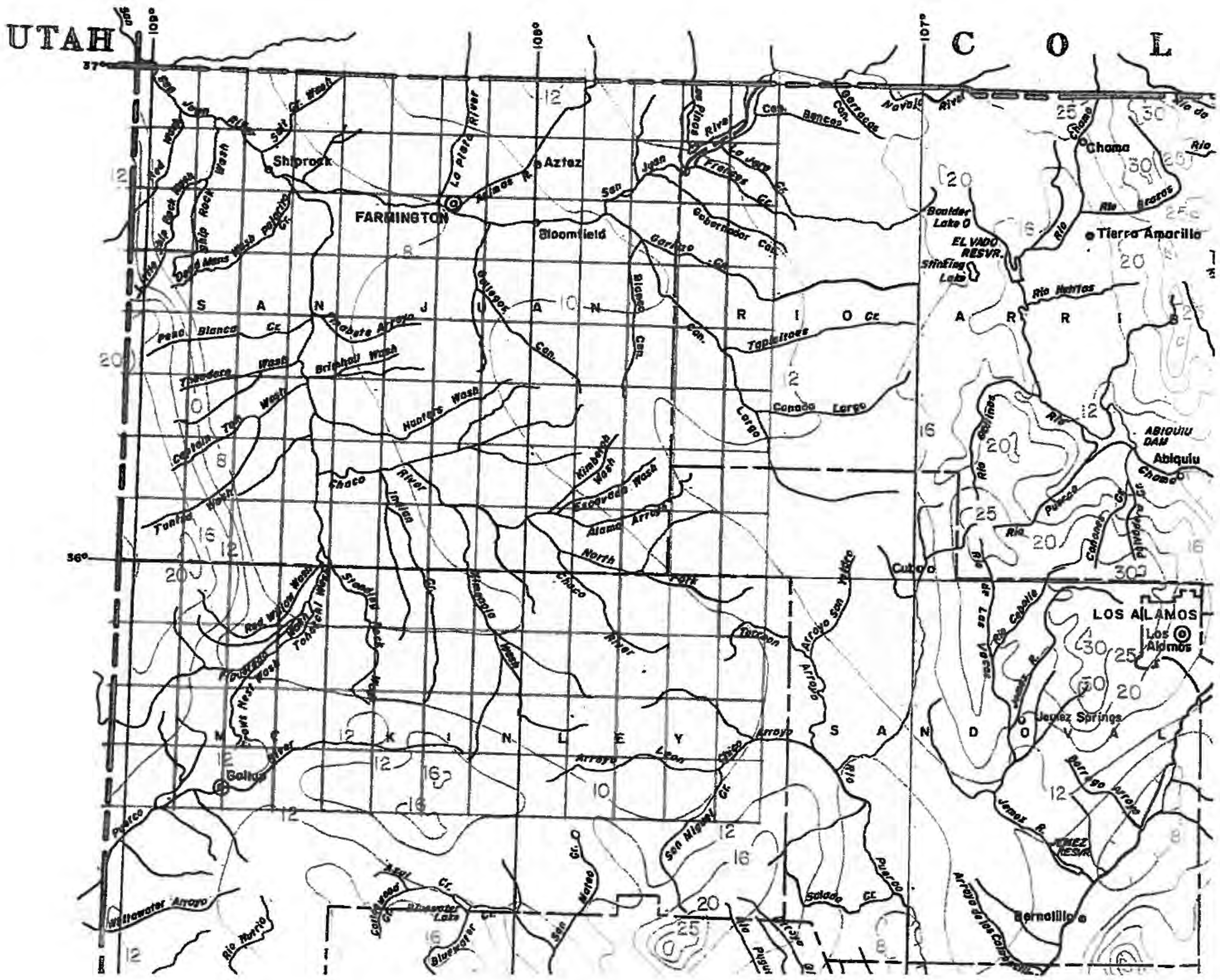
Figure 1. Assumed Percentage Depletion Impact on San Juan River Flows of Navajo Nation Tributary Surface Water Uses by Quadrangle

Figure 2. Gross Annual Lake Evaporation in Northwestern New Mexico



Lines of equal gross evaporation in inches. Data developed by SCS River Basin Staff in cooperation with New Mexico State Engineer. USGS National Atlas 1:1,000,000 Albers Equal-Area projection (1967) used as source for base map and adapted for SCS use. Scale = 24 miles per inch. Copied from Gross Annual Lake Evaporation, New Mexico, prepared by the SCS and dated April 1972 (see New Mexico Water Resources Assessment for Planning Purposes, US Department of the Interior, Bureau of Reclamation in cooperation with the State of New Mexico, November 1976, supporting maps).

Figure 3. Normal Annual Precipitation in Northwestern New Mexico



Lines of equal precipitation in inches. Isohyetal analyses prepared by the Water Supply Forecast Center, Salt Lake City, Utah, using adjusted climatological data (1931-1960) and values derived by correlation with physiographic factors. USGS National Atlas 1:1,000,000 Albers Equal-Area projection (1967) used as source for base map and adapted for SCS use. Scale = 24 miles per inch. Copied from Normal Annual Precipitation, New Mexico, prepared by the SCS and dated April 1972 (see New Mexico Water Resources Assessment for Planning Purposes, US Department of the Interior, Bureau of Reclamation in cooperation with the State of New Mexico, November 1976, supporting maps).

APPENDIX A

Aerial Imagery Showing Selected Fields Claimed by the US Survey for Tributary Non-Project Irrigation Uses on Navajo Nation Trust Lands

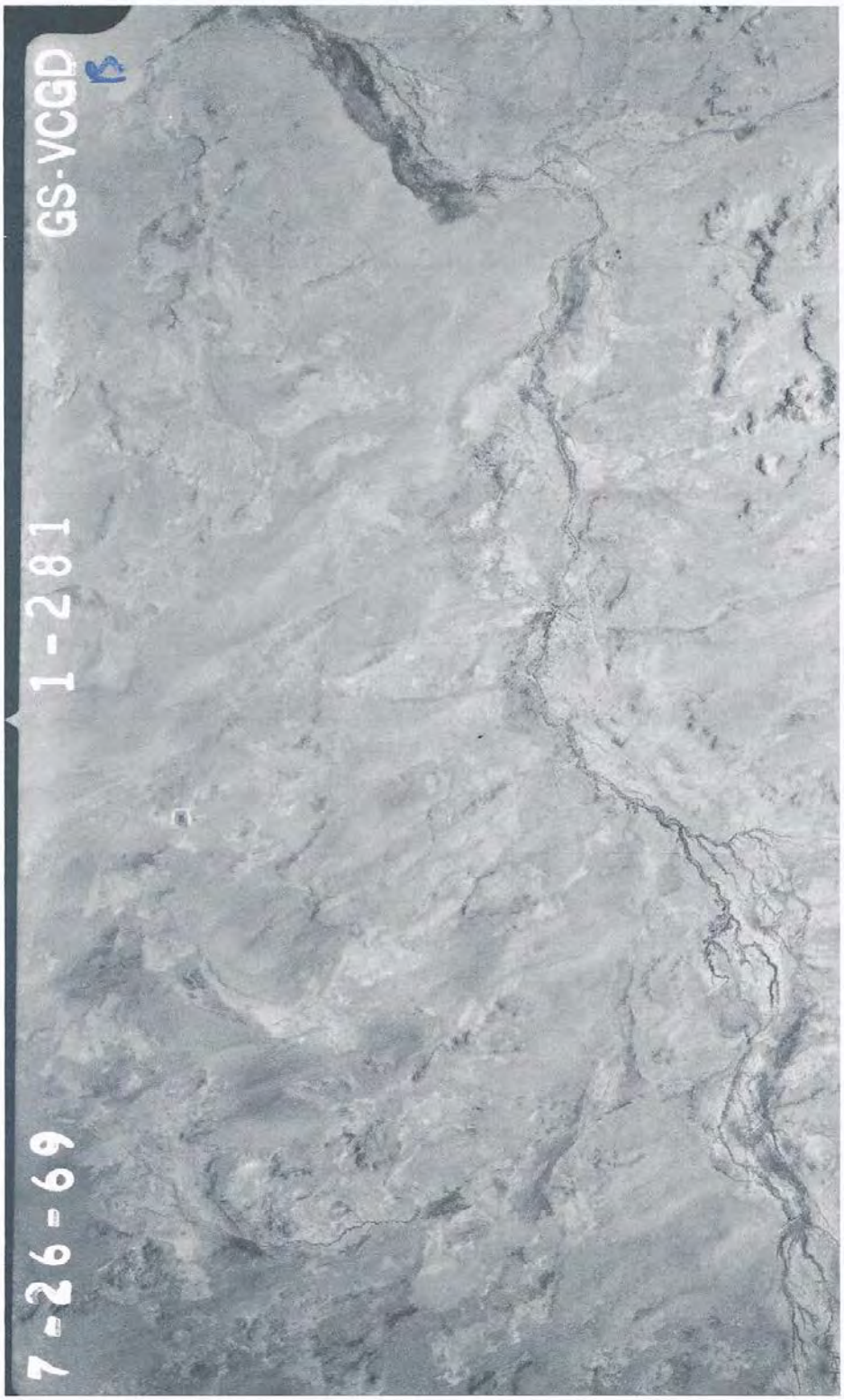


Image A-1(a). Aerial Imagery Dated 1969 Showing Portions of the Project Area for the I.K. Westbrook Spreader Dams on Indian Creek (Top and Bottom of Image)

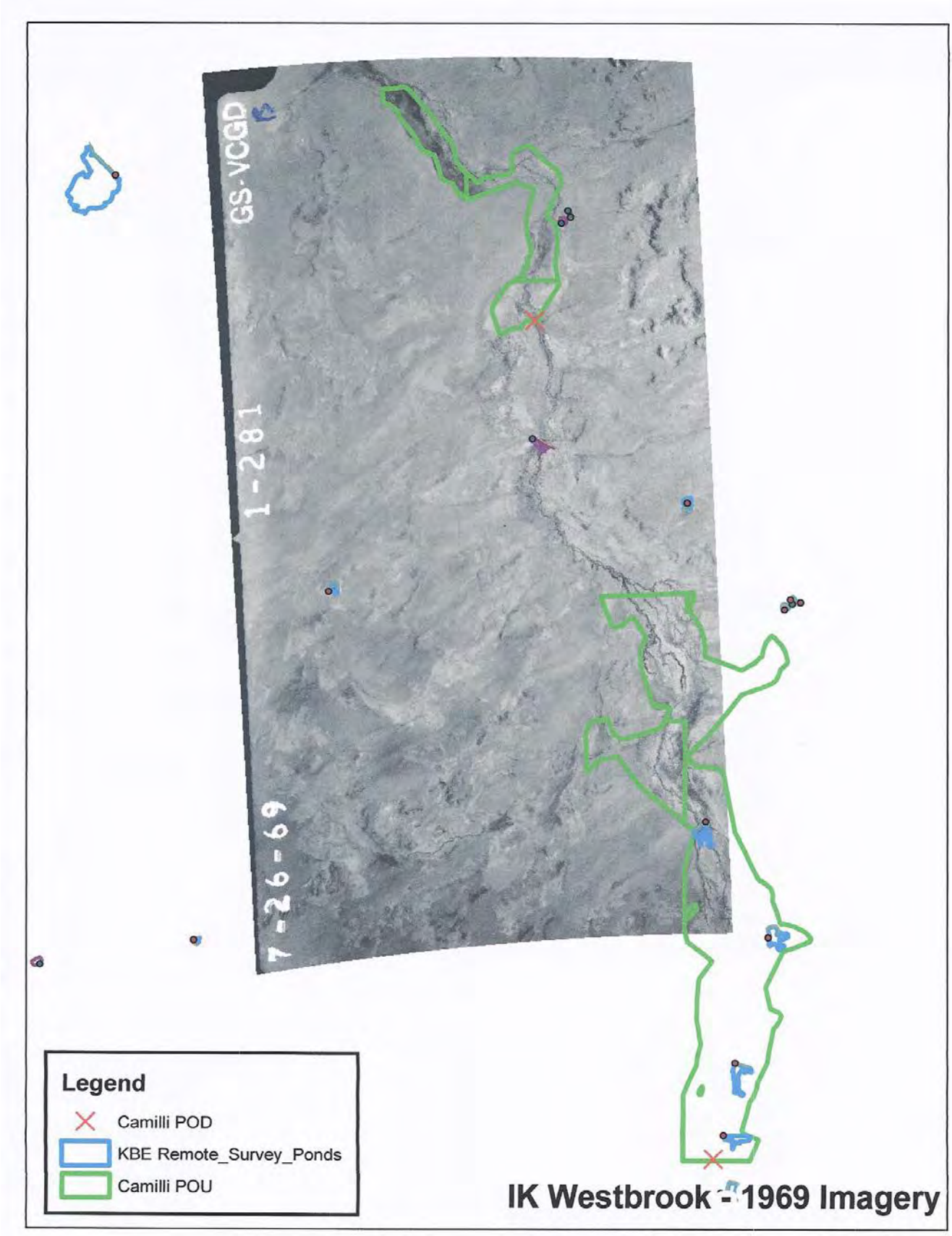


Image A-1(b). Aerial Imagery Dated 1969 Overlain with Irrigated Tracts for the I.K. Westbrook Spreader Dams on Indian Creek Claimed by the US Survey

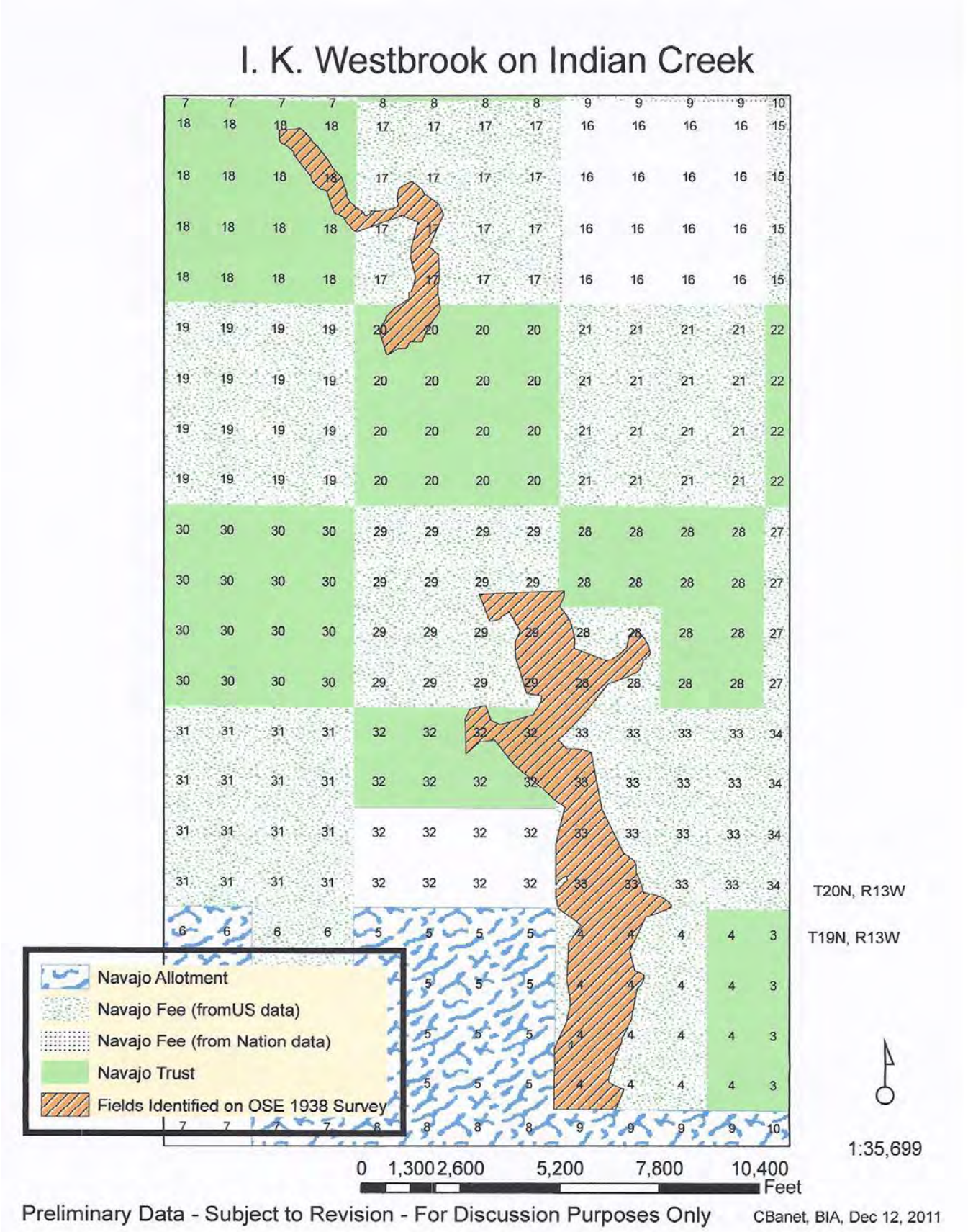


Image A-1(c). Map Prepared by the BIA Showing Portions of the Irrigated Areas Claimed for the I.K. Westbrook Spreader Dams on Indian Creek on Navajo Trust or Fee Lands

Image A-2(a). Aerial Imagery Dated 1935 Showing Non-Project Field No. 178 Claimed by the US Survey from This Imagery

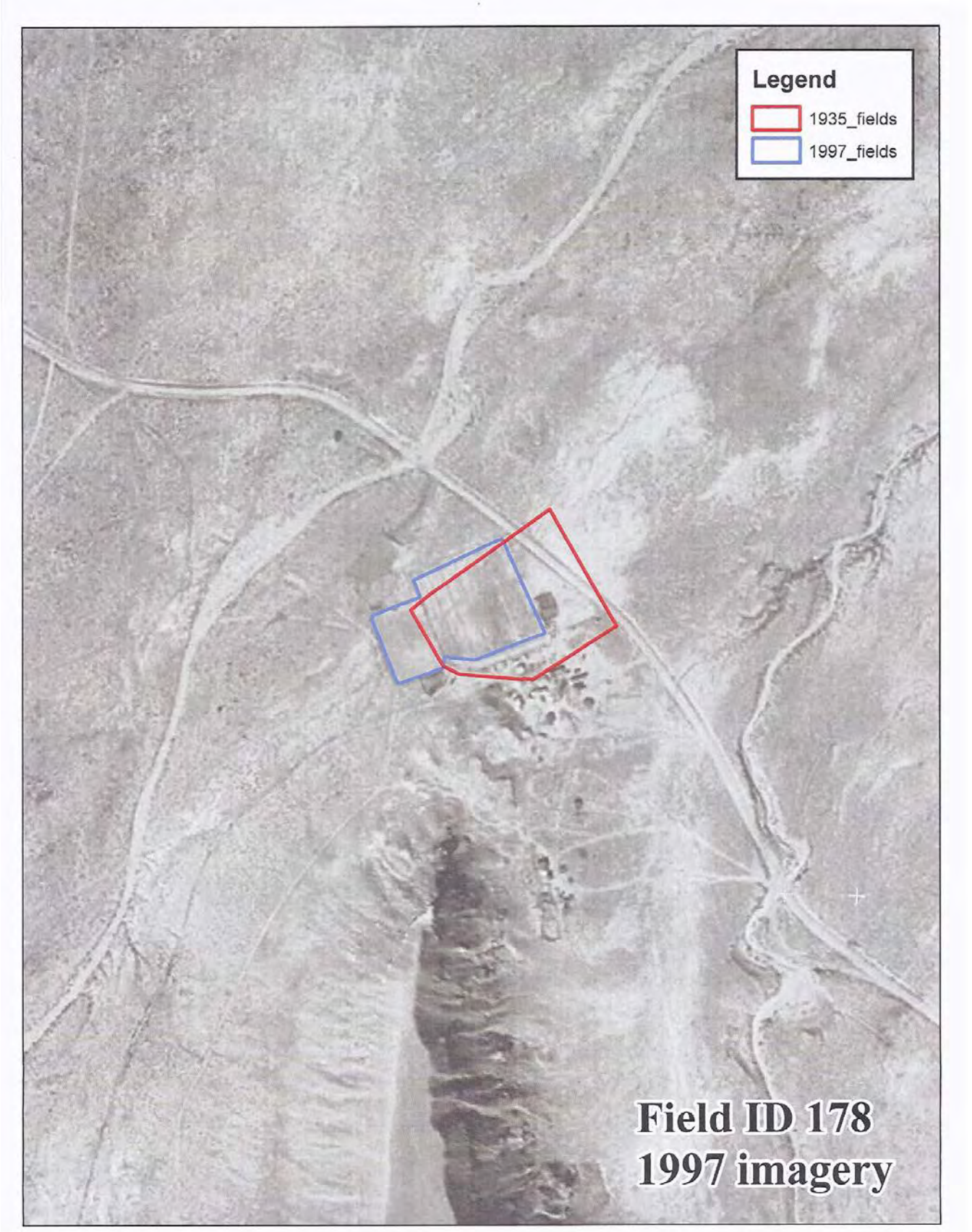


Image A-2(b). Aerial Imagery Dated 1997 Showing Non-Project Field No. 178 Claimed by the US Survey from Imagery for 1935 and 1997

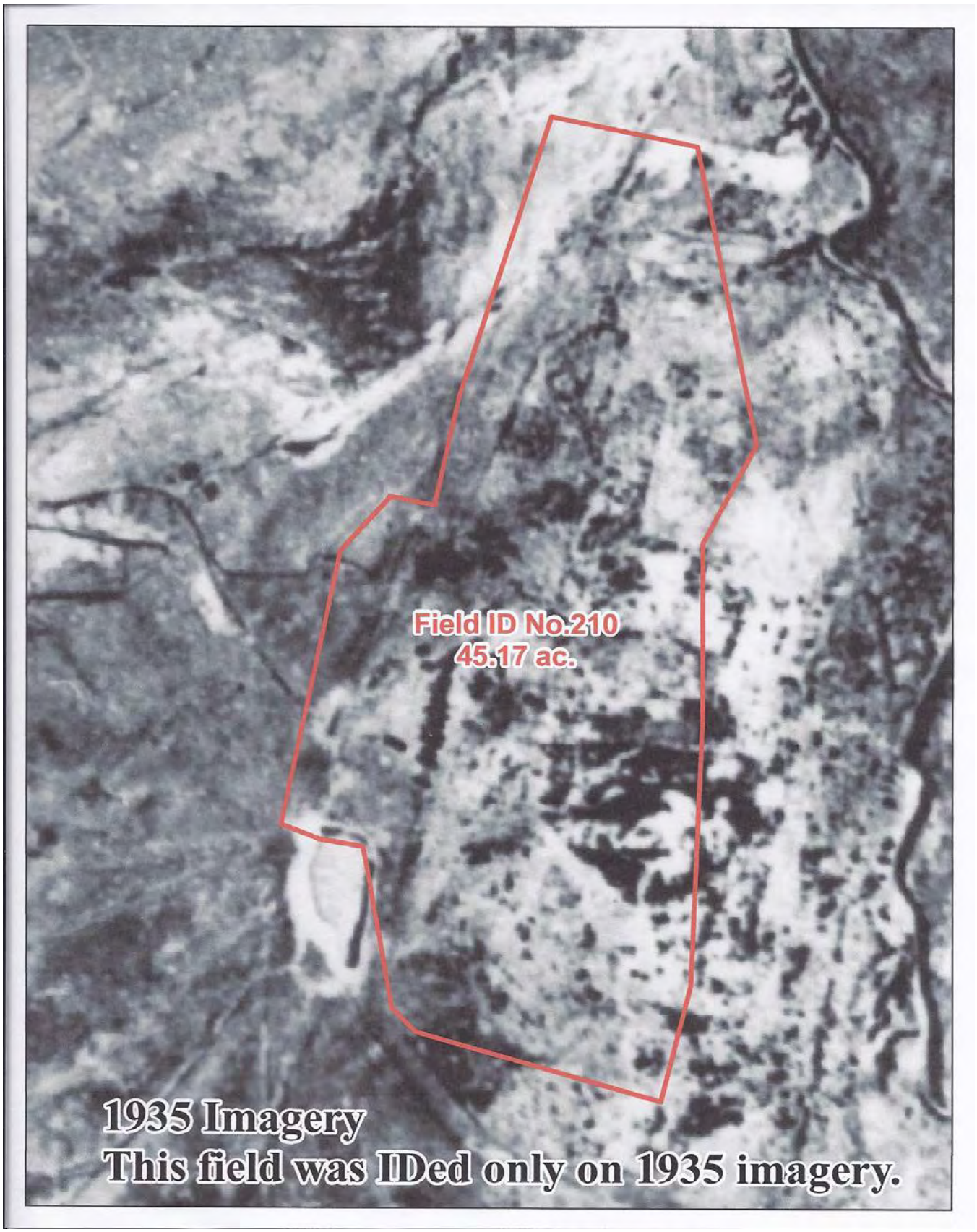


Image A-3. Aerial Imagery Dated 1935 Showing Non-Project Field No. 210 Claimed by the US Survey from This Imagery

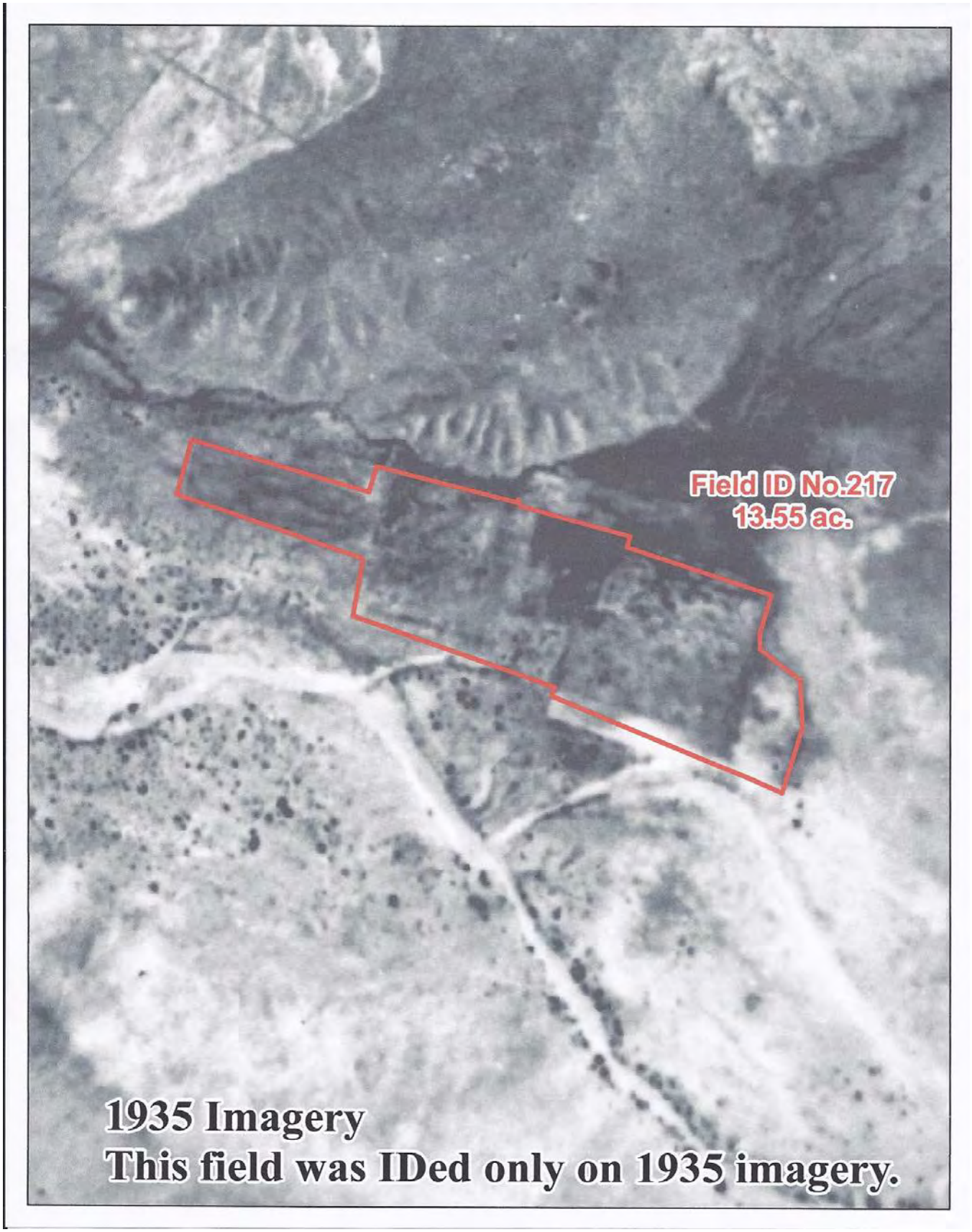


Image A-4. Aerial Imagery Dated 1935 Showing Non-Project Field No. 217 Claimed by the US Survey from This Imagery

Image A-5. Aerial Imagery Dated 1951 Showing Non-Project Field Nos. 191 and 192 Claimed by the US Survey from This Imagery

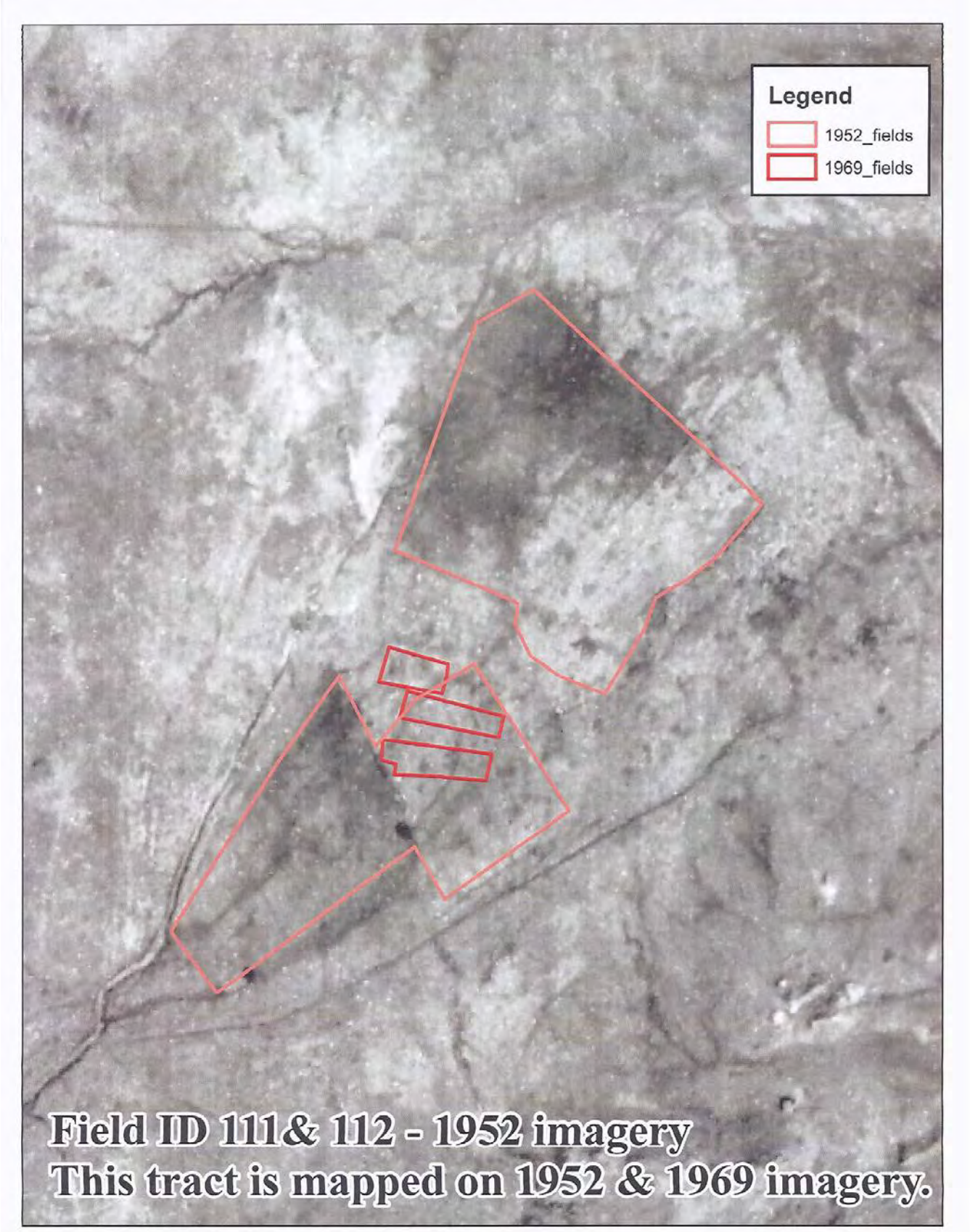


Image A-6(a). Aerial Imagery Dated 1952 Showing Non-Project Field Nos. 111 and 112 Claimed by the US Survey from Imagery for 1952 and 1969

Image A-6(b). Aerial Imagery Dated 1969 Showing Non-Project Field Nos. 111 and 112 Claimed by the US Survey from Imagery for 1952 and 1969

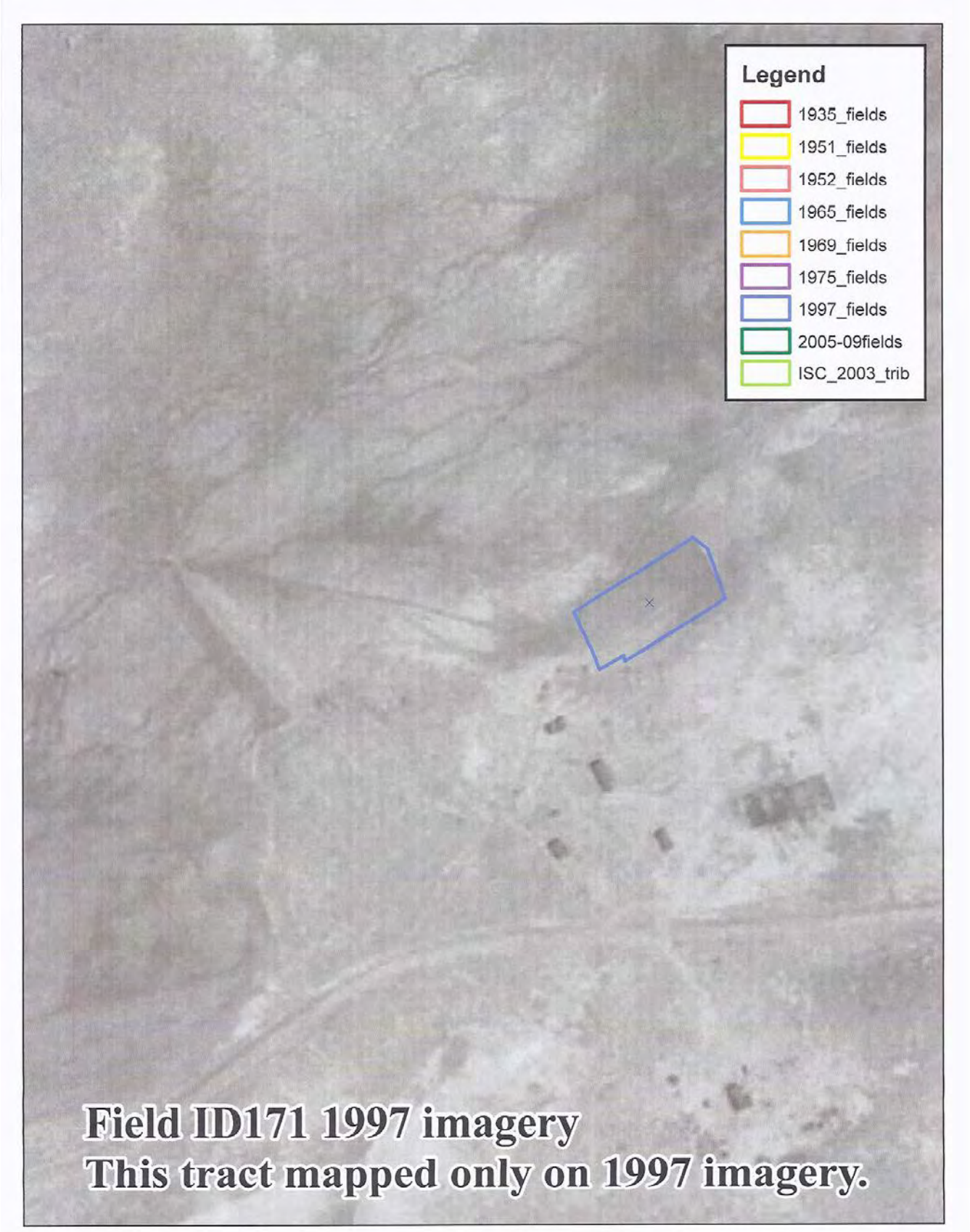


Image A-7. Aerial Imagery Dated 1997 Showing Non-Project Field No. 171 Claimed by the US Survey from This Imagery

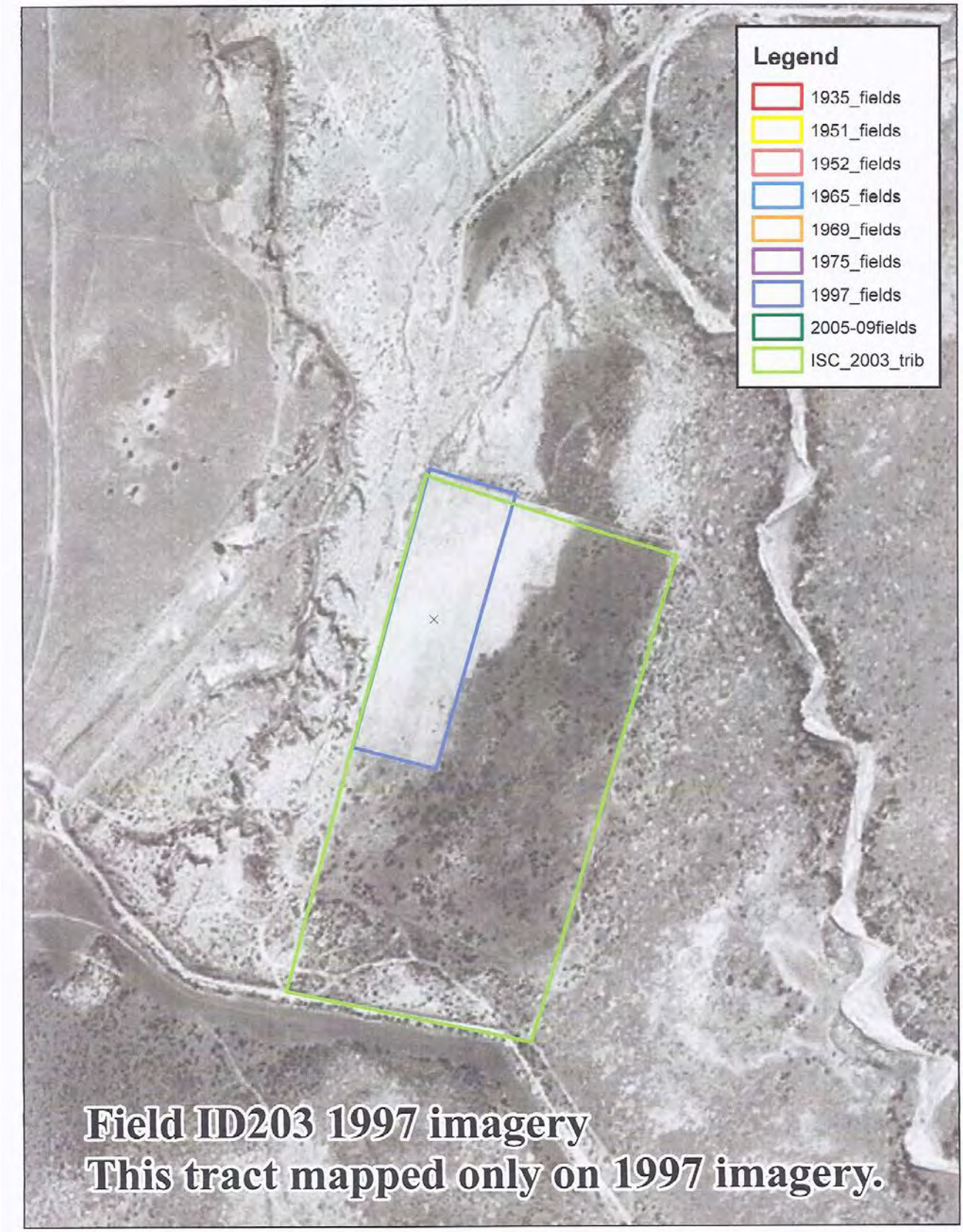


Image A-8. Aerial Imagery Dated 1997 Showing Non-Project Field No. 203 Claimed by the US Survey from This Imagery

Image A-9. Aerial Imagery Dated 1997 Showing Non-Project Field Nos. 56, 57 and 60 Claimed by the US Survey from Imagery for 1997 and 2005-2009

Image A-10. Aerial Imagery Dated 2005 Showing Non-Project Field No. 189 Claimed by the US Survey from This Imagery

APPENDIX B

Relationships between Reservoir Areas Determined by Field Survey and Stereo Analysis, between OSE Photo-Interpreted High Water Mark Reservoir Areas and US Survey Reservoir Areas, and between Measured Reservoir Areas and Maximum Depths by Reservoir Type

Figure B-1(a). Relationship of Field Measured Reservoir Area to Stereo Analysis Interpreted Reservoir Area Based on Data Used to Verify US Survey Methodology for Estimating Reservoir Sizes

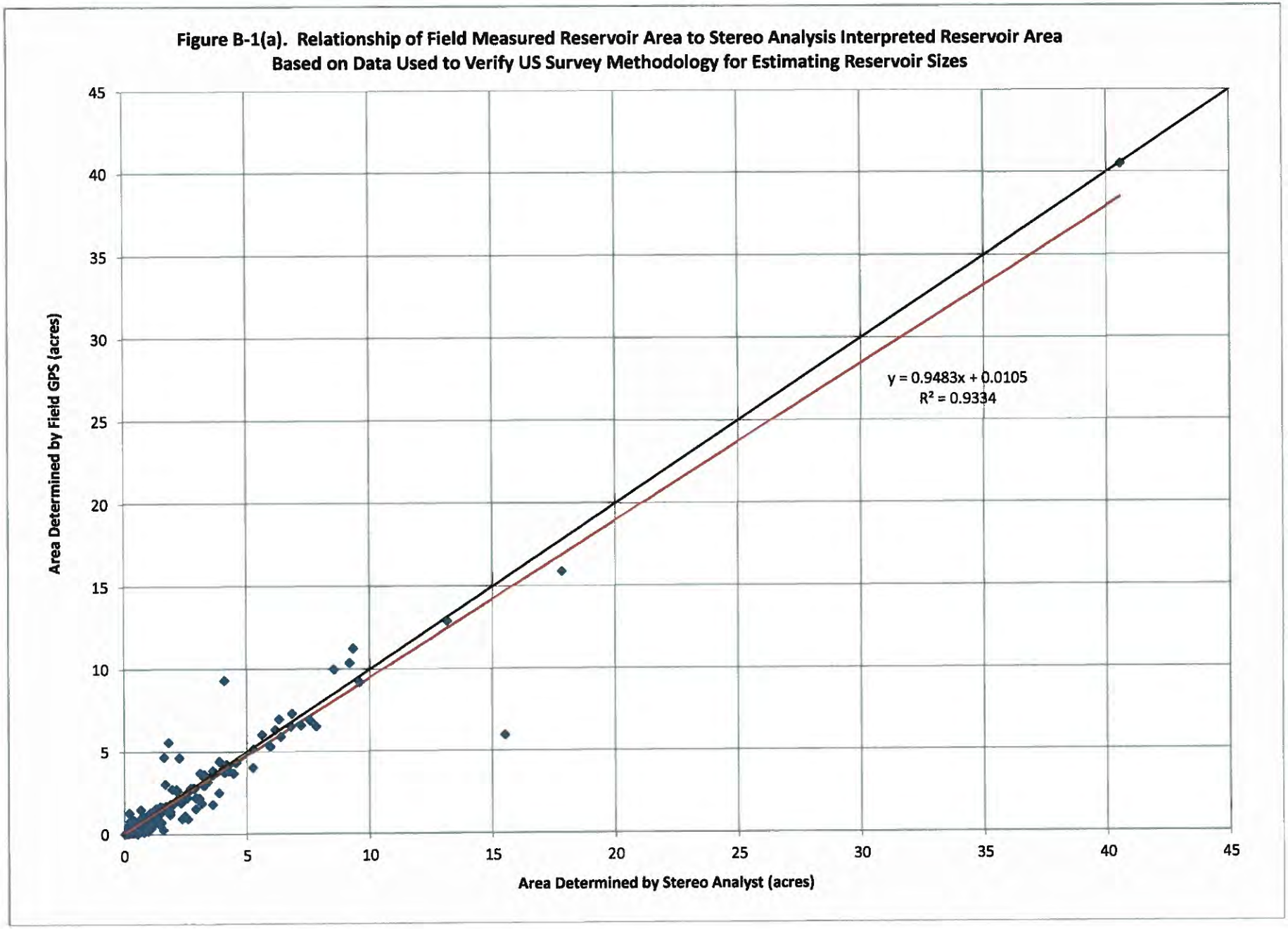


Figure B-1(b). Relationship of Field Measured Reservoir Area to Stereo Analysis Interpreted Reservoir Area Based on Data Used to Verify US Survey Methodology for Estimating Reservoir Sizes

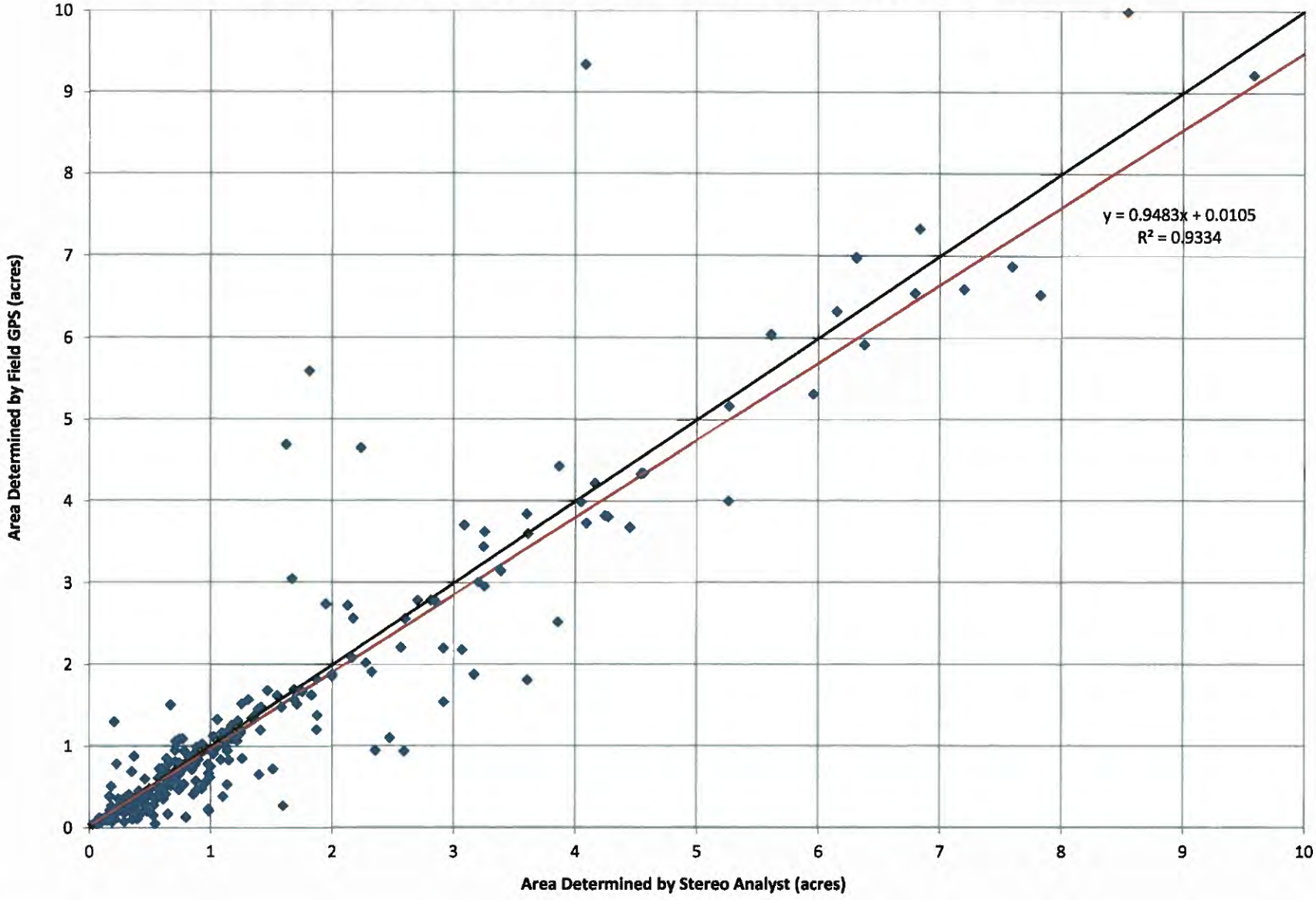


Figure B-1(c). Relationship of Field Measured Reservoir Area to Stereo Analysis Interpreted Reservoir Area Based on Data Used to Verify US Survey Methodology to Estimate Reservoir Sizes

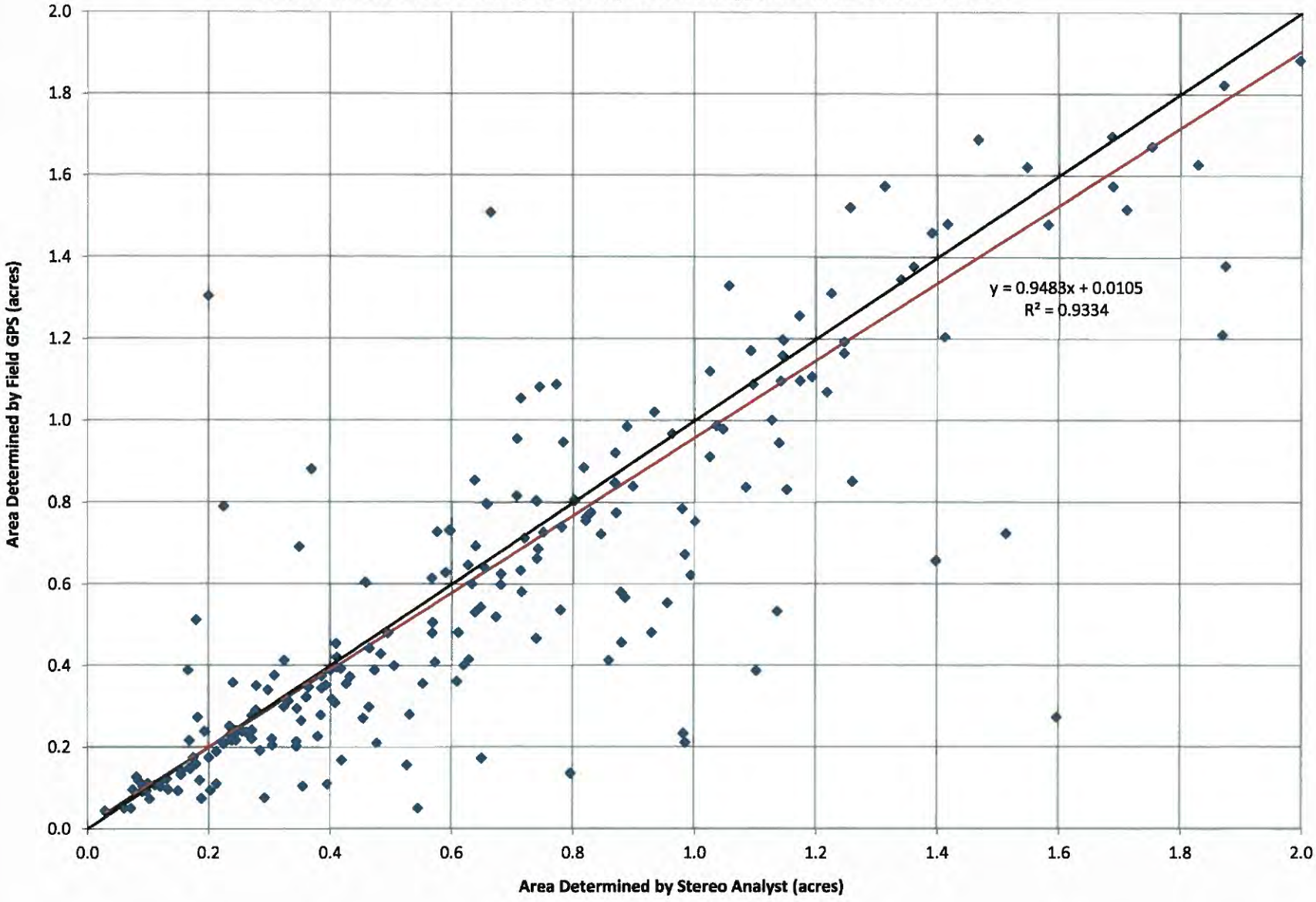


Figure B-2(a). Error in Stereo Analysis Interpreted Reservoir Area Based on Field Measured Reservoir Area for Data Used by US Survey to Verify Methodology for Estimating Reservoir Sizes

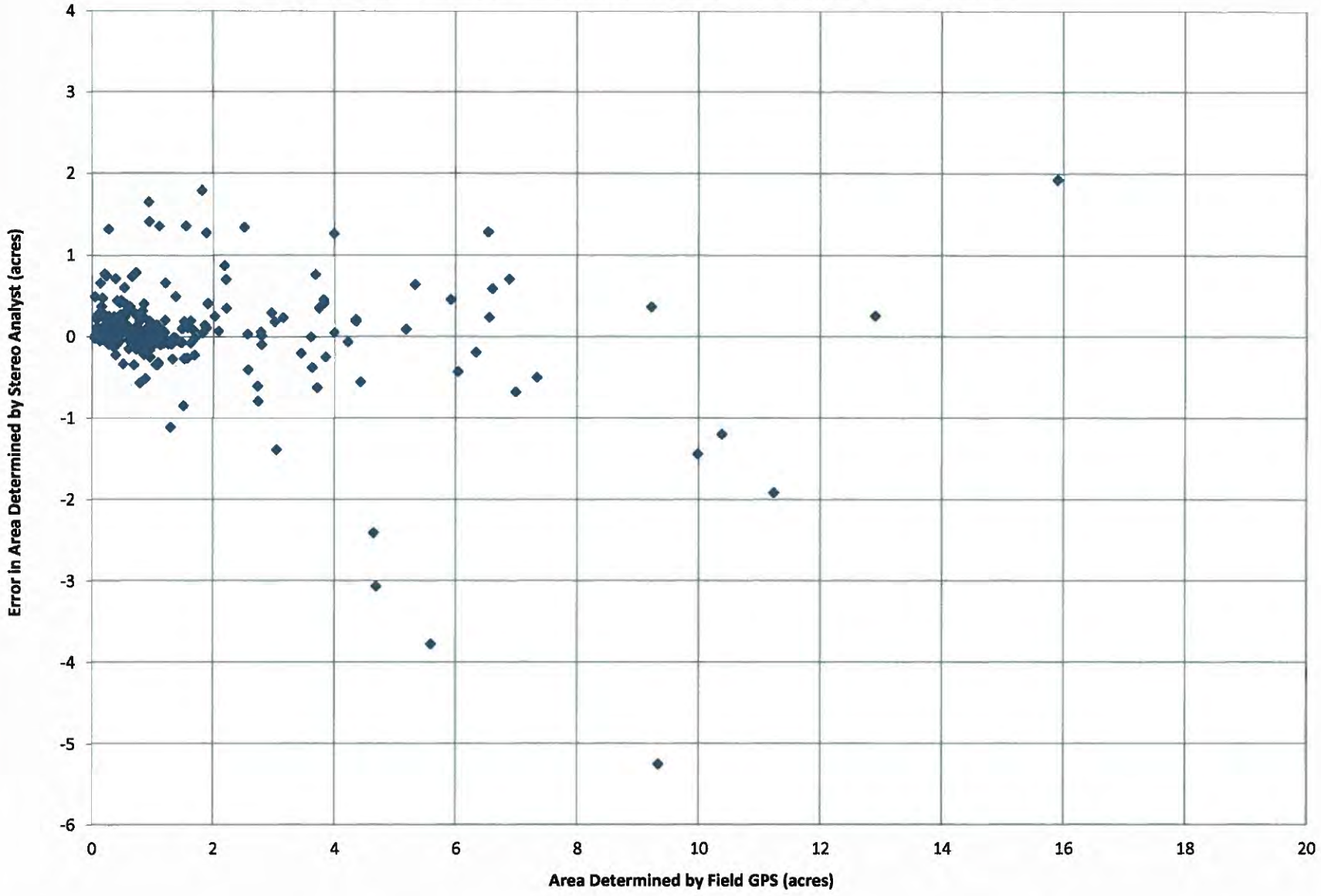


Figure B-2(b). Error in Stereo Analysis Interpreted Reservoir Area Based on Field Measured Reservoir Area for Data Used to Verify US Survey Methodology for Estimating Reservoir Sizes

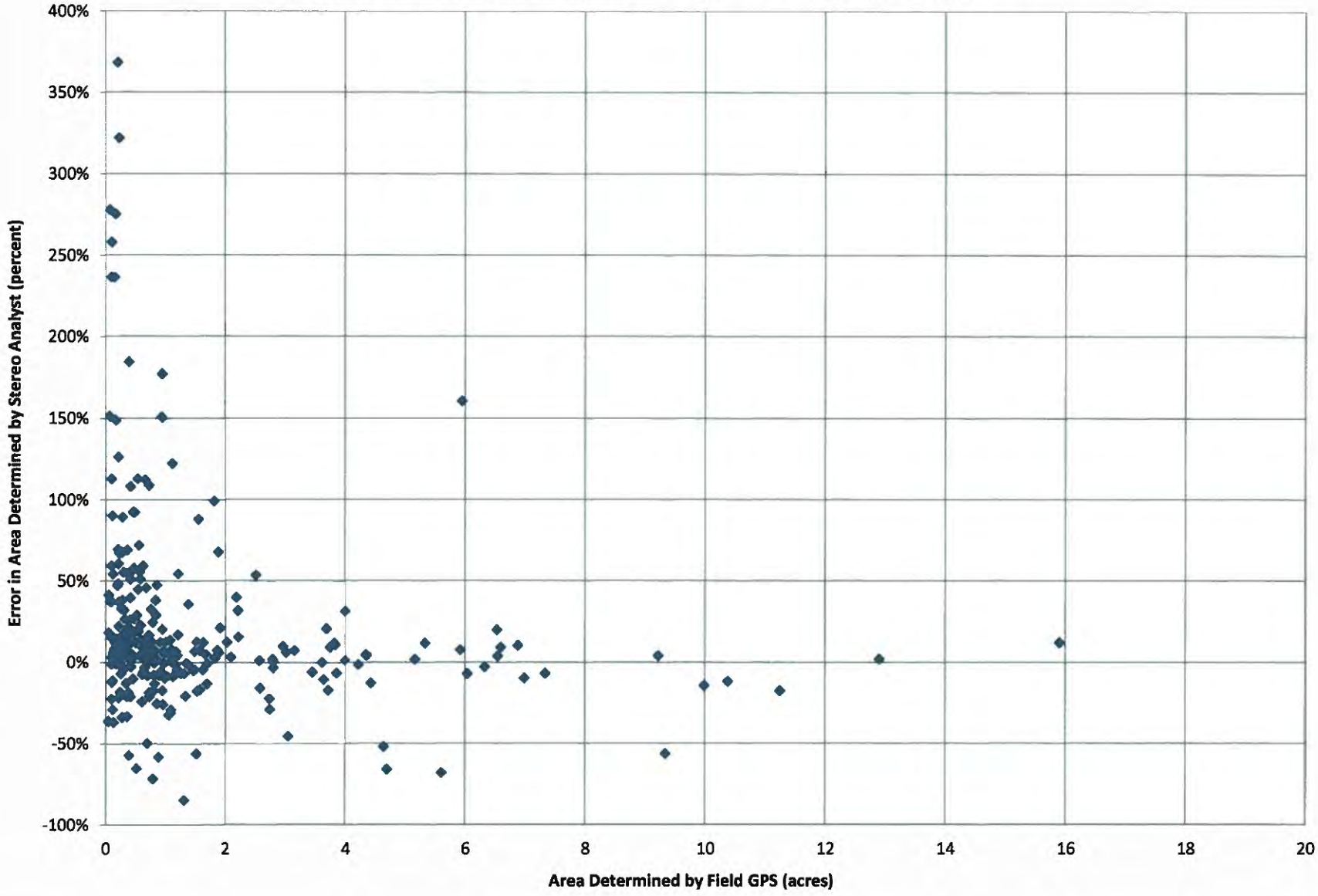


Figure B-3(a). Relationship of Field Measured Reservoir Area to Stereo Analysis Interpreted Reservoir Area Including Data Collected but Omitted from US Survey Verification Analysis

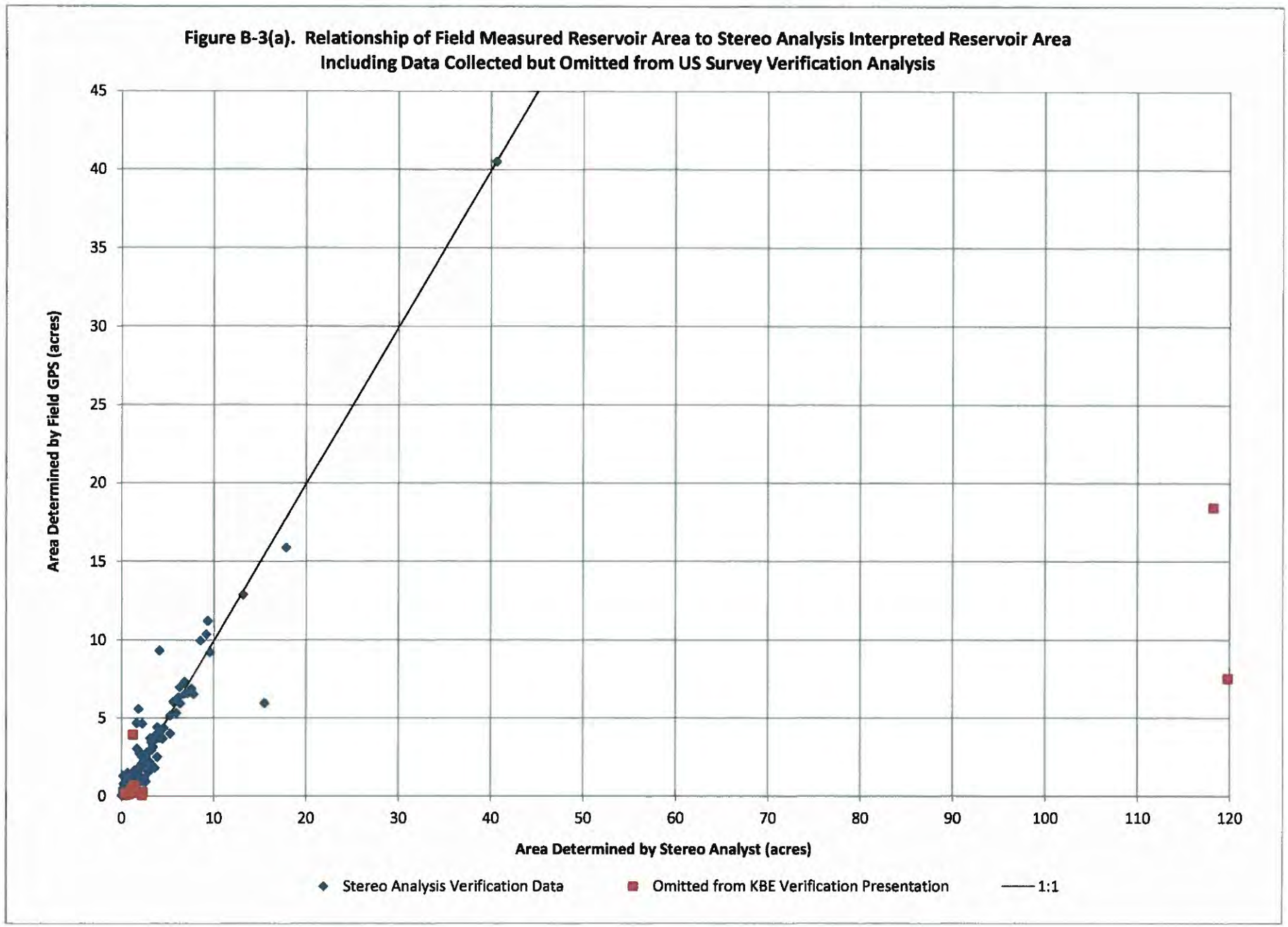


Figure B-3(b). Relationship of Field Measured Reservoir Area to Stereo Analysis Interpreted Reservoir Area Including Data Collected but Omitted from US Survey Verification Analysis

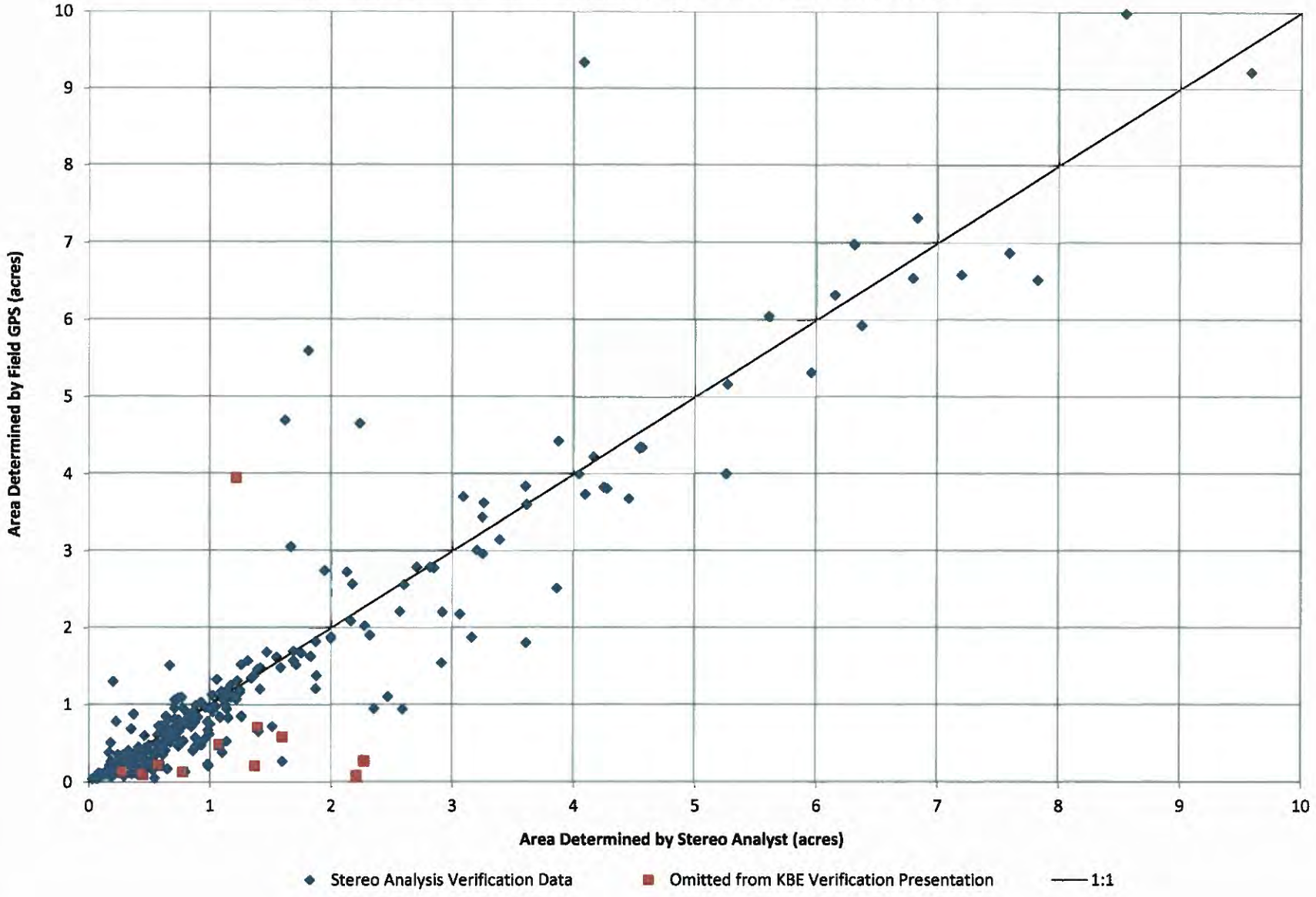


Figure B-4(a). Relationship of Field Measured Reservoir Area to Stereo Analysis Interpreted Reservoir Area for Reservoirs with Interpreted Areas Less Than 8 Acres, Including Data Omitted from US Survey Verification

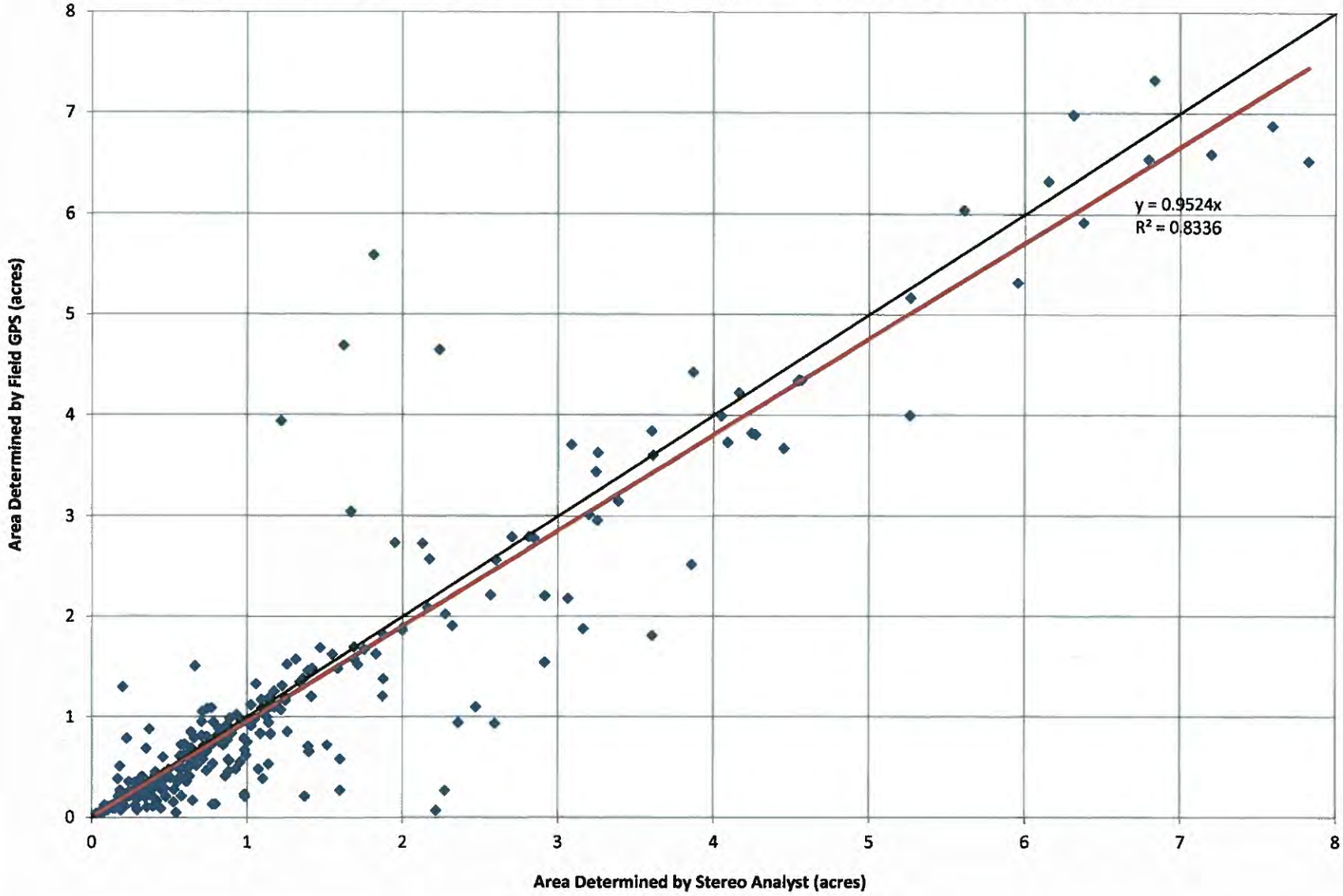


Figure B-4(b). Relationship of Field Measured Reservoir Area to Stereo Analysis Interpreted Reservoir Area, Including Data Omitted from US Survey Verification Analysis, by Reservoir Type

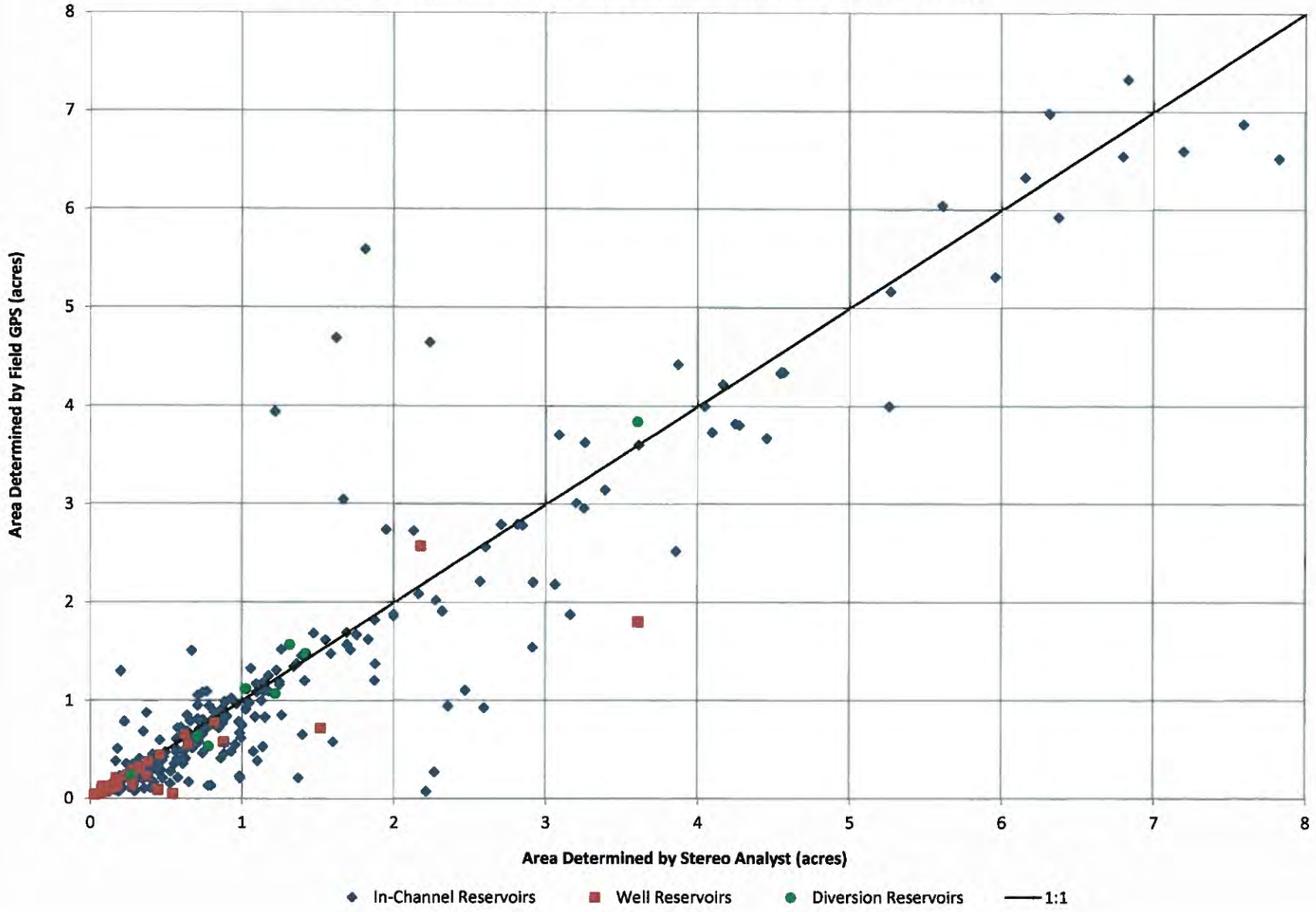


Figure B-5(a). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Field Measured Spillway Crest Area Based on 23 (100%) of Stock Reservoirs Greater Than 6 Acres and 31 (8%) of Stock Reservoirs Less Than 6 Acres

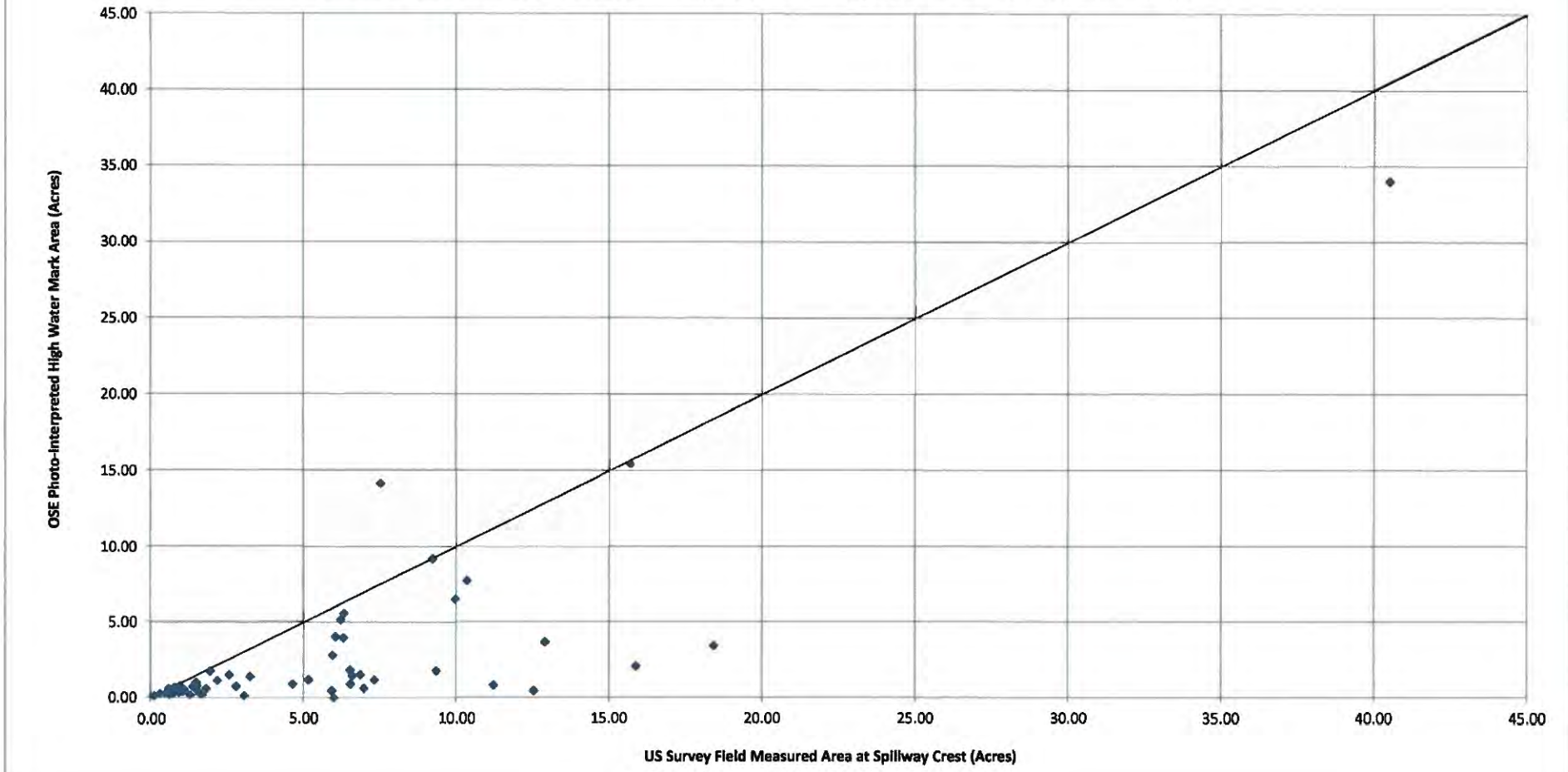


Figure B-5(b). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Field Measured Spillway Crest Area For Livestock Reservoirs Claimed by the US Survey to be Less Than 20 Acres

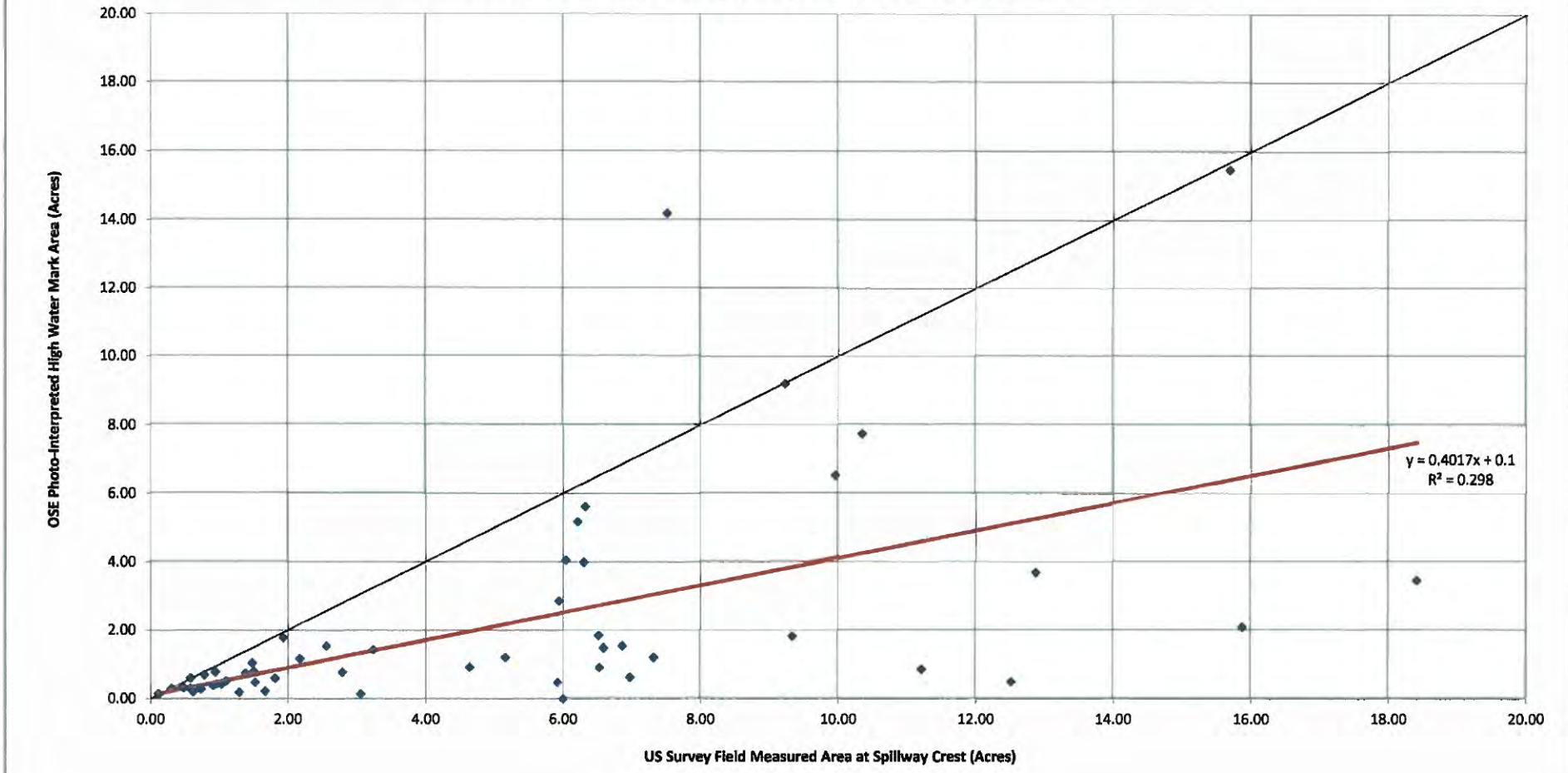


Figure B-5(c). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Field Measured Spillway Crest Area For Livestock Reservoirs Claimed by the US Survey to be Less Than 20 Acres, by Reservoir Type

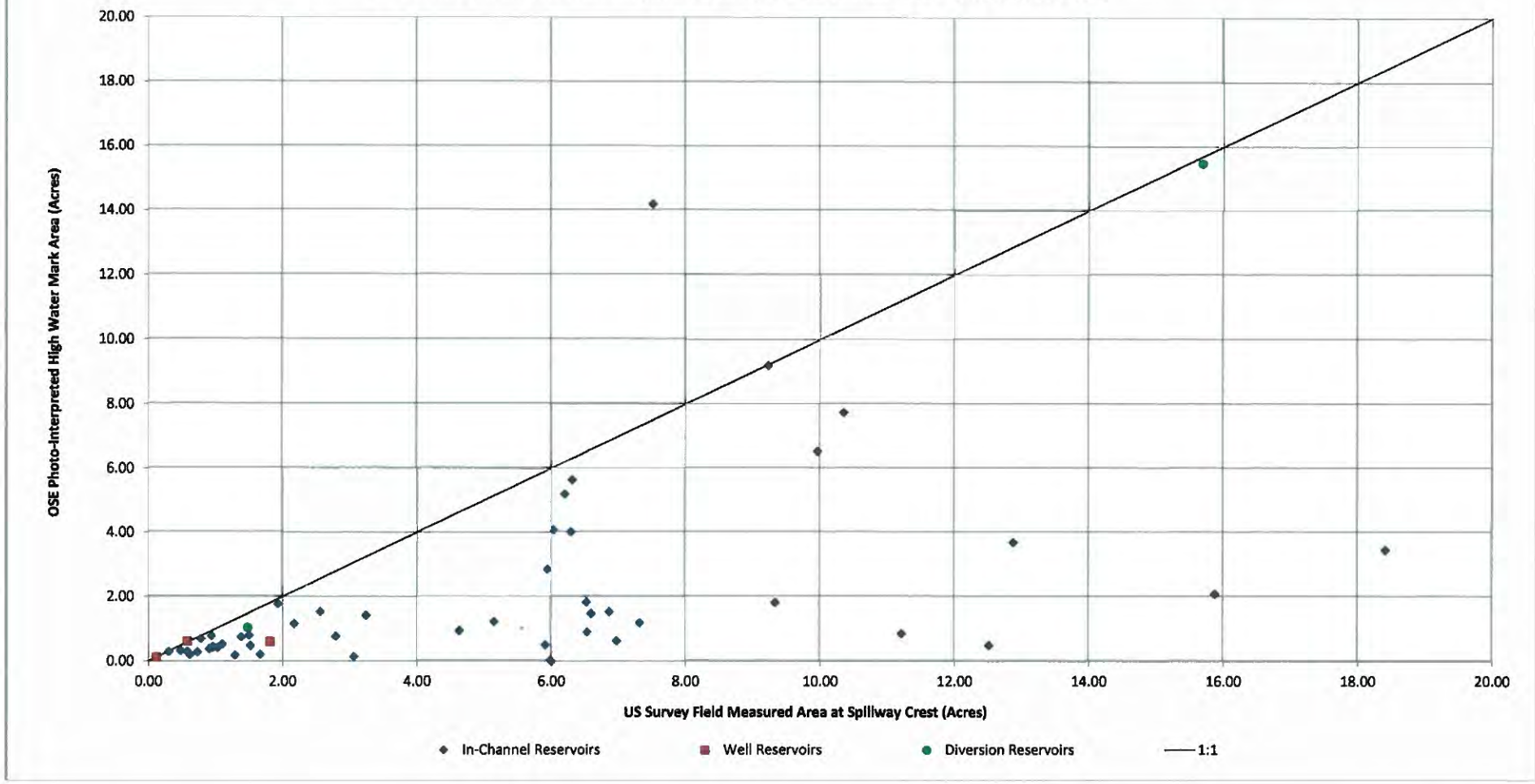


Figure B-6(a). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Stereo Analysis Interpreted Spillway Crest Area Based on 140 (100%) of Reservoirs Greater Than 6 Acres and 115 (9%) of Reservoirs Less Than 6 Acres

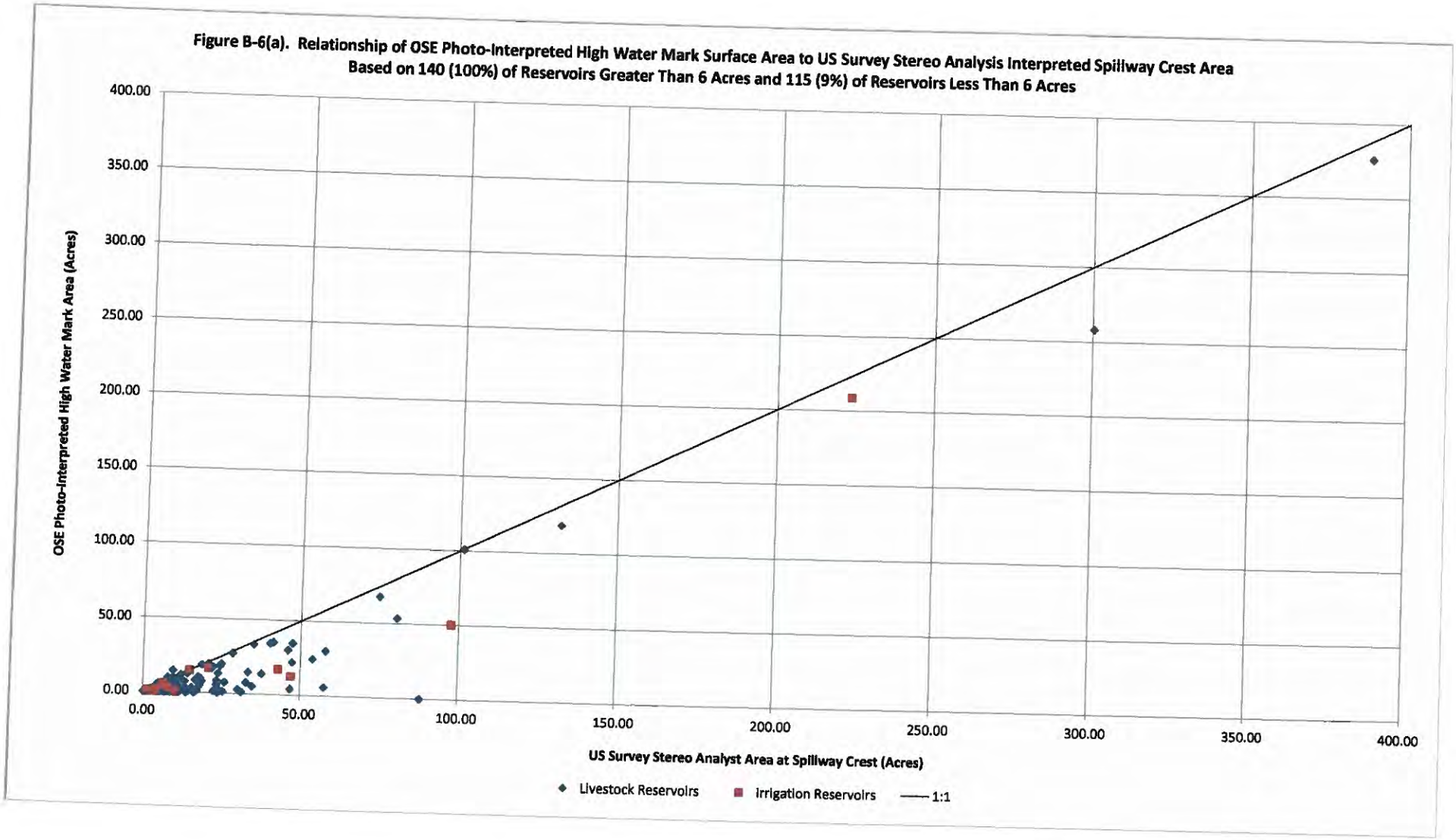


Figure B-6(b). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Stereo Analysis Interpreted Spillway Crest Area Based on 135 (100%) of Reservoirs Between 6 and 100 Acres and 115 (9%) of Reservoirs Less Than 6 Acres

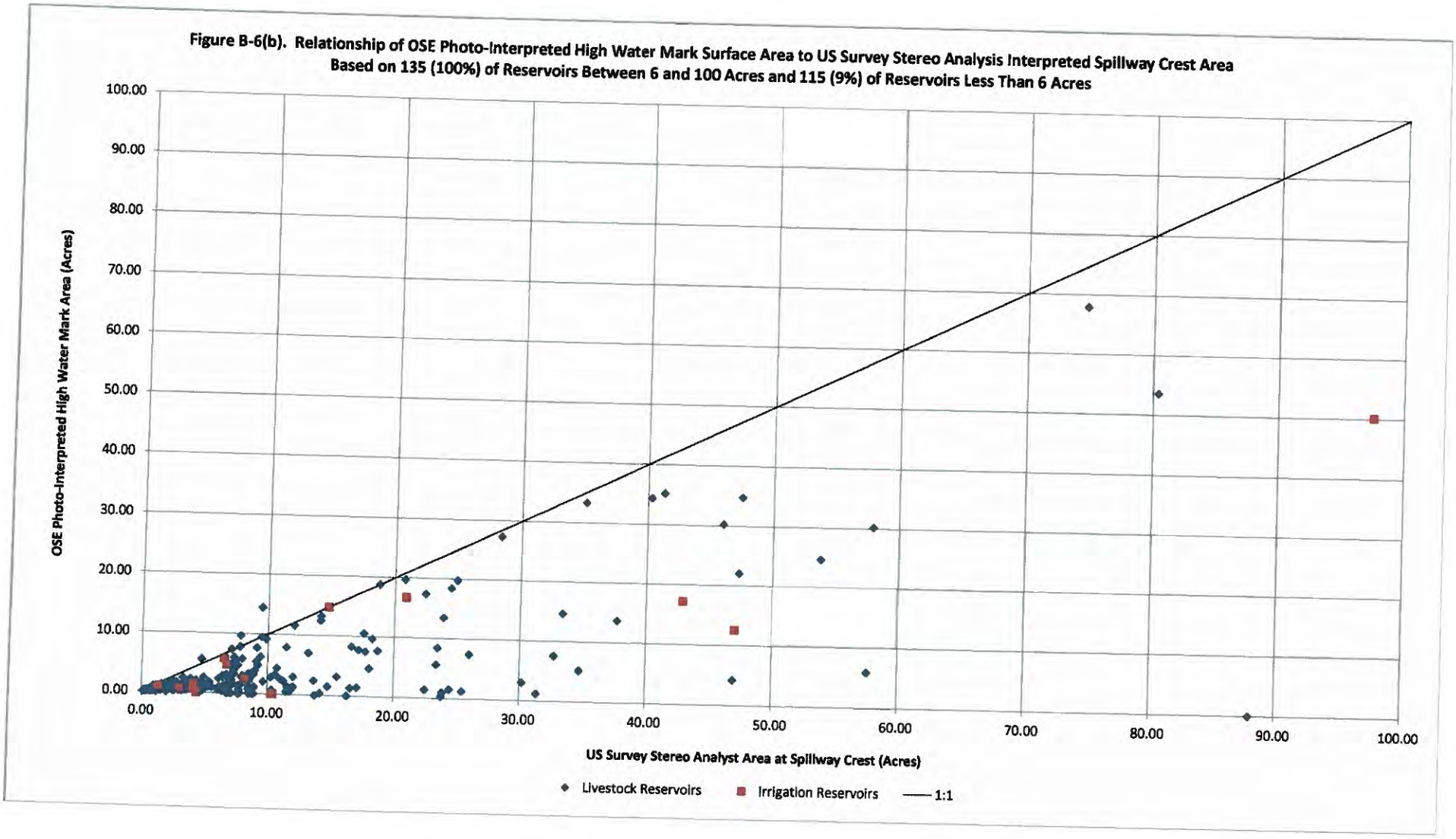


Figure B-6(c). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Stereo Analysis Interpreted Spillway Crest Area For Livestock and Irrigation Reservoirs Claimed by the US Survey to be Less Than 20 Acres

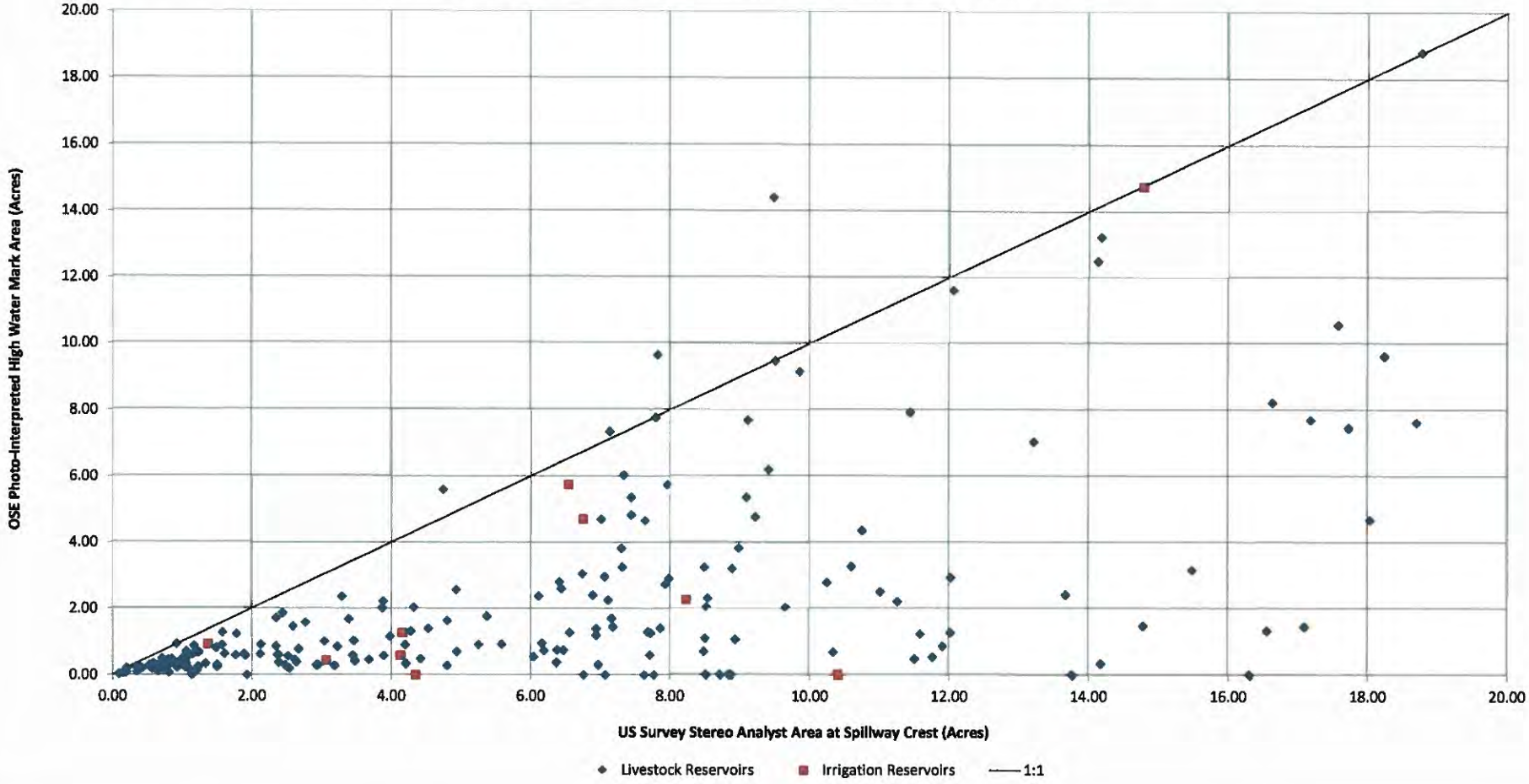


Figure B-6(d). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Stereo Analysis Interpreted Spillway Crest Area For Livestock and Irrigation Reservoirs Claimed by the US Survey to be Less Than 20 Acres

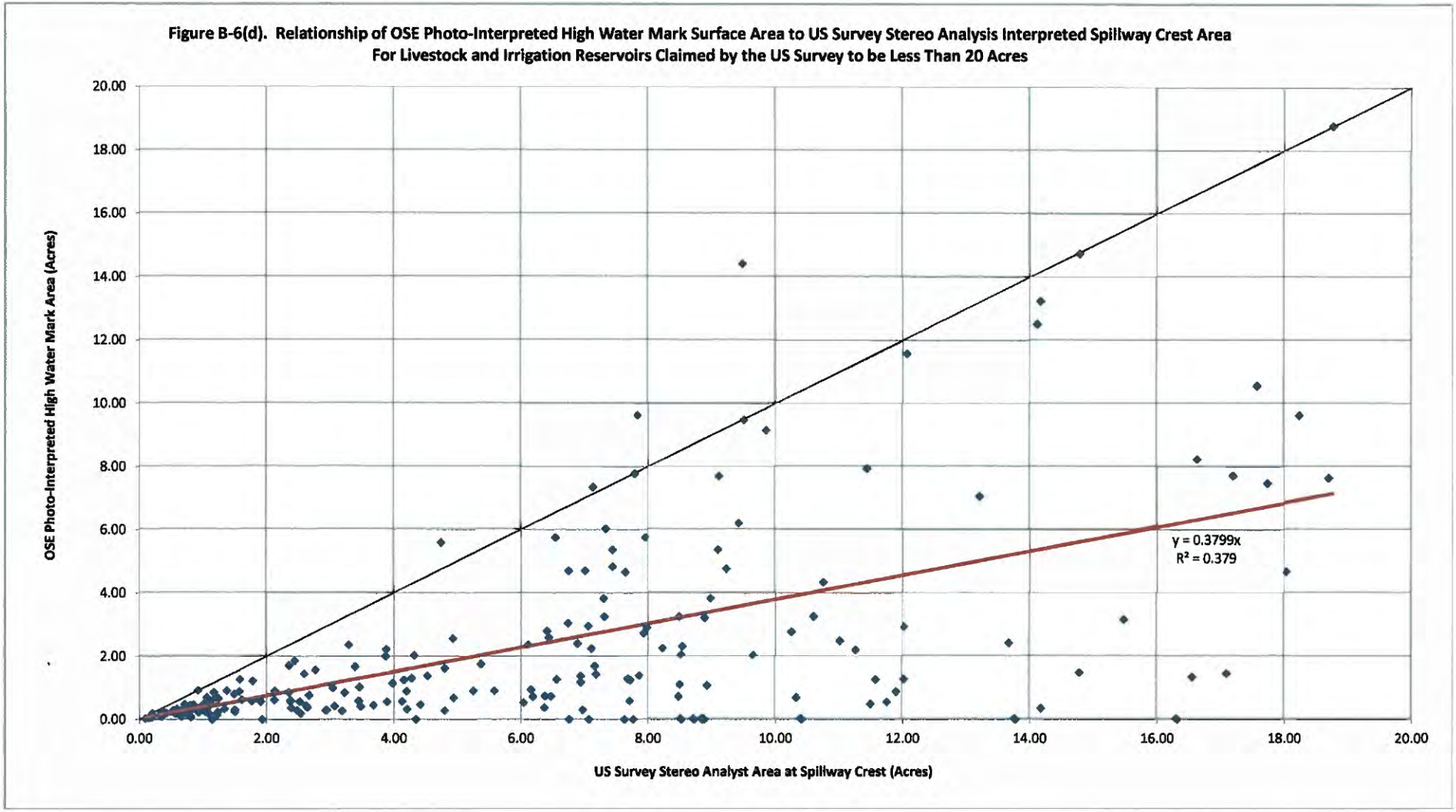


Figure B-6(e). Relationship of OSE Photo-Interpreted High Water Mark Surface Area to US Survey Stereo Analysis Interpreted Spillway Crest Area For Livestock and Irrigation Reservoirs Claimed by the US Survey to be Less Than 20 Acres, by Reservoir Type

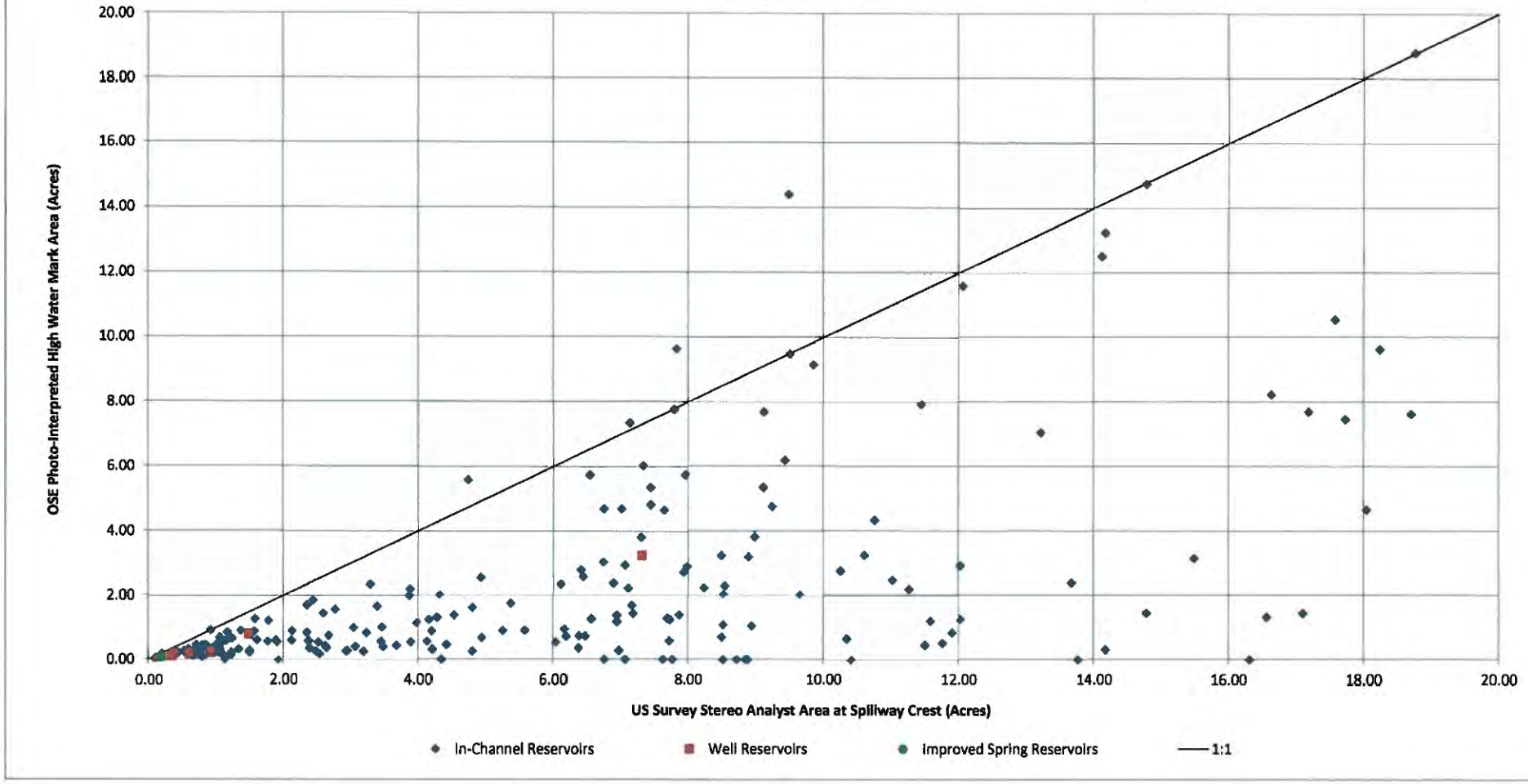


Figure B-7. Relationship of US Survey Depths at Spillway Crest Measured from the Invert versus Measured from the Toe, by Reservoir Type

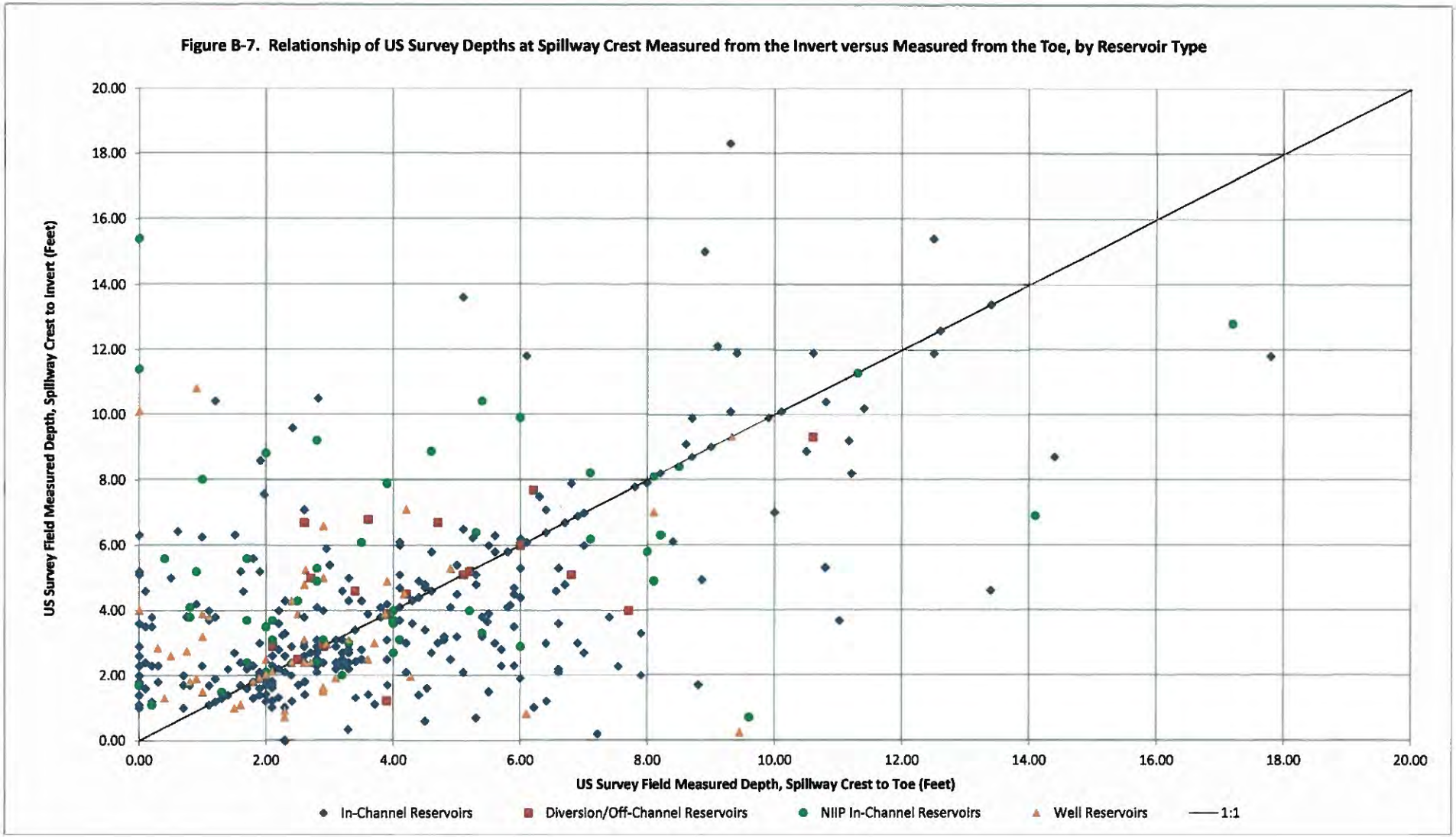


Figure B-8(a). Relationship of US Survey Measured Depths at Spillway Crest to Measured Area at Spillway Crest, by Reservoir Type

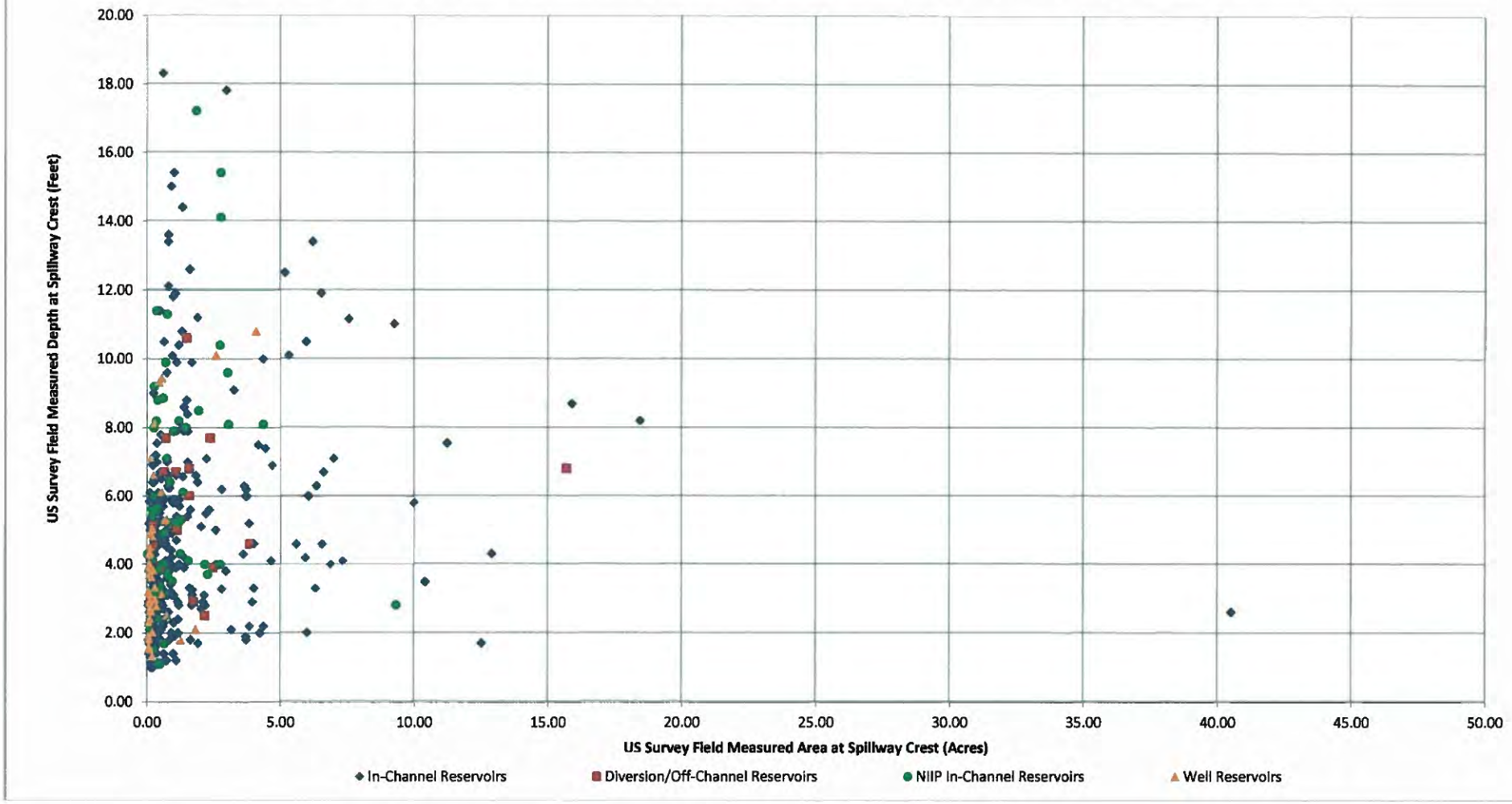
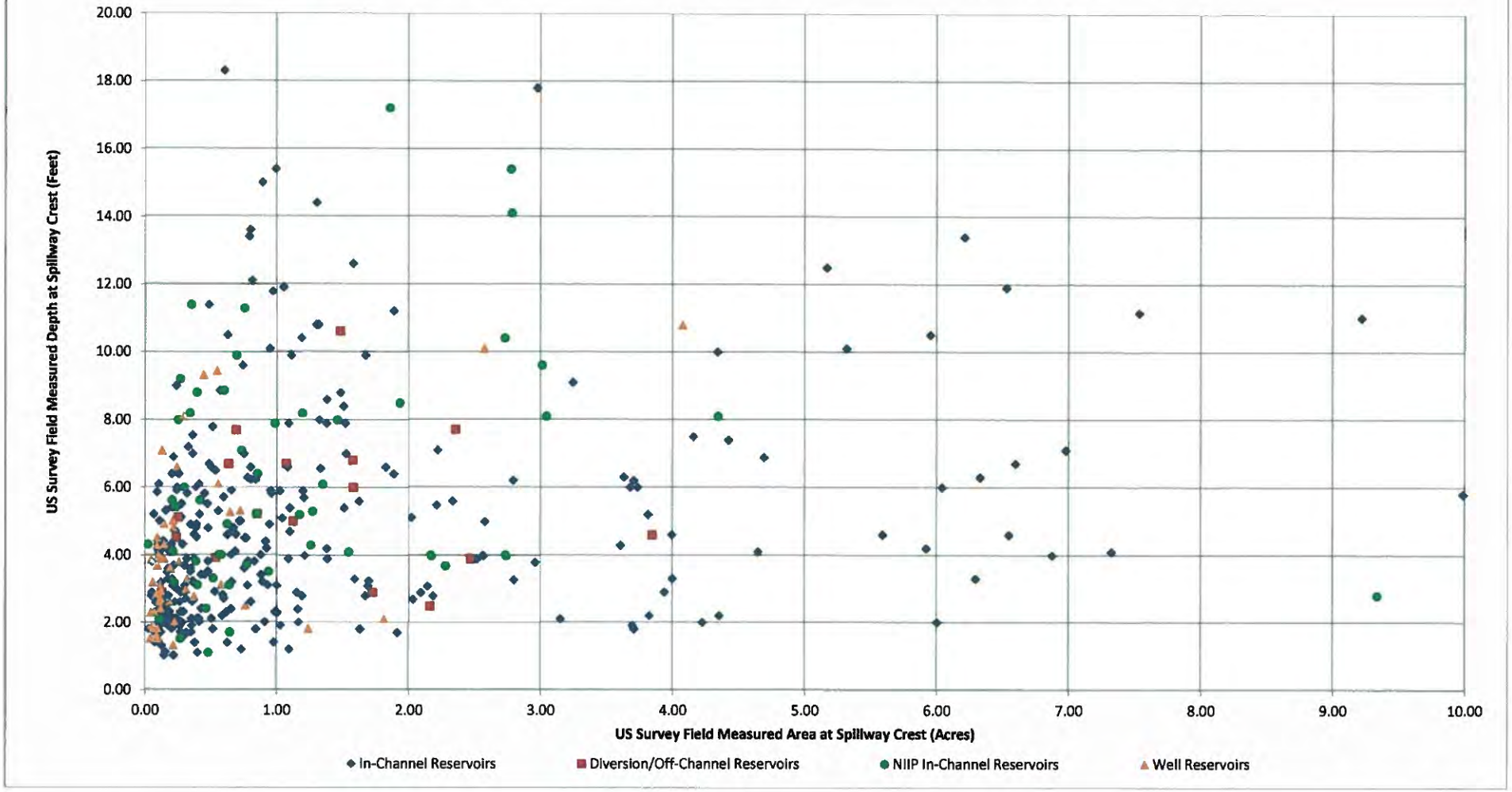
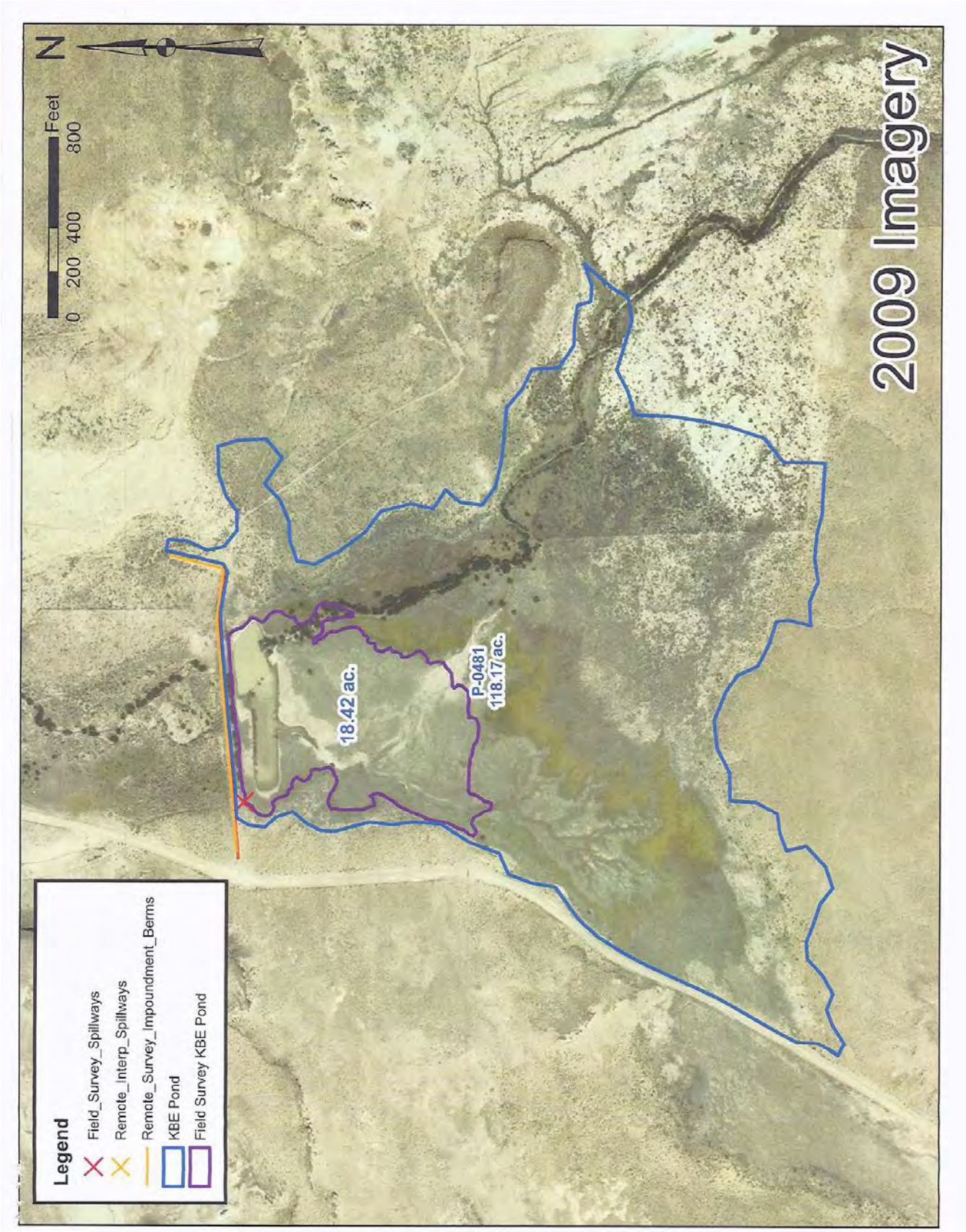


Figure B-8(b). Relationship of US Survey Measured Depths at Spillway Crest to Measured Area at Spillway Crest, by Reservoir Type



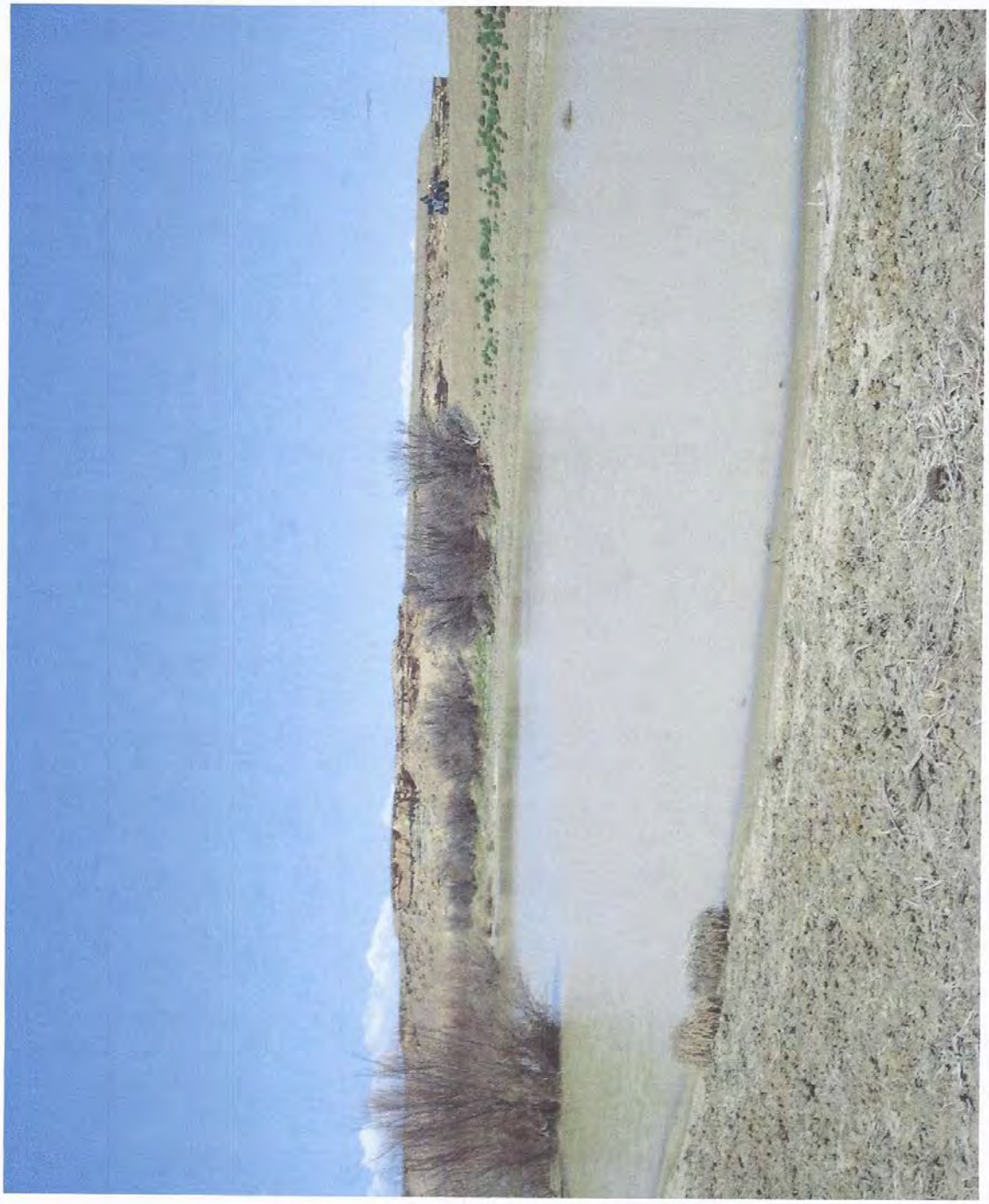
APPENDIX C

Aerial Imagery and Photographs Showing Selected Reservoir Sites
Claimed by the US Survey for Tributary Livestock and Irrigation Reservoirs



Picture C-1(a). Aerial Imagery Showing Livestock Impoundment No. P-5033 (field surveyed area) and Impoundment No. P-0481 (stereo analysis interpreted area)

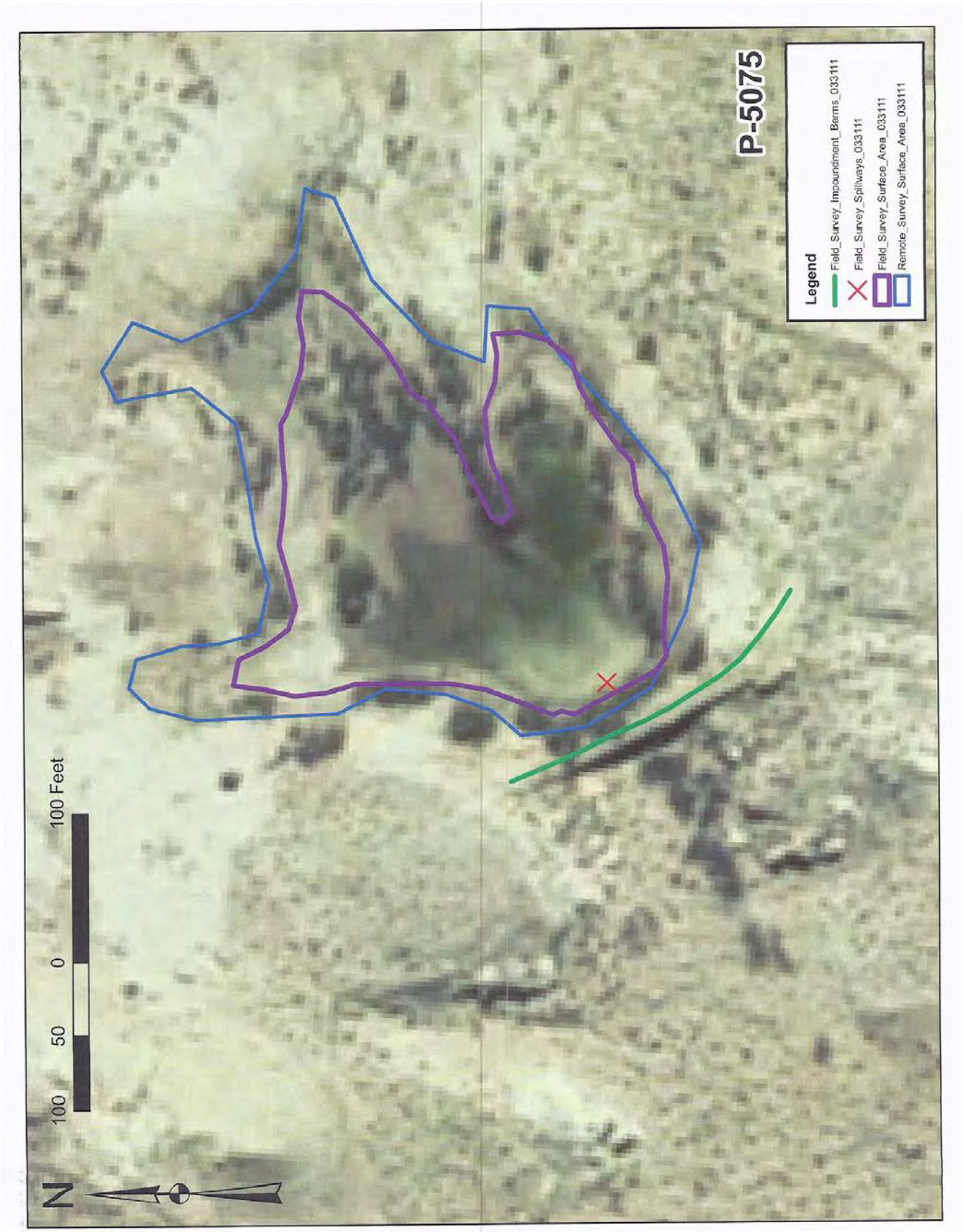
Picture C-1(b). Photograph Showing Livestock Impoundment No. P-5033 Outlet Pipe



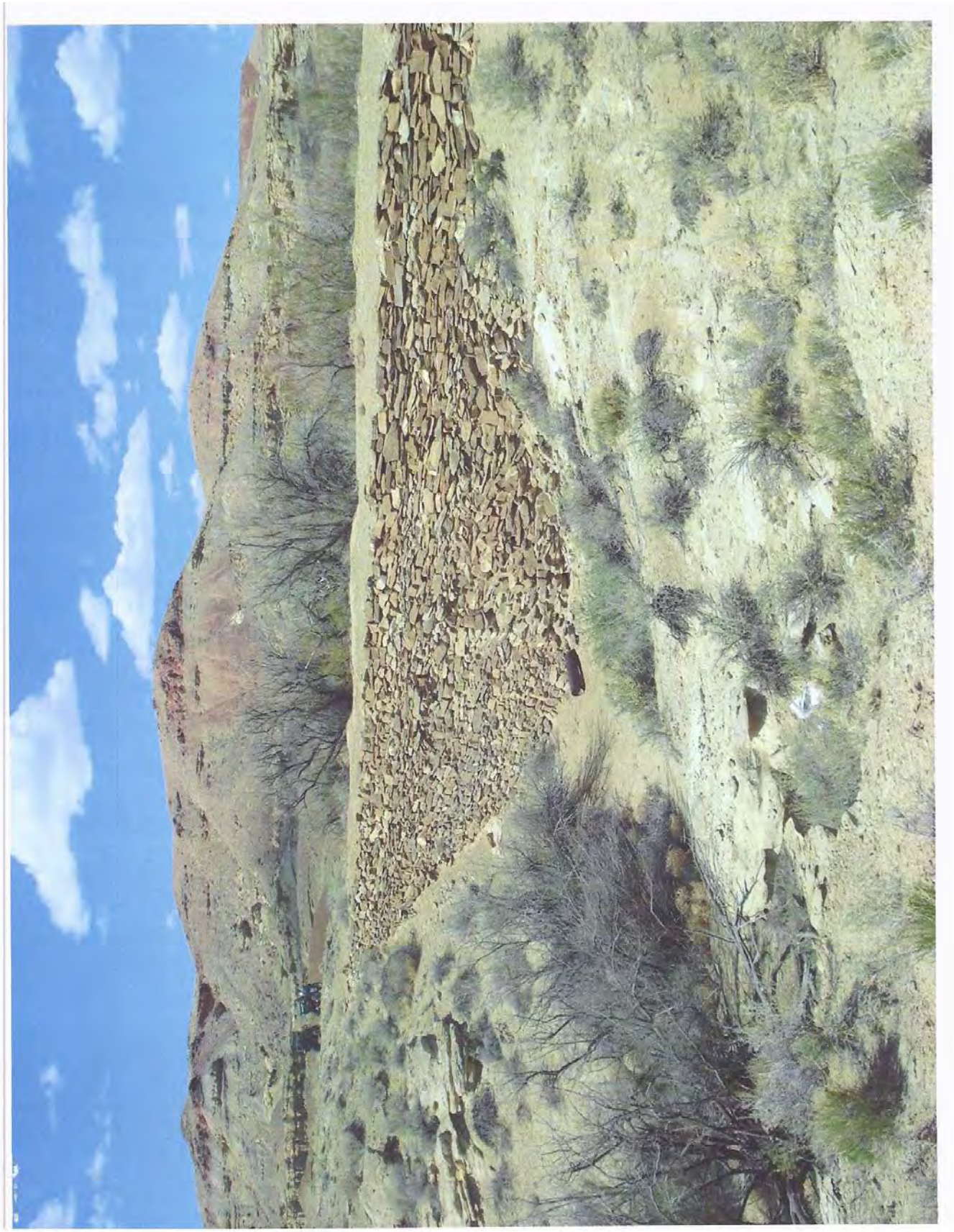
Picture C-1(c). Photograph Showing Livestock Impoundment No. P-5033

Picture C-2(a). Aerial Imagery Showing Livestock Impoundment No. P-5215 (field surveyed and associated stereo analysis interpreted area)

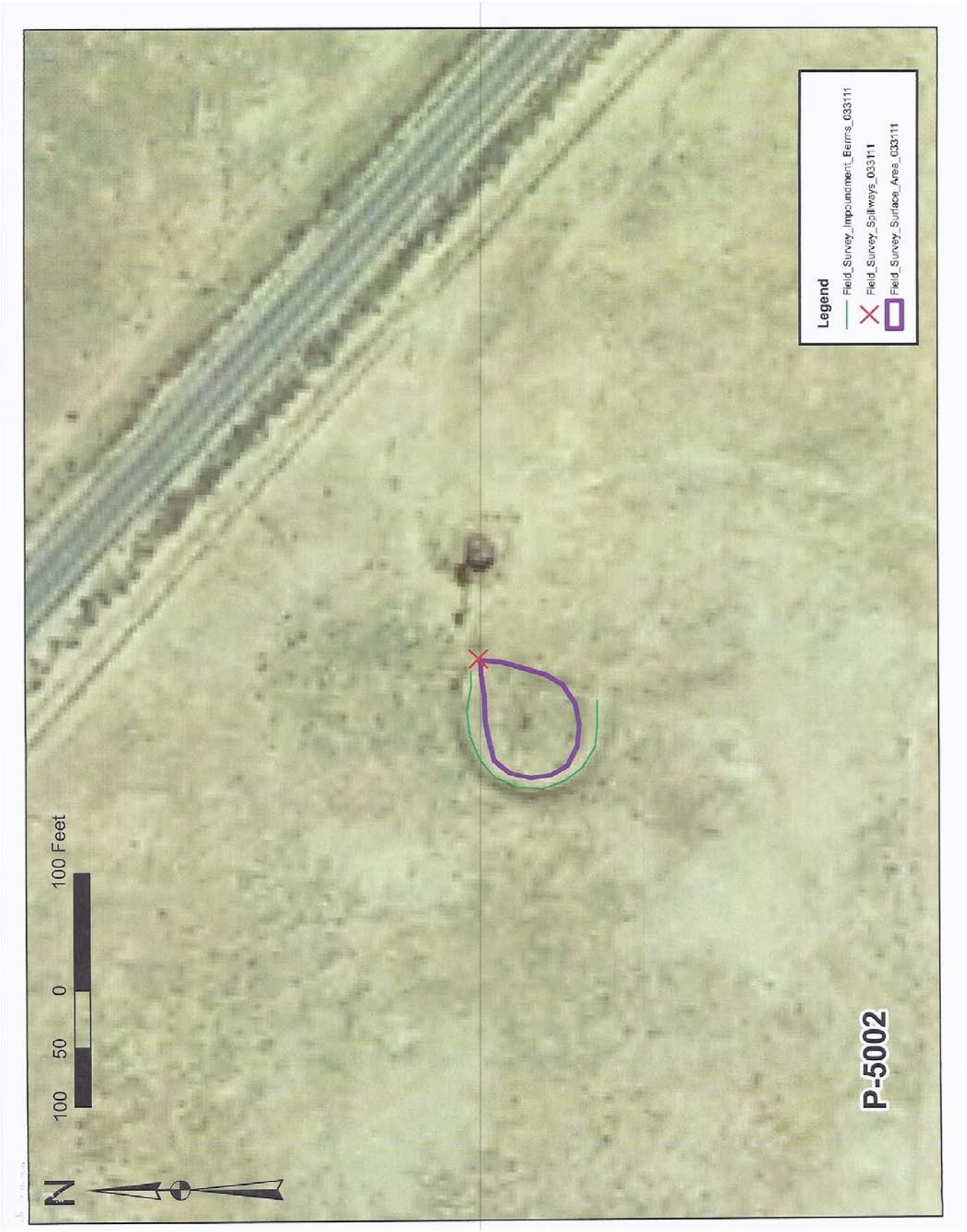
Picture C-2(b). Photograph Showing Livestock Impoundment No. P-5215



Picture C-3(a). Aerial Imagery Showing Livestock Impoundment No. P-5075 (field surveyed and associated stereo analysis interpreted area)



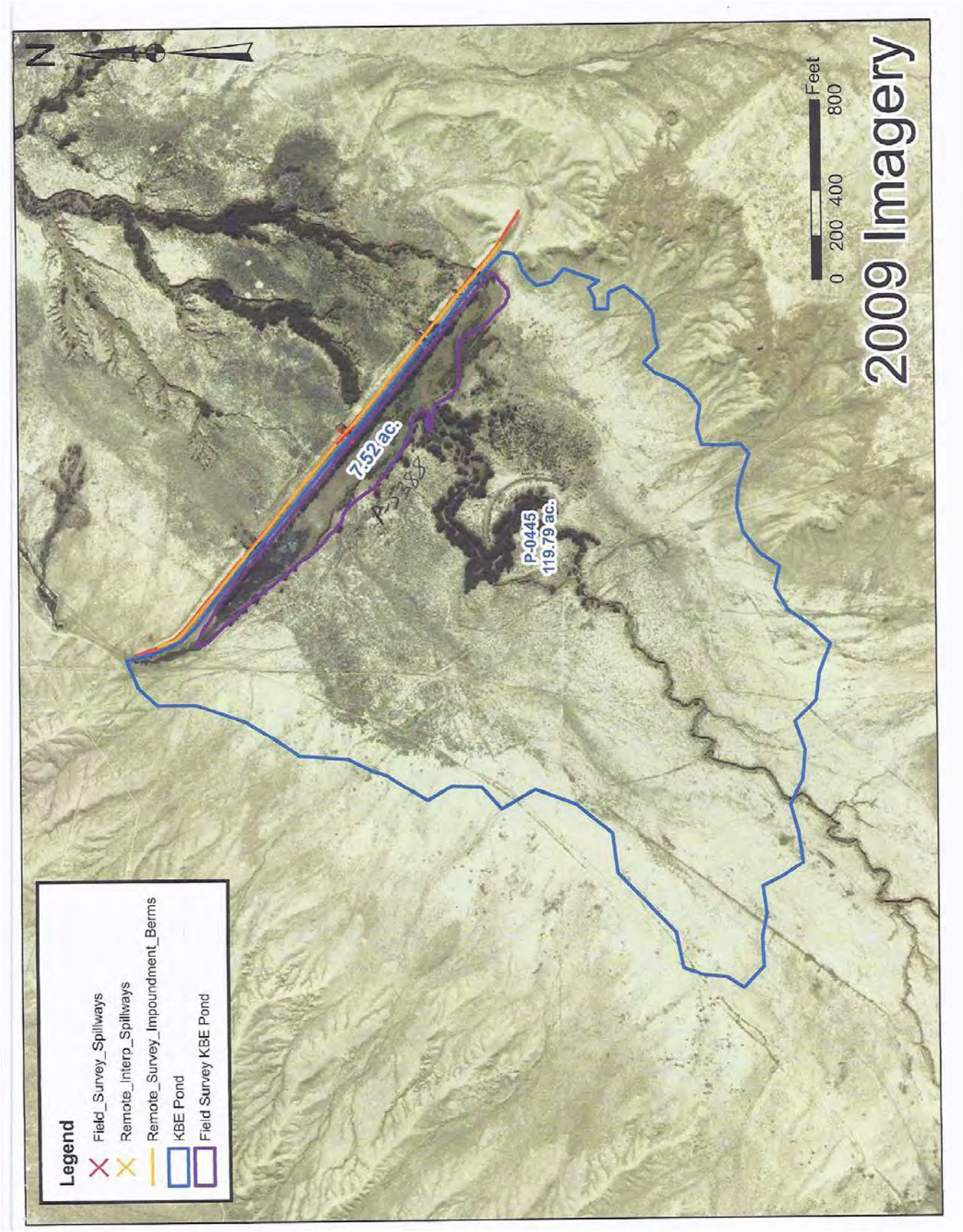
Picture C-3(b). Photograph Showing Livestock Impoundment No. P-5075 Dam and Outlet Pipe



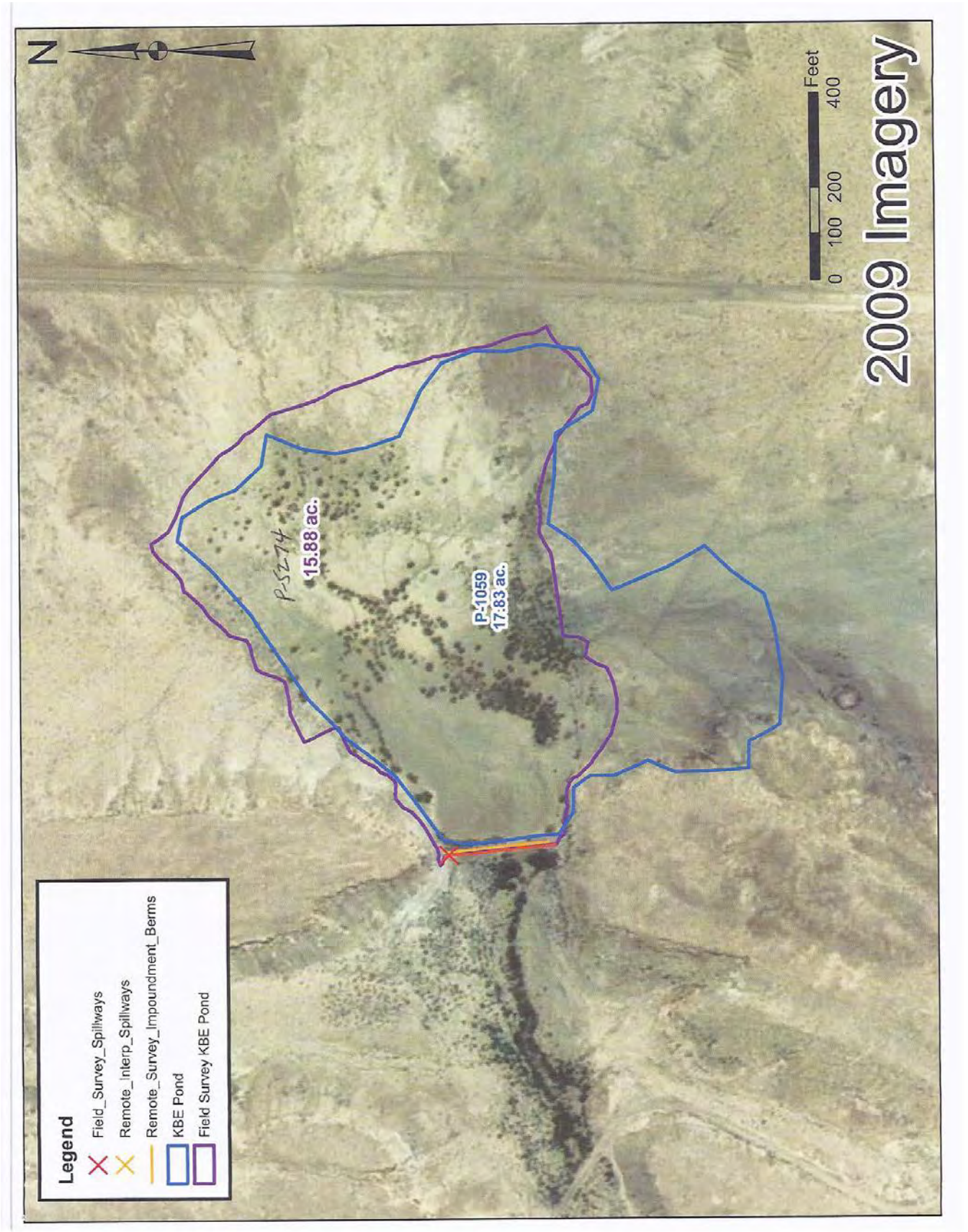
Picture C-4(a). Aerial Imagery Showing Livestock Impoundment No. P-5002 (field surveyed area)

Picture C-4(b). Photograph Showing Livestock Impoundment No. P-5002

Picture C-5. Photograph Showing Livestock Impoundment No. P-5201

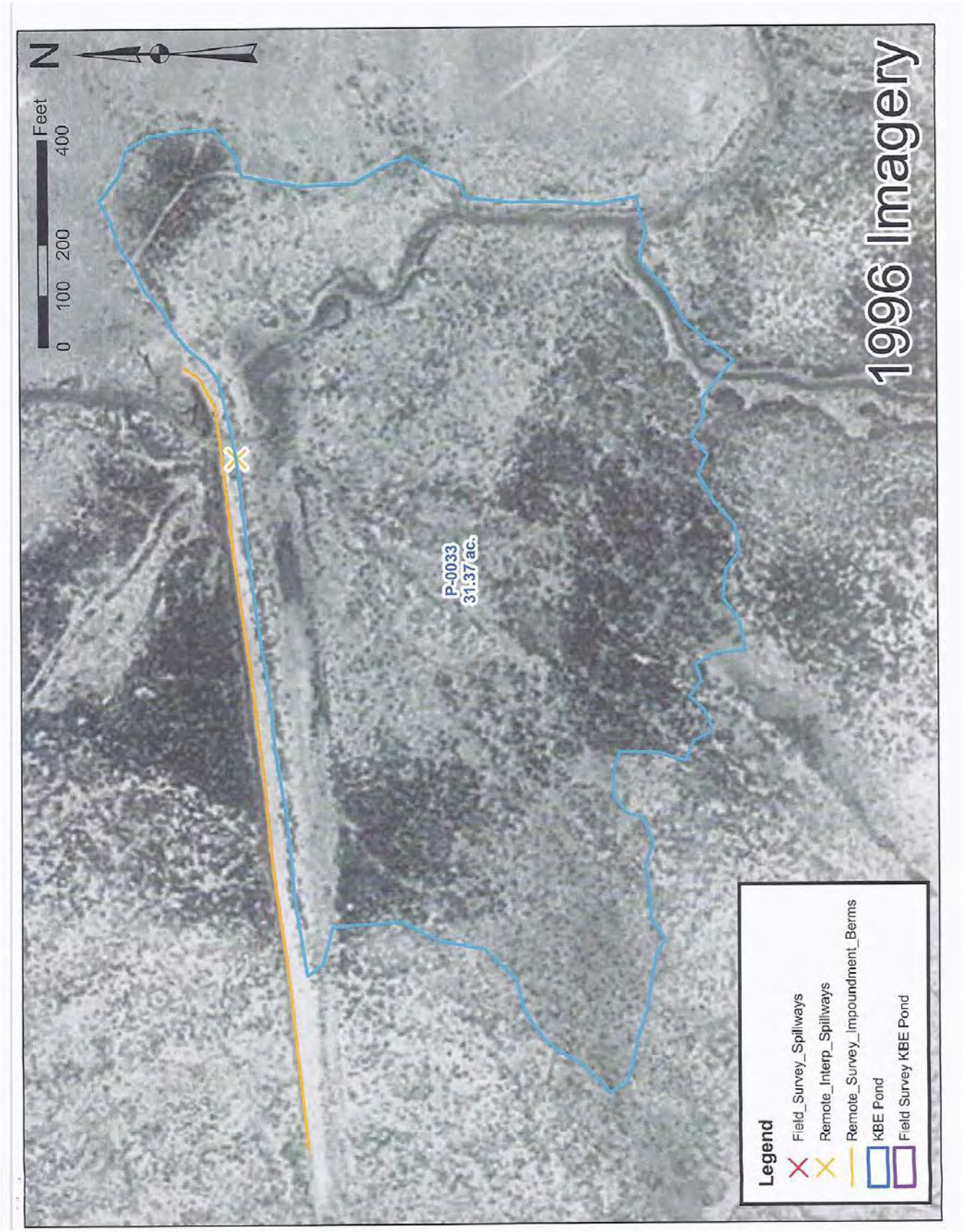


Picture C-6. Aerial Imagery Showing Livestock Impoundment No. P-5388 (field surveyed area) and Impoundment No. P-0445 (stereo analysis interpreted area)

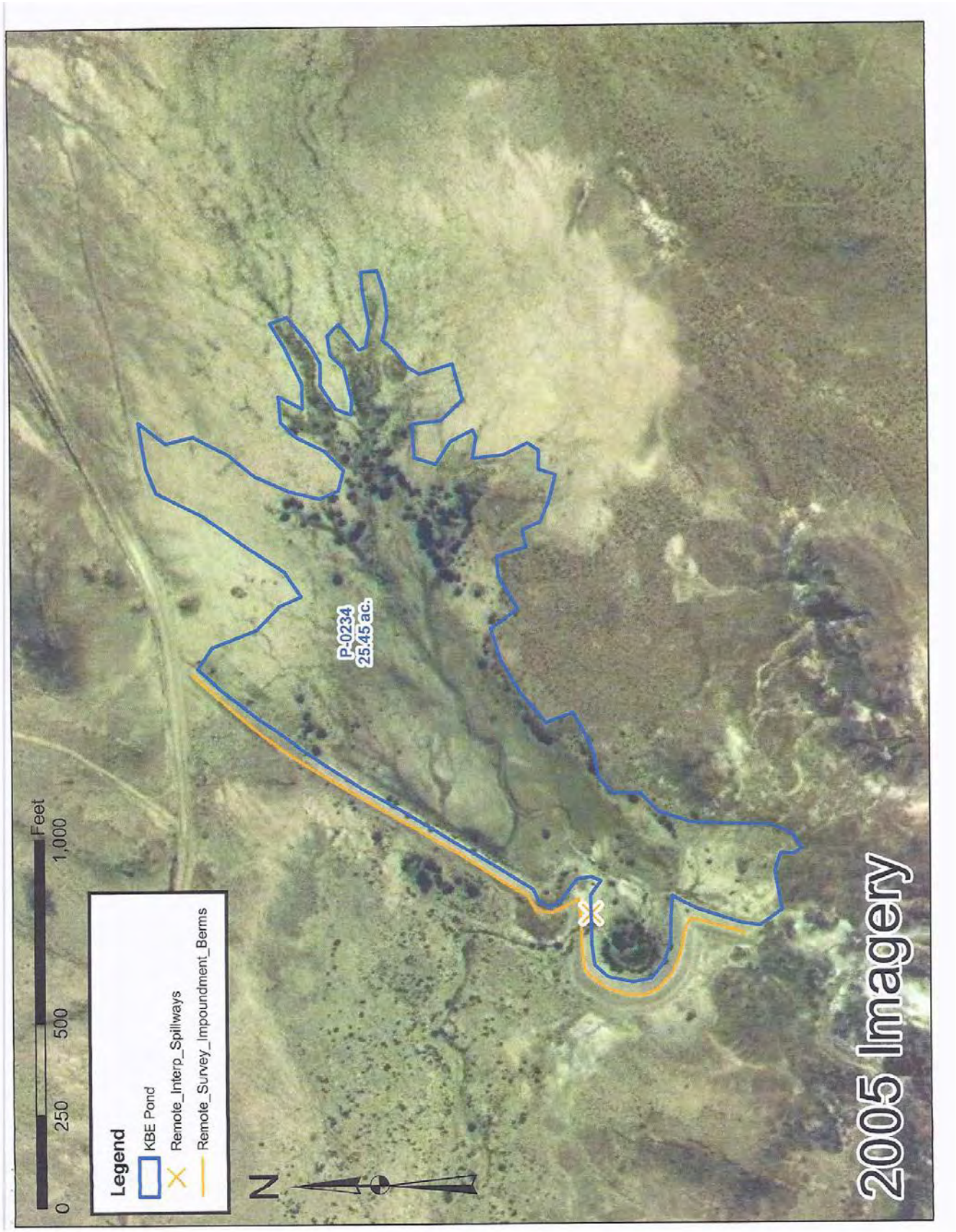


Picture C-7. Aerial Imagery Showing Livestock Impoundment No. P-5274 (field surveyed area) and Impoundment No. P-1059 (stereo analysis interpreted area)

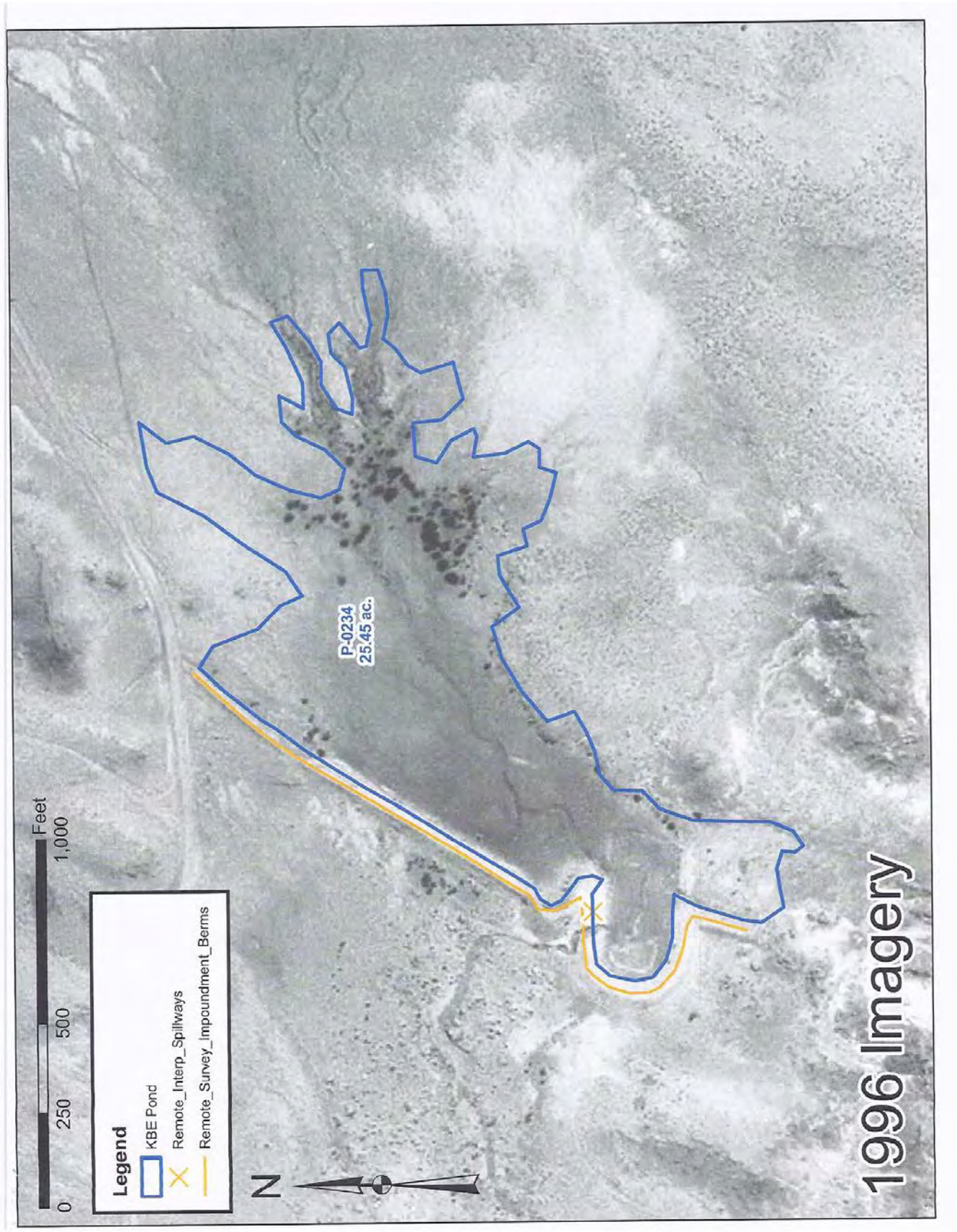
Picture C-8(a). Aerial Imagery Showing Livestock Impoundment No. P-0033 (stereo analysis interpreted area)



Picture C-8(b). Aerial Imagery Showing Livestock Impoundment No. P-0033 (stereo analysis interpreted area)



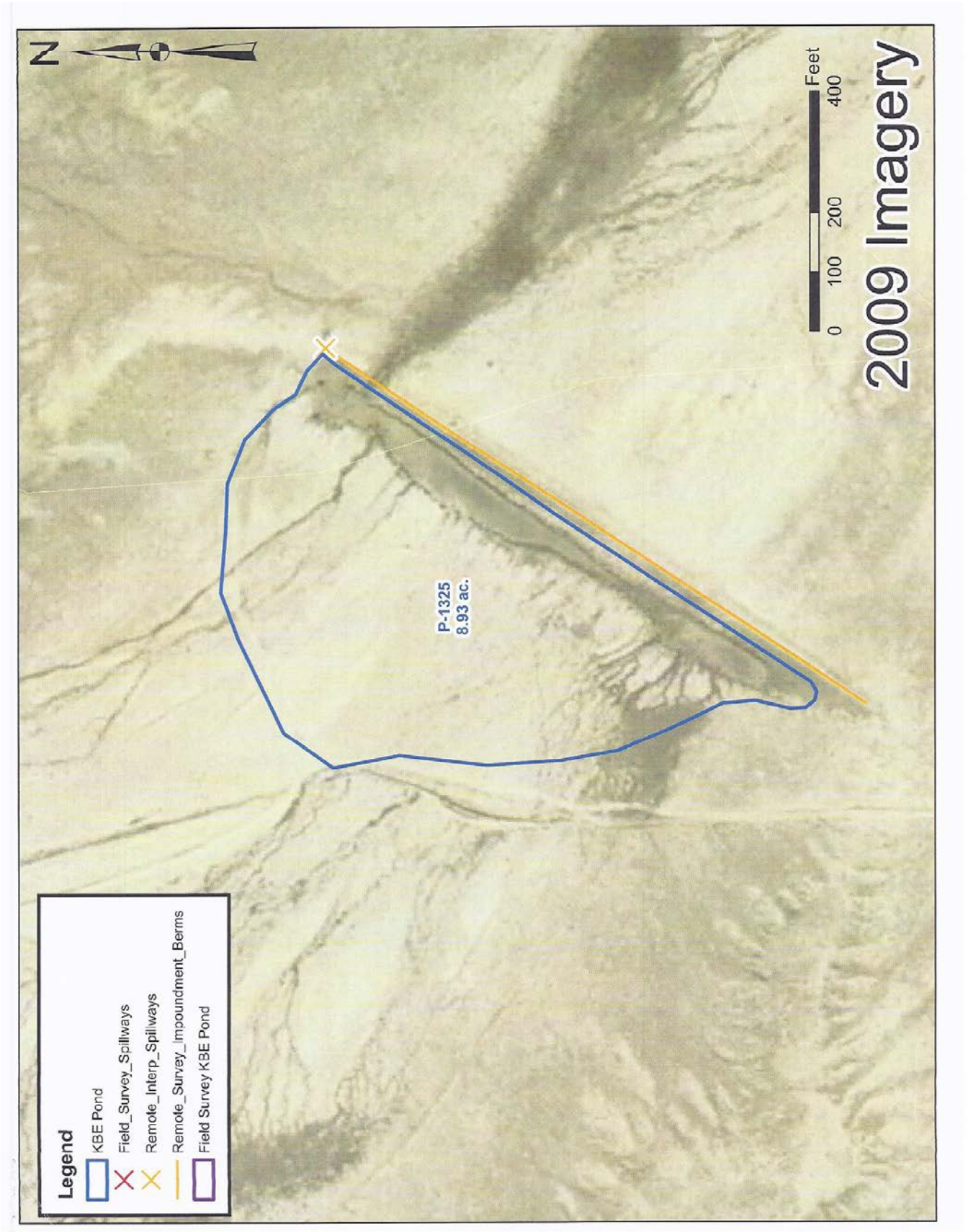
Picture C-9(a). Aerial Imagery Showing Livestock Impoundment No. P-0234 (stereo analysis interpreted area)



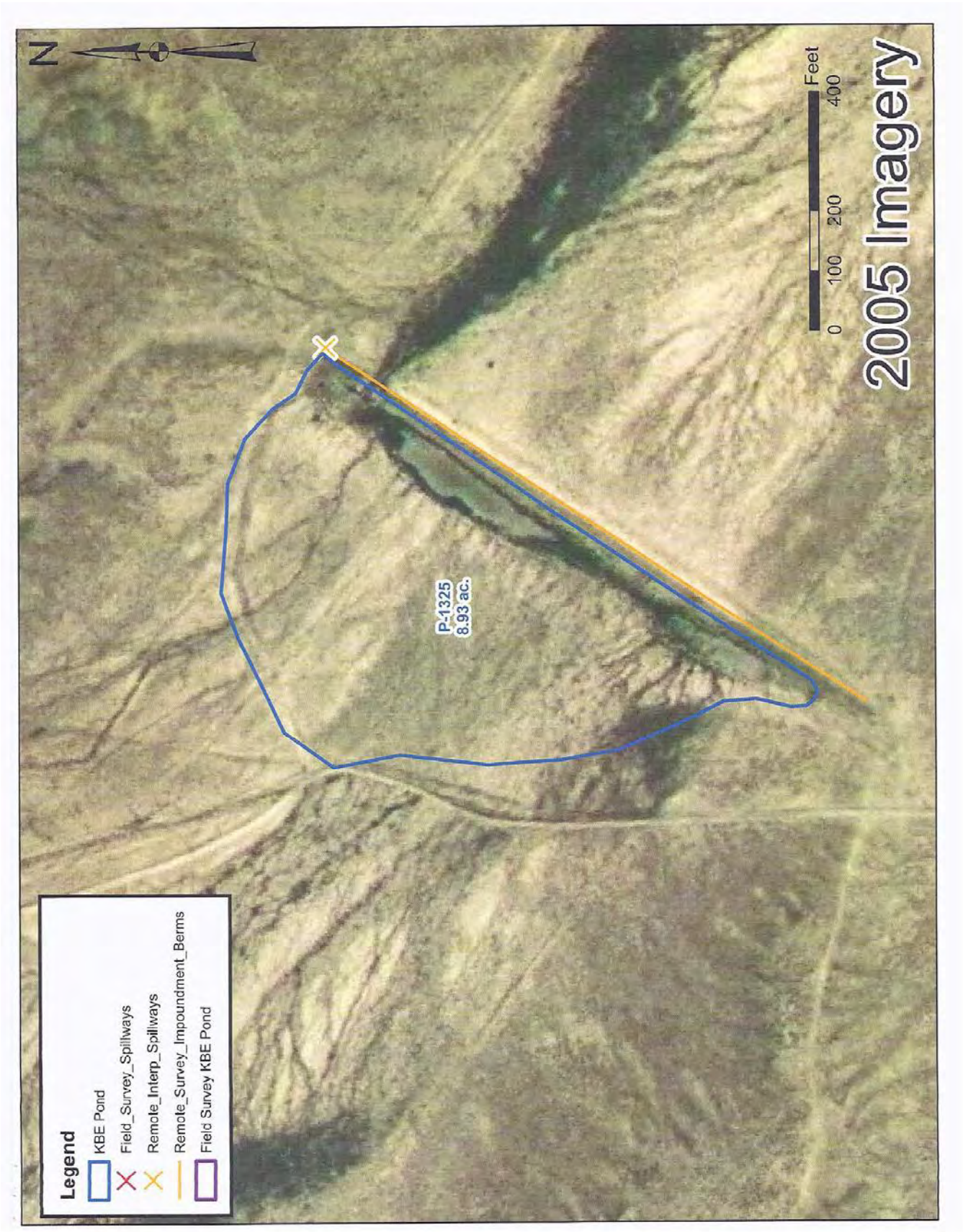
Picture C-9(b). Aerial Imagery Showing Livestock Impoundment No. P-0234 (stereo analysis interpreted area)

Picture C-10. Aerial Imagery Showing Livestock Impoundment No. P-0470 (stereo analysis interpreted area)

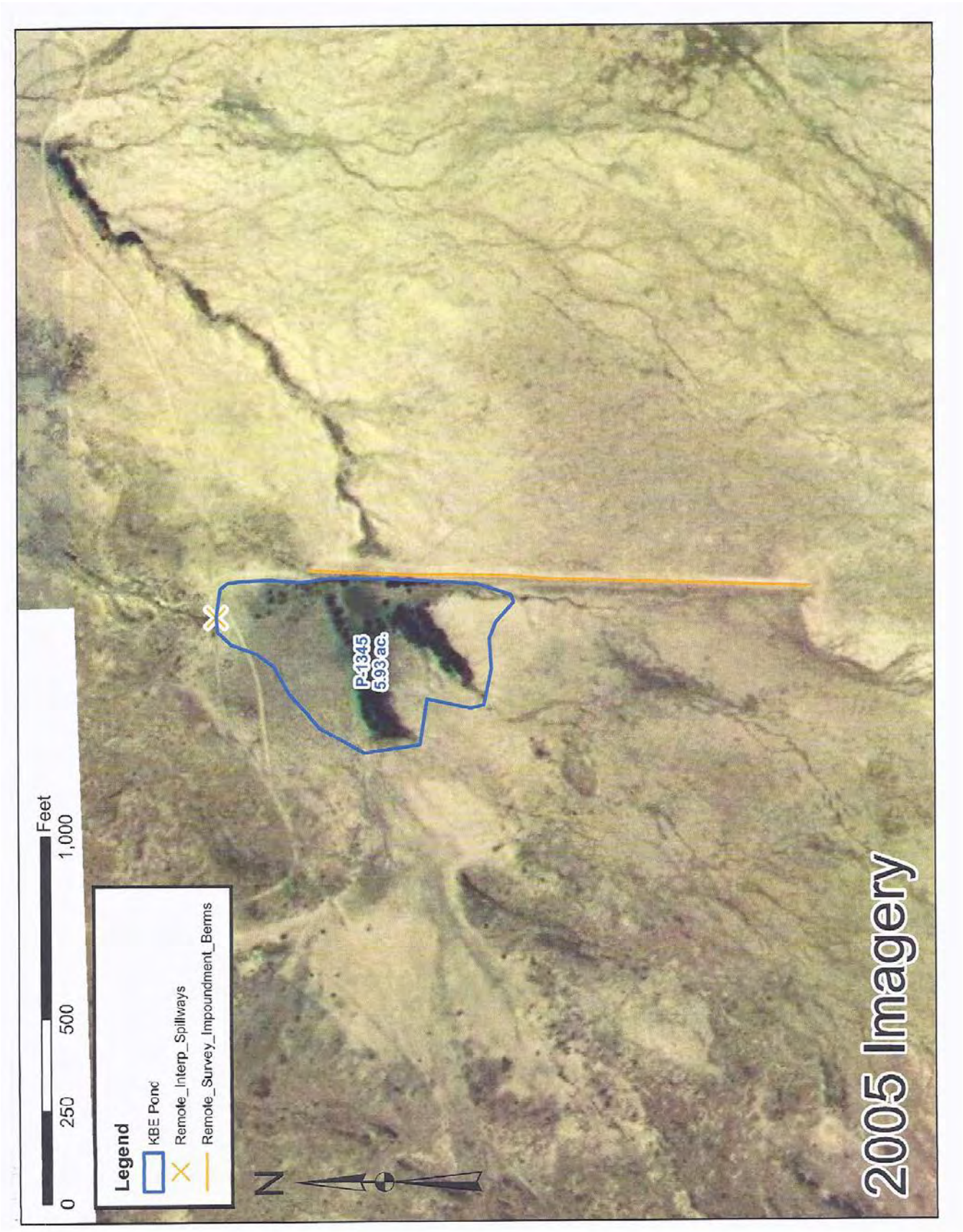
Picture C-11. Aerial Imagery Showing Livestock Impoundment No. P-0740 (stereo analysis interpreted area)



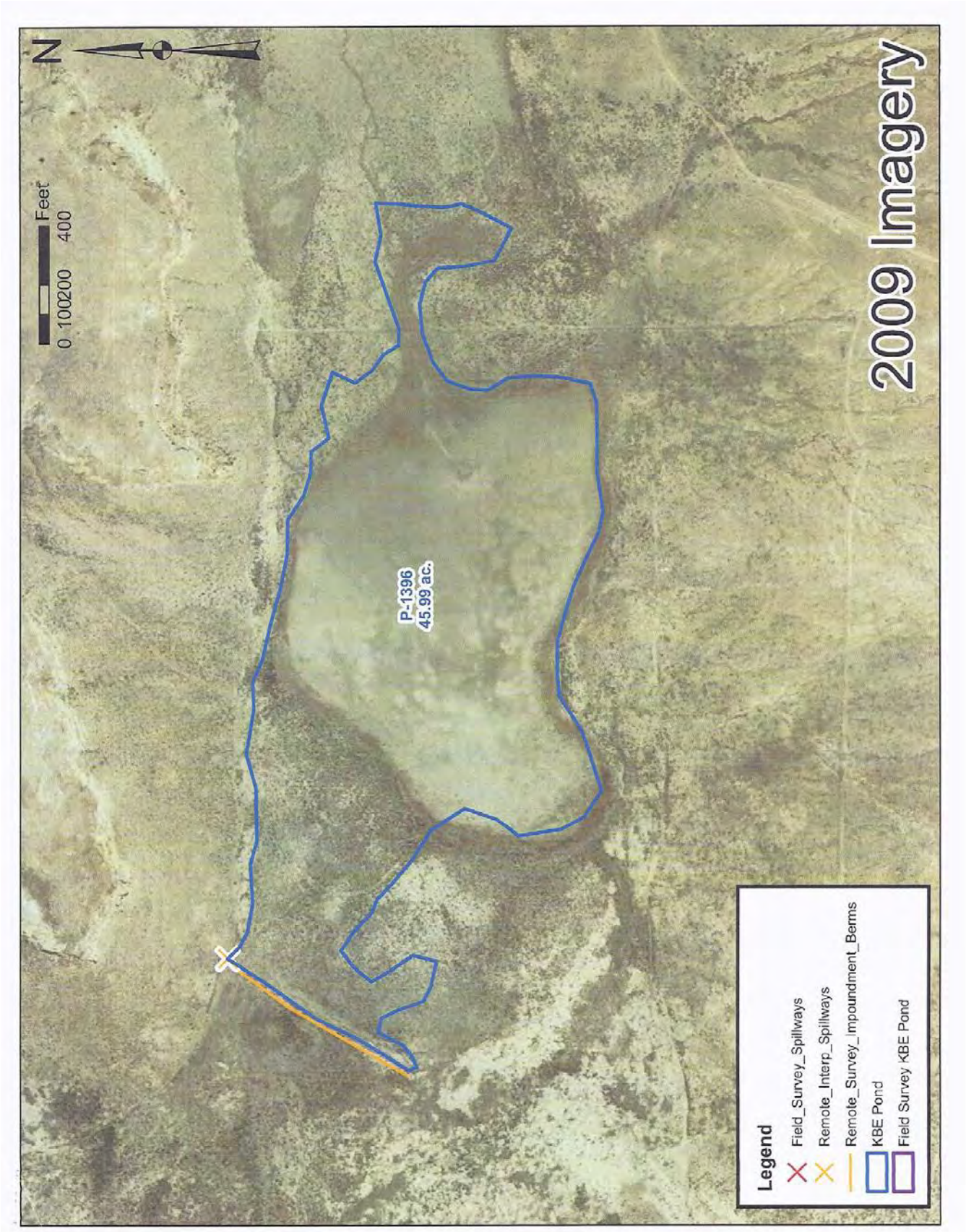
Picture C-12(a). Aerial Imagery Showing Livestock Impoundment No. P-1325 (stereo analysis interpreted area)



Picture C-12(b). Aerial Imagery Showing Livestock Impoundment No. P-1325 (stereo analysis interpreted area)

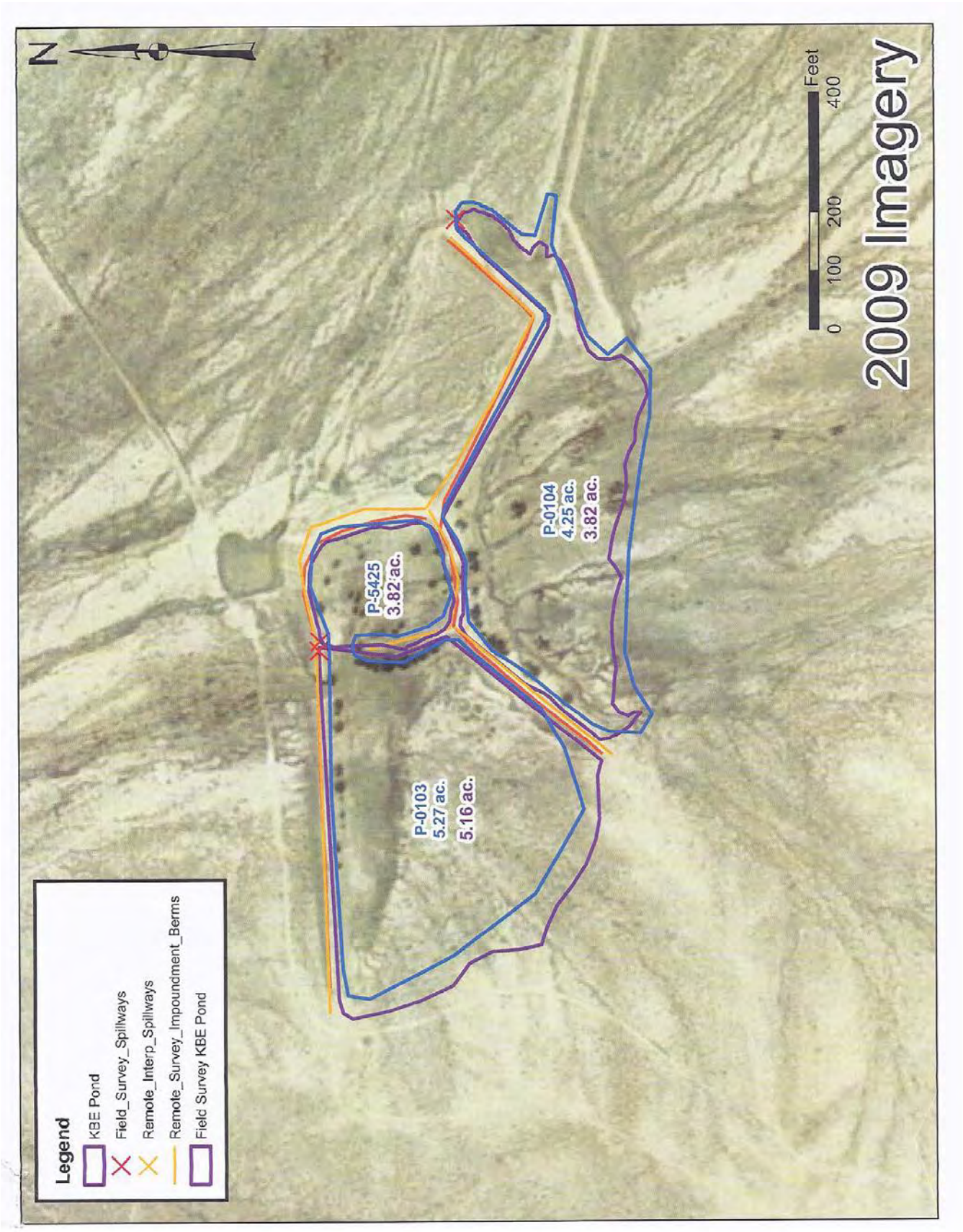


Picture C-13. Aerial Imagery Showing Livestock Impoundment No. P-1345 (stereo analysis interpreted area)

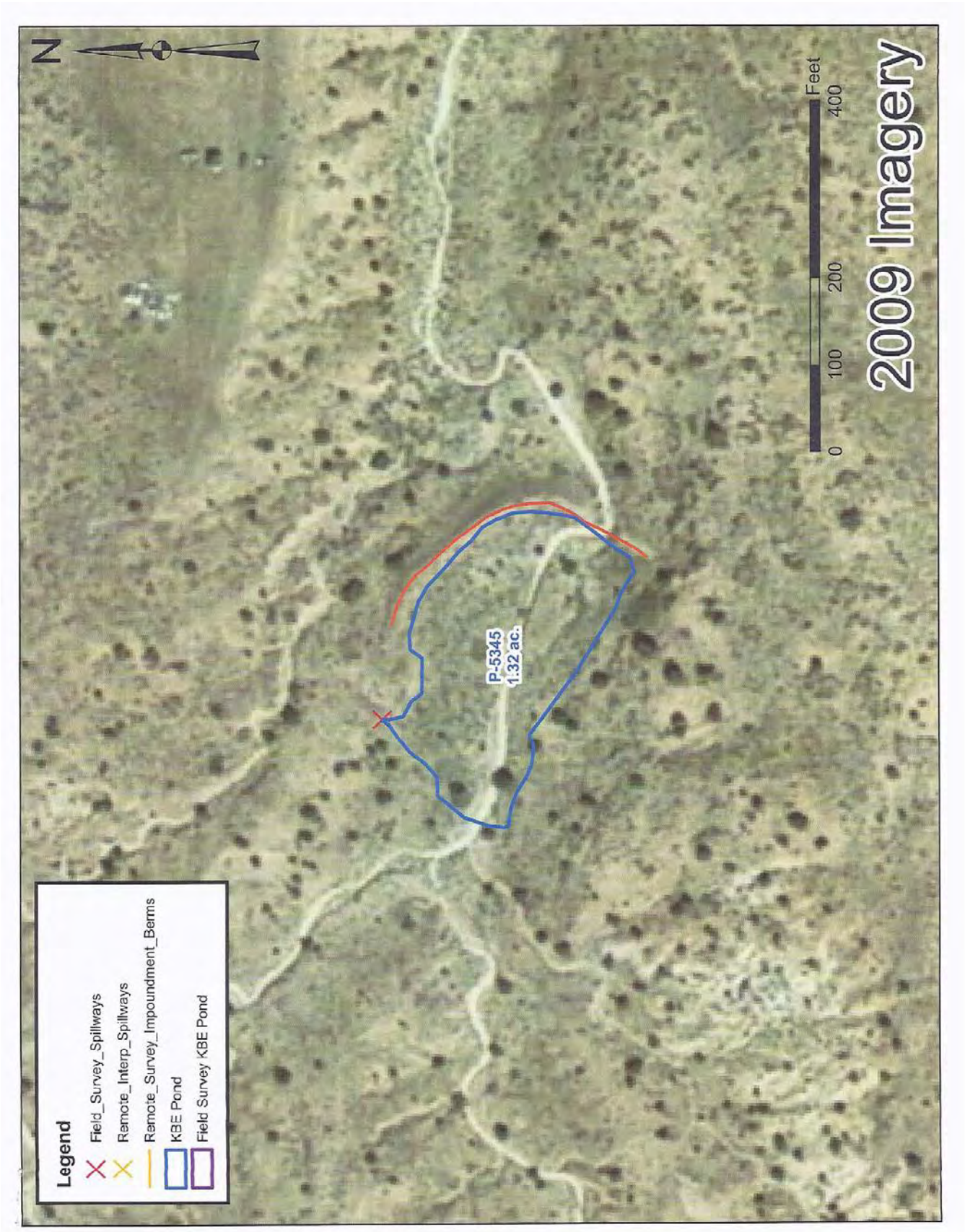


Picture C-14(a). Aerial Imagery Showing Livestock Impoundment No. P-1396 (stereo analysis interpreted area)

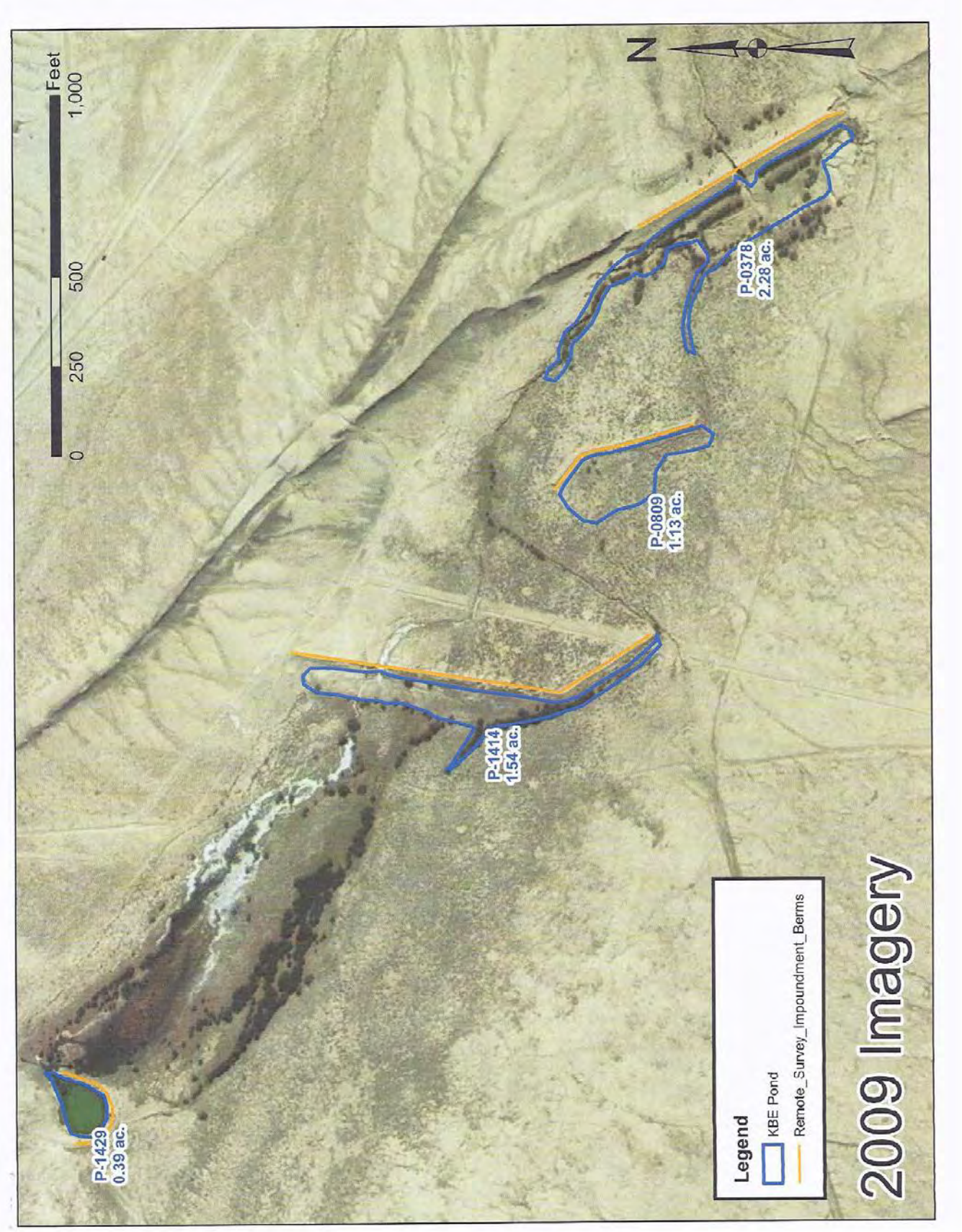
Picture C-14(b). Aerial Imagery Showing Livestock Impoundment No. P-1396 (stereo analysis interpreted area)



Picture C-15. Aerial Imagery Showing Livestock Impoundment Nos. P-0103, P-0104 and P-5425 (field measured and stereo analysis interpreted areas)



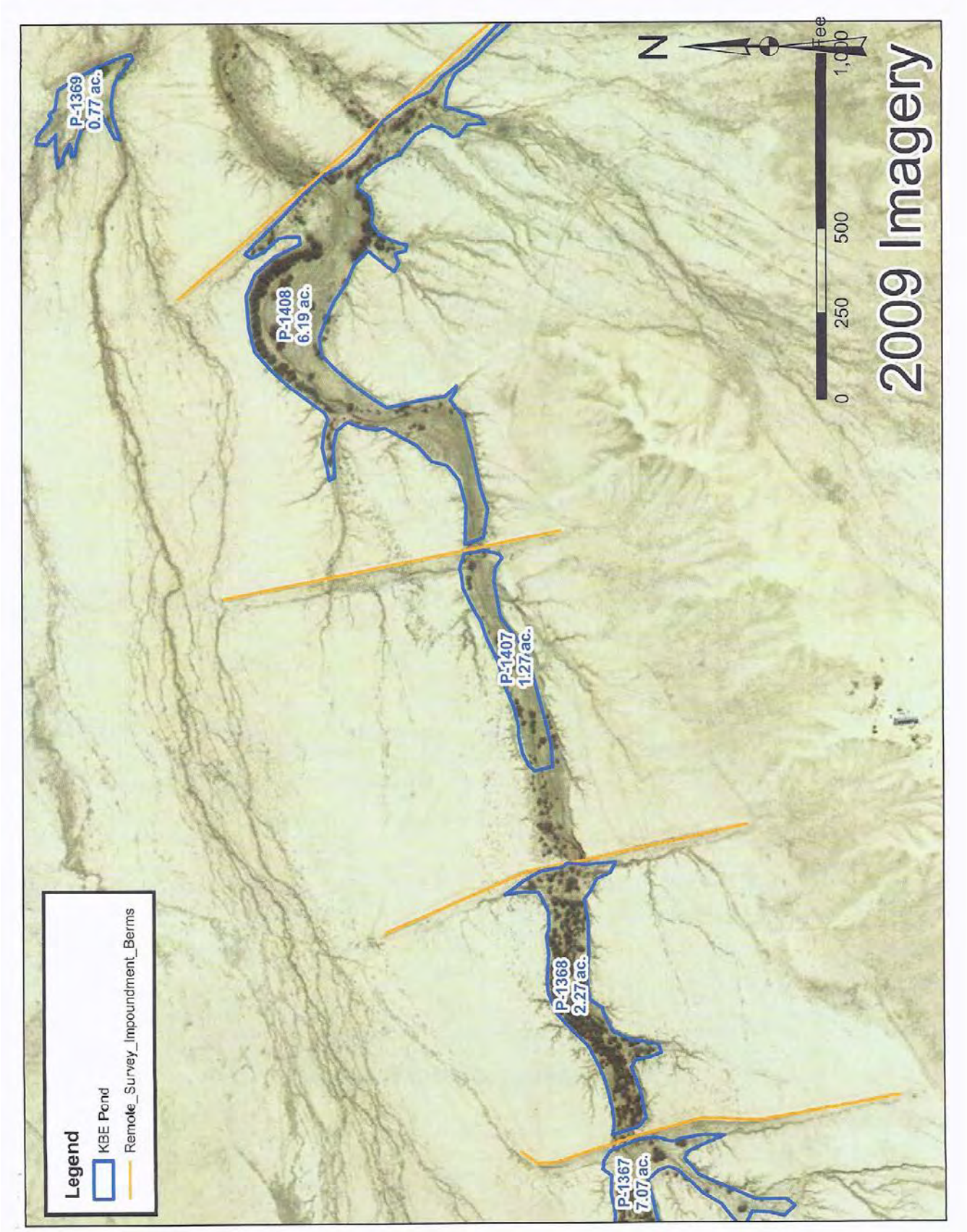
Picture C-16. Aerial Imagery Showing Livestock Impoundment No. P-5345 (field surveyed area)



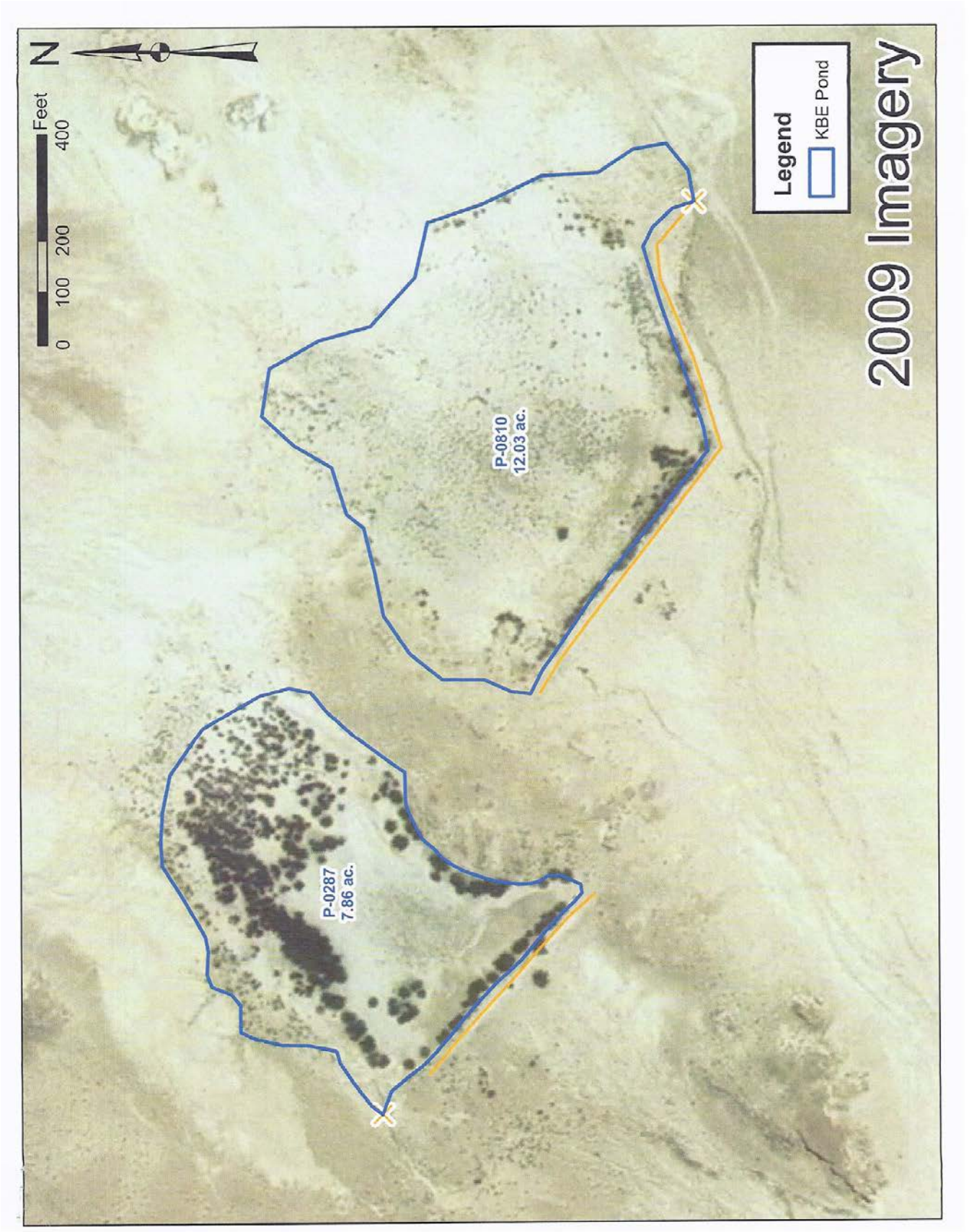
Picture C-17. Aerial Imagery Showing Livestock Impoundment Nos. P-1429, P-1414, P-0809 and P-0378 (stereo analysis interpreted areas)

Picture C-18. Photograph Showing Livestock Impoundment No. P-5408

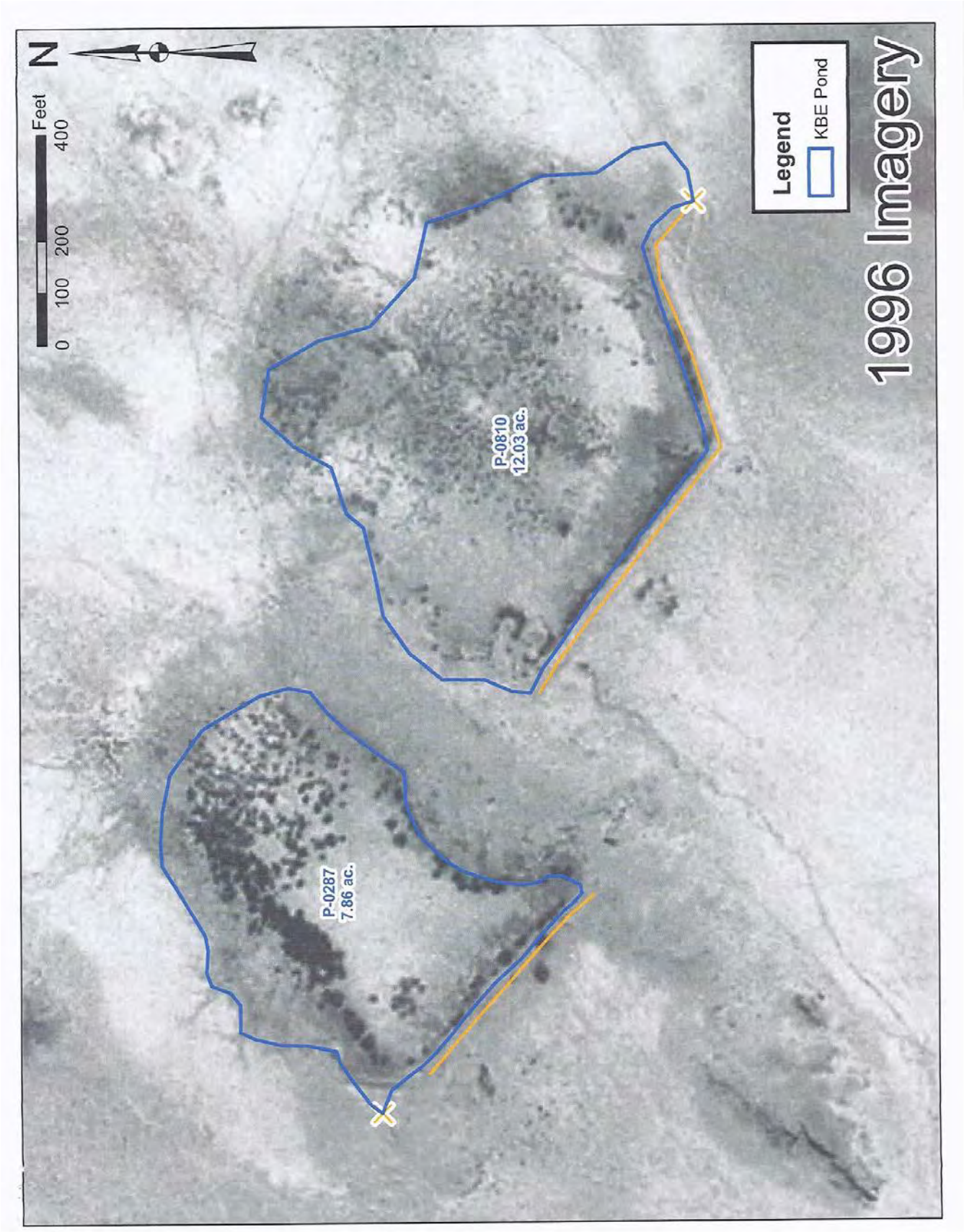
Picture C-19. Photograph Showing Livestock Impoundment No. P-5413



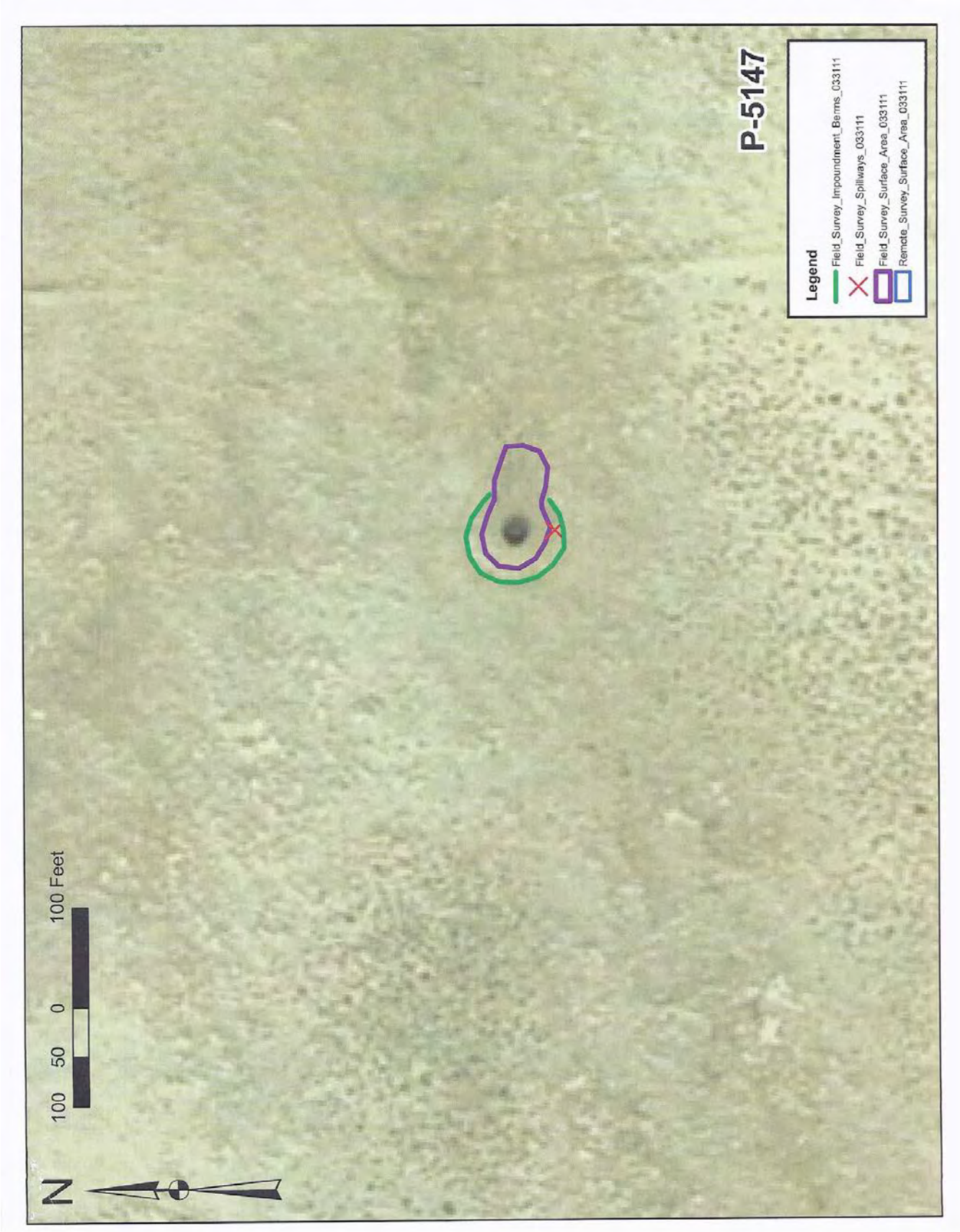
Picture C-20. Aerial Imagery Showing Livestock Impoundment Nos. P-1367, P-1368, P-1369, P-1407 and P-1408 (stereo analysis interpreted areas)



Picture C-21(a). Aerial Imagery Showing Livestock Impoundment Nos. P-0287 and P-0810 (stereo analysis interpreted areas)



Picture C-21(b). Aerial Imagery Showing Livestock Impoundment Nos. P-0287 and P-0810 (stereo analysis interpreted areas)



Picture C-22(a). Aerial Imagery Showing Livestock Impoundment No. P-5147 (field surveyed area)

Picture C-22(b). Photograph Showing Livestock Impoundment No. P-5147

Picture C-23. Photograph Showing Livestock Impoundment No. P-5050 at the Long Lake Irrigation Project (Top) and Livestock Impoundment No. P-5160 at the Red Rock Canyon Irrigation Projects (Bottom)

Picture C-24. Photographs of Irrigation Impoundment Nos. P-1409 and P-1410 on the Red Rock Canyon Projects

Picture C-25. Photographs Showing Irrigation Impoundment No. P-1807 on the Sand Springs Project from Opposite Views

Picture C-26. Photographs of Long Lake (Livestock Impoundment No. P-0042): Top View Shows Reservoir Area to Left of Dam, Bottom View Shows Lake at a Distance Upstream from Dam

APPENDIX D

Office of the State Engineer Hydrographic Survey and Mapping Bureau
Report on Photo-Interpretation of Maximum Areas for
All Reservoirs Claimed to be Larger Than 6 Acres Surface Area and for a
Sampling of Reservoirs Claimed to be Smaller Than 6 Acres Surface Area

APPENDIX E

Calculation of Adjusted Maximum Surface Areas and Storage Volumes, and of Historic Maximum High Water Mark Areas, for Livestock and Irrigation Reservoirs Claimed by the US Survey