Final Report
Santa Ana Watershed Project Authority
Middle Santa Ana River
Agricultural Land Use

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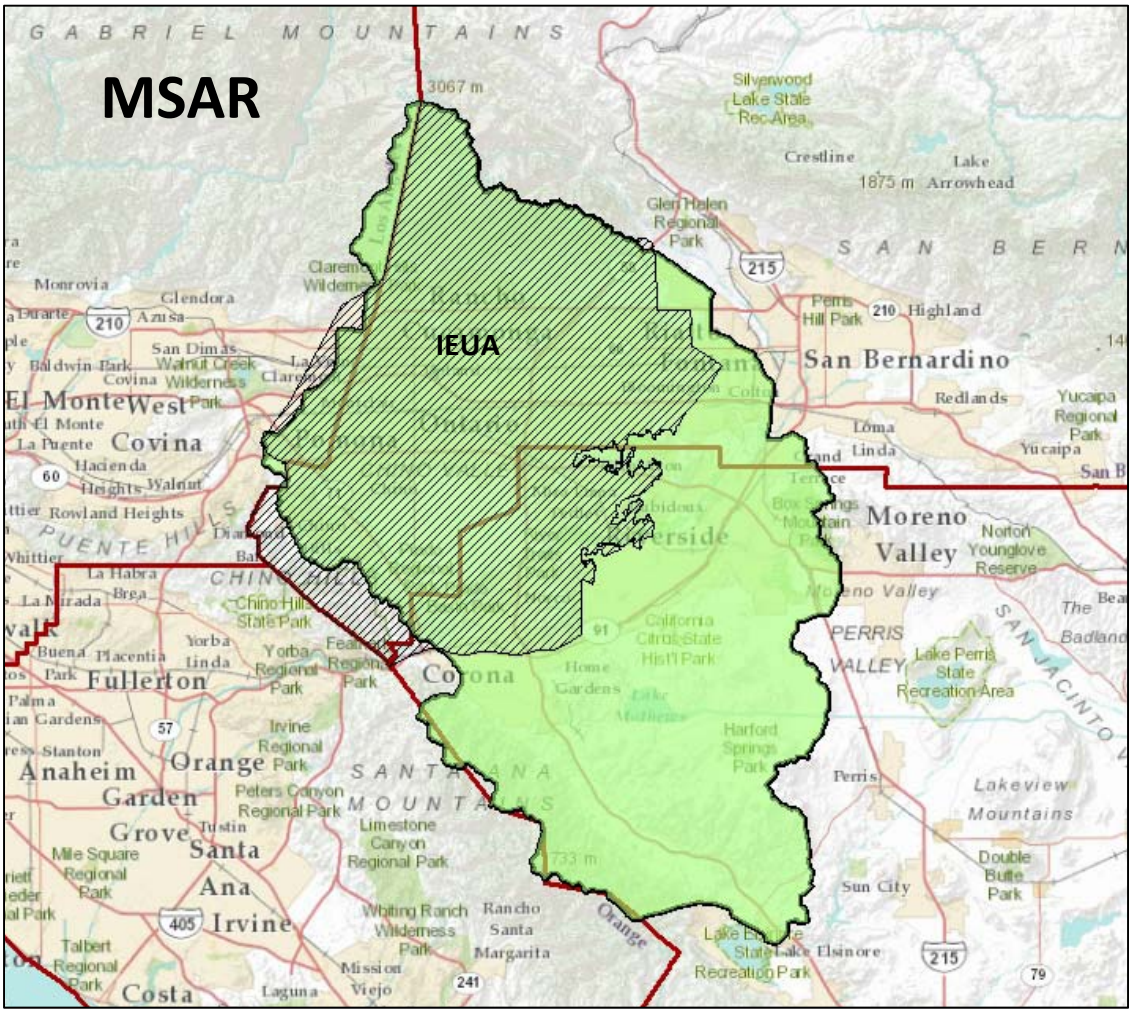
Aerial GIS land use mapping of the Middle Santa Ana River Watershed was supported by the Middle Santa Ana River Watershed Pathogen TMDL Task Force and the California Regional Water Quality Control Board.

I. Overview

The Santa Ana Watershed Project Authority (SAWPA) contracted Aerial Information Systems, Inc. (AIS) to create an Agriculture Land Use (AgLU) GIS geodatabase for the Middle Santa Ana River (MSAR) watershed. The MSAR AgLU study area is 477,621 acres in size and covers portions of Riverside, San Bernardino, Los Angeles, and Orange counties. The study area includes the major portion of the Inland Empire Utilities Agency (IEUA) Land Use and Impervious Surface project area, performed by AIS for IEUA in 2010. The final MSAR dataset will include the AgLU data captured during the IEUA project along with newly mapped features for the remainder of the MSAR watershed. The AgLU data will be used to assist in the MSAR Total Maximum Daily Load (TMDL) fee assessment process, to monitor agricultural conditions in the watershed, and for modeling and analysis purposes.



MSAR study area (green) with IEUA project area overlay

Digital natural color National Agriculture Image Program (NAIP) orthophotos, 1 meter resolution, dated 2010, were used as the MSAR project base. AIS obtained county parcel files, project imagery and other digital files from open source internet websites, including sites for municipal, county, and federal agencies.

AgLU features in the non-IEUA portion of the MSAR study area were captured using the direct digital input (heads-up digitizing) technique, classification, and data capture criteria developed for the Western Riverside County Agriculture Coalition's (WRCAC) San Jacinto River watershed AgLU inventories. On-site windshield field checks were performed to verify features in question and to validate the mapped data.

The IEUA AgLU features were extracted directly into the MSAR AgLU layer from the IEUA data. The IEUA AgLU features were originally captured using the same class definitions and data capture criteria as the current MSAR effort, therefore SAWPA did not task AIS to update the IEUA AgLU. No windshield surveys were performed for the IEUA portion of the MSAR study.

The MSAR Ag-parcel layer was created using current county assessor's parcel data, as available. The Ag-parcel layer includes property boundaries and Assessor's parcel numbers (APNs), as available from the original Assessor's GIS data. The APN serves as the link between the AgLU feature and the assessor's ownership information, including owner name and mailing address. Only parcels that contained a valid AgLU were brought into the Ag-parcel layer. Those parcels were then adjusted as needed to match the imagery.

Tabular files containing ownership information and AgLU acreages were generated by linking the assessor's parcel number (APN) associated with each MSAR AgLU feature to current ownership and address information in the county assessor's data, where available.

The GIS layers were delivered in an ArcGIS 10.1 file geodatabase format.

The project was performed over an 8 month period from February through October 2012.

II. AgLU Photo Interpretation Mapping Criteria

General Feature Delineation Criteria

1. Where roads and features on the orthophoto differed from those represented on other data sources, i.e. assessor's parcel information, county and city zoning data, etc., the orthophoto signature was used to depict the feature boundaries.

2. AgLU feature delineations were drawn as closely as possible to the boundaries observed on the project imagery. Where boundaries were particularly jagged, however, some cartographic smoothing was deemed appropriate. This was generally applied along natural boundaries and was rarely needed along man-made boundaries.

3. Man-influenced land uses often follow features such as fence lines, roads, and property boundaries. These boundaries were often mapped using straight lines and right angle corners. Structures were typically not dissected by polygon boundaries.

Minimum Mapping Unit (MMU)

The minimum mapping unit (MMU) describes the smallest size at which the AgLU classes were captured. The AgLU project MMU was established at one (1) acre. AgLU features observed on the aerial photography that did not meet the MMU were considered below resolution (BR) and were not delineated. Where possible, BR AgLU features were aggregated into surrounding above-MMU AgLU types. If there weren't any adjacent above-MMU AgLU types, the BR features were not captured.

Minimum Mapping Width (MMW)

The minimum mapping width (MMW) describes the smallest width at which linear AgLU classes were captured. The AgLU project MMW was established at 90'. The linear AgLU feature had to conform to the 1 acre project MMU. Linear features that met the MMW but did not meet the MMU were either aggregated into surrounding AgLU features or not delineated. Typical examples of linear AgLU classes include *1436 Water Transfer* and *1437 Flood Control*. However, it was possible for other AgLU types to exhibit a linear form; where this occurred, the MMW rules were applied.

Below-MMW features were mapped when they provided connectivity to larger units over a short distance. For example, if a flood control feature met the MMW but narrowed for a small distance, the below-MMW portion was delineated. However, if the narrower portion continued for a great length, then the below-MMW area was not delineated.

III. Method

The following major tasks were performed for the MSAR AgLU project:

1. Obtain existing data sources and project imagery

2. Create MSAR AgLU layer
    a. Non-IEUA area of MSAR: capture AgLU features using computer interactive photo interpretation (direct digital capture) techniques.
    b. IEUA area of MSAR: extract existing AgLU features from the IEUA study into the MSAR AgLU layer.

3. On-site Field Check: Non-IEUA area only

4. Create Ag-parcel layer
    a. Non-IEUA area of MSAR: extract parcels associated with AgLU features from current county assessor's data, as available.
    b. IEUA area of MSAR: extract existing parcels associated with AgLU from IEUA data; update parcels to current county assessor's data, as available.

5. Create tabular files listing AgLU and ownership information.

Project Materials

Digital Orthophotos

Year 2010, National Agriculture Imagery Program (NAIP) natural color, 1 meter resolution, digital orthophotos were used as the base imagery for the project.

Study Area Boundary

The MSAR study area includes portions of Los Angeles, Orange, Riverside, and San Bernardino counties. The northwest half of the study area was previously mapped as part of the IEUA Land Use and Impervious Surface mapping project. The southeast half of the study area was newly mapped in 2012 for this AgLU project.

Los Angeles County Parcel Data

2010 Los Angeles County parcels were used.

Orange County Parcel Data

No AgLU features were captured in Orange County, therefore Orange County parcel data was not used.

Riverside County Parcel Data

2012 Riverside County parcels were used.

San Bernardino County Parcel Data

2012 San Bernardino County parcels were used.

Zoning Data

AIS obtained digital .jpg or .pdf files of city/county zoning data by downloading them directly from the individual city/county websites where available.

AgLU Layer – Computer Interactive Data Capture Methods

Example of project imagery

AIS staff divided the study area into working production modules. ArcGIS tool sets were created or modified to facilitate the photo interpretation effort.

Working in a systematic fashion, the photo interpreters reviewed the 2010 base imagery and on-line image sources. Where an AgLU was identified, the interpreters collected the data by using direct digital capture (heads-up digitizing) techniques. Feature boundaries and codes were captured per the mapping criteria and AgLU classification. Identified AgLU features were evaluated against the MMU/MMW guidelines. Below resolution (BR) features were aggregated according to the aggregation criteria.

Problematic photo signatures were flagged in the database by the interpreters for further investigation during the field verification task. Most areas identified as *2120 Non-irrigated Agriculture* during the initial photo interpretations were flagged for on-site field visits due to the variability of photo signature displayed by this class. In addition, all polygons classified as *2610 Manure and Compost Piles* were also flagged for on-site verification.

Upon completion of the photo interpretations, the working modules were edgematched to the adjacent module(s) to ensure the accurate representation of polygon delineations and codes across module boundaries, in preparation for producing a seamless dataset during the final processing tasks.

Example of AgLU polygons

On-site Field Check

The On-site Field Check task ensures the overall accuracy of the interpreted data features. It consists of three distinct steps: in-house field preparation, on-site windshield field visits, and revision of the geodatabase.

The field preparation step consists of creating hardcopy field plots, with the AgLU polygons and code attributes overlain onto the project imagery. The field plots were annotated with street names and daily routes. Polygons flagged by the interpreters for field checking were highlighted in a different color to ensure the field crew did not overlook them during the field.

The windshield field visits were performed by a two-person field crew. The field crew used the hardcopy plots prepared during the previous step to navigate within the study area. The interpreted feature boundaries and code attributes shown on the plots were compared to the conditions on the ground. Field notes were recorded directly onto the plots. If the on-site review did not resolve the issue, detailed notes of the area were taken to assist with discussion of the problem signatures at a later time. Several non-flagged features were also verified to ensure the accuracy of established correlations between photo signatures and specific AgLU feature types.

Upon return to the office, the interpreters entered the field corrections and changes directly into the AgLU dataset from the field plot notations. Where necessary, the field observations were discussed amongst the project team to determine the appropriate AgLU class for problematic signatures.

Quality Control of Photo Interpretations

A separate quality control step was performed for each production module upon completion of the photo interpretation and field survey effort. A senior photo interpreter reviewed each polygon for completeness, consistency, and adherence to the mapping criteria and guidelines, and the data was revised as needed.

Final Processing

The individual production modules were joined into a single seamless AgLU coverage. This final AgLU layer was examined by a senior photo-interpreter to verify the registration of linework to the orthophoto image base. Final checks were conducted to identify any invalid codes, missing or extra lines, or edgematch problems.

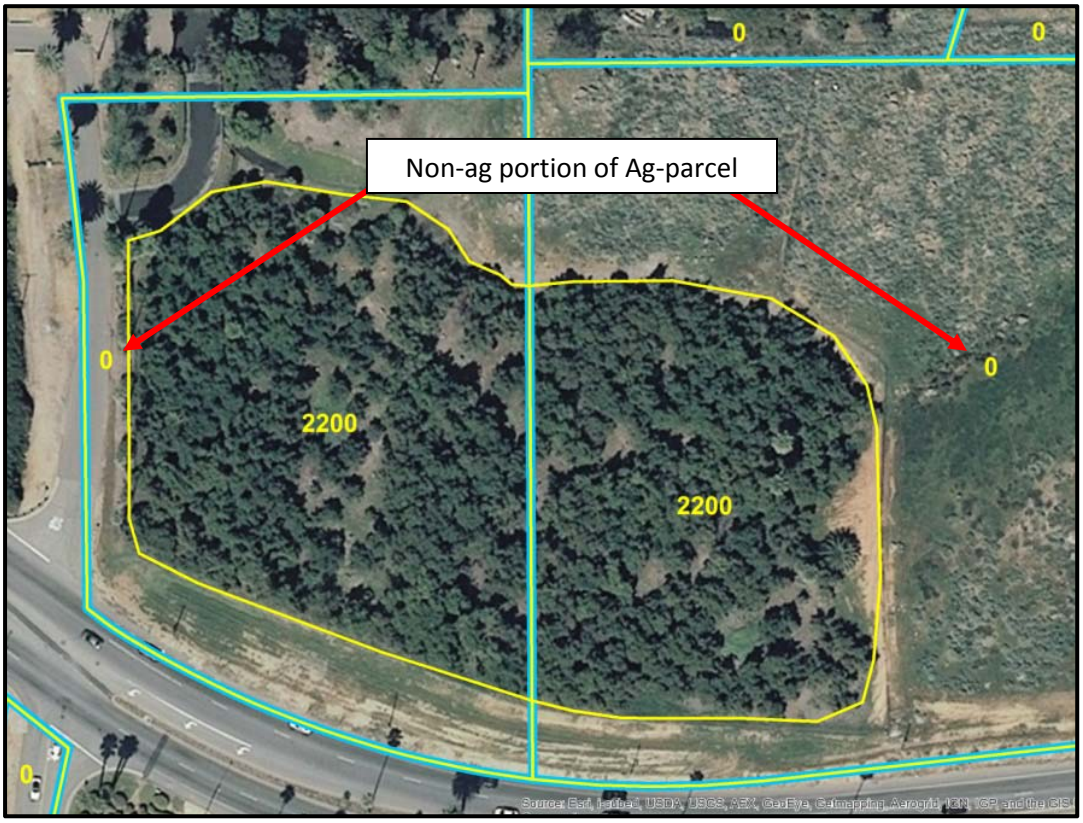
Ag-parcel Layer

Only parcels containing AgLU features were captured in the MSAR Ag-parcel layer. Two different approaches were used to create the Ag-parcel layer: one for the IEUA portion of MSAR, since the IEUA data contained adjusted parcel boundaries and APN information; and one for the non-IEUA area.

For the IEUA area, the parcel boundaries and APNs associated with AgLU features were extracted from the IEUA data. For Riverside and San Bernardino counties, the IEUA derived Ag-parcels were programmatically compared to the current assessor's data to identify any APN and/or spatial changes. Parcels flagged during this process were investigated and updated as needed, including boundary adjustments to match the base imagery. Los Angeles County assessor's data was not made available for the MSAR project, therefore the existing parcels were not updated. Orange County did not contain any AgLU features.

In the non-IEUA portion of MSAR, the parcel boundaries and APNs associated with AgLU features were extracted directly from the current Riverside and San Bernardino county assessor's data. Boundaries were adjusted, as needed, to register to the correct location as shown on the project imagery.

For both the IEUA and non-IEUA portions of MSAR, the Ag-parcels were captured in their entirety. Any portion of an Ag-parcel that did not contain an Ag-LU feature was assigned an AgLU code of *0 Non-ag portion of Ag-parcel*.



Blue/Yellow = Ag-parcel boundary, Yellow only = AgLU feature boundary

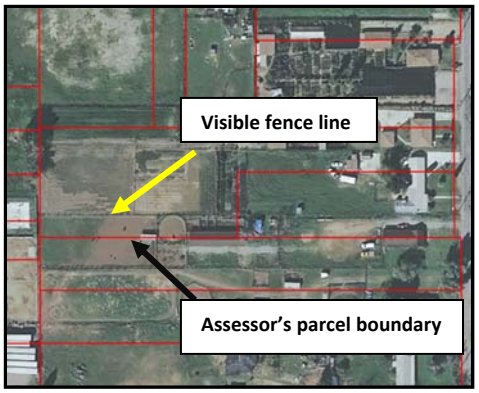
IV. Project Specific Issues

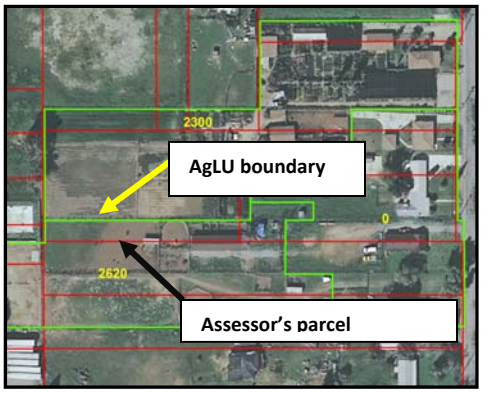
The following section describes some issues related to this MSAR AgLU project. It is important that potential users of this dataset are aware of how these issues influenced the final outcome of the project and the potential limitations of the mapped dataset.

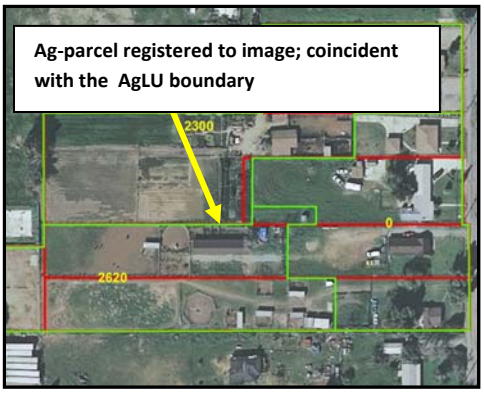
Parcel Registration Issues

The parcel data obtained from the counties contained a number of parcel boundary registration problems to the project imagery, especially in Riverside County. In some cases, the boundary off-sets were severe enough to create erroneous correlations between the AgLU and parcel ownership data.

To correct this problem, AIS developed the concept of an Ag-parcel layer. Parcels containing AgLU were copied from the original assessor's data into a separate GIS layer. The boundaries were then adjusted as needed to register to the correct location as shown on the project imagery. The APN for each adjusted parcel was transferred from the assessor's original parcel data, thus providing the link needed between the AgLU feature and the parcel ownership information. It is important for the end user to note that the Ag-parcel data cannot be co-registered back to the County's assessor's parcel dataset due to the boundary manipulations required.







Availability of Current Assessor's Parcel Data

2012 parcel data were obtained for Riverside and San Bernardino counties but were not made available for Los Angeles County. Parcel data from 2010 was used in the Los Angeles County portion of the study area. No AgLU was identified in Orange County, so Orange County parcel information was not needed.

IEUA Portion of MSAR

One of the primary goals of the MSAR AgLU project was to complete the AgLU inventory for the watershed that was started during the 2010 IEUA mapping project. As discussed previously, for the MSAR project AIS extracted the IEUA AgLU features directly into the MSAR AgLU layer. The IEUA AgLU features were not updated, with some exceptions, as noted below.

The IEUA data also included parcel boundaries and APNs but no ownership information. For the MSAR project, parcels associated with IEUA AgLU features were extracted directly from the IEUA parcel layer into the MSAR Ag-parcel layer. The IEUA Ag-parcels were then programmatically compared to the 2012 Riverside and San Bernardino county assessor data to identify any APN and/or spatial changes. Current parcel information for Los Angeles County was not made available for the MSAR project, so no parcel updates were conducted.

Changes were investigated and the Ag-parcel layer was updated, as needed, including revising Ag-parcel boundaries to match the imagery. For areas where parcel change was caused by the conversion of agriculture to a non-agricultural use, the AgLU data was also revised. The resulting Ag-parcel data was linked to available ownership and address information via the APNs to create the tabular AgLU ownership files.

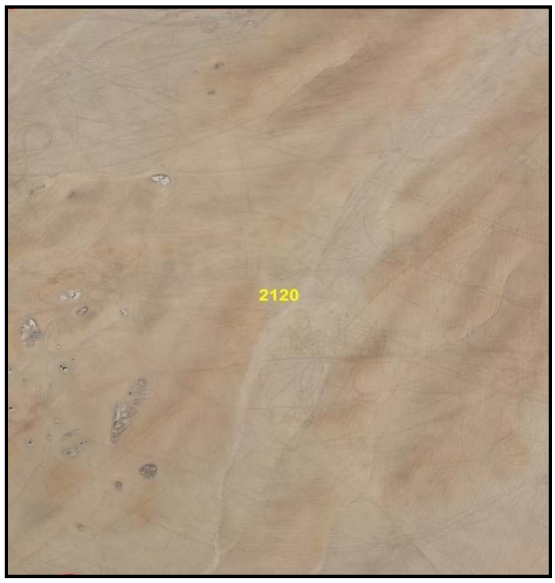
Photo Signature vs. On-Site Field Observations

The user should be aware that the data represents the AgLU as it existed at the date of the project photography, with some exceptions. In general, if on-site field surveys revealed that the AgLU had changed significantly since the 2010 photography, the polygon was coded for the 2012 field observation, not the 2010 photo signature. The criteria were not applied to temporal AgLU types, i.e. differences between irrigated and non-irrigated fields.

Irrigated Agriculture (2110) vs. Non-irrigated Agriculture (2120) vs. Turf Farms (2310)

Agriculture field crops are transitional in nature. Depending upon the time of year, or the timing of the agricultural crop cycle, the same acreage can be planted in dry-farming crop, irrigated crop, or appear vacant (fallow). Using aerial photos to determine the differences between the three stages of agriculture can be very problematic.

Example of irrigated photo signature



Example of non-irrigated photo signature

Irrigated cropland is easier to identify on the aerial photo if it is actively being irrigated at the time of the photography. Non-irrigated agriculture is more difficult to identify although certain inferences can be drawn, again based on the aerial images. For example, in Southern California the majority of rainfall occurs in the winter and early spring. If the aerial photos were flown during that time, it can be assumed that some of the actively growing crops are non-irrigated, although it is difficult to distinguish them from irrigated crops. Conversely, if the aerial photos were flown during the late summer, then it can be assumed that virtually all of the actively growing crops are irrigated.

During the photo interpretation effort, the interpreters referred to a number of on-line sources including Google Earth, Google Images, and MSN Bing to help provide them with a historical perspective of the area. Google Earth proved particularly useful due to its "timeline" feature as this allowed the interpreters to view multiple years of imagery (typically from the early 1990s through June 2012). During this task, the interpreters

flagged polygons identified as *2120 Non-irrigated agriculture* for the on-site field verification effort.

During the on-site verification visits, the field team looked for evidence of irrigation in the form of sprinkler pipes, irrigation wells, tanks, and open water reservoirs. However, this method was not always conclusive because some irrigation features, such as stand pipes and wells, were not always visible from a windshield survey and because of the transitory nature of current irrigation practices. Irrigated cropland is typically watered using temporary irrigation installations that can be easily moved from one field to another. Depending upon the timing of the field effort, it could appear that a crop was not being irrigated because the installation had been moved to another field.

Another issue is the practice of seasonal crop rotation where the same property can be planted with non-irrigated crop in the fall/winter season and planted with irrigated crop in the spring/summer. Under these circumstances, the AgLU was classified for the typical crop conditions as seen on the various image sources and during the field observations.

Similar issues affect the interpretations of the *2310 Turf Farms* and *2110 Irrigated agriculture* AgLU classes. At certain times during the crop-cycle of both, it's very difficult to tell them apart on the aerial photos (see examples below). Seasonal crop rotations are also an issue.

In order to consistently capture these three land use types, AIS followed the following mapping criteria:

1. If the photo signature showed an irrigated crop signature but the on-site field visit did not, or the field team observed irrigated crop being grown within the confines of a Turf farm, the polygon was coded for the irrigated crop.

2. Where the photo signature appeared to be non-irrigated but the field team observed evidence of irrigation, the polygon was coded as irrigated.

3. Where the photo signature appeared to be non-irrigated and the field team did not see evidence of irrigation, the polygon was coded as non-irrigated.

4. Where the photo signature was problematic and the field team found no evidence of irrigation, the polygon was coded as non-irrigated.

5. If the photo signature appeared to be vacant but the field team observed that the soil was prepared for planting, the polygon was considered agriculture, not vacant, and coded as *2120 Non-irrigated agriculture* or *2110 Irrigated agriculture* depending upon the surrounding agricultural fields and evidence of irrigation. If there was evidence of irrigation on-site, i.e. irrigation pipes, wells, stand-pipes, irrigation equipment storage areas, then the area was classed as irrigated (2110). If there was no evidence of irrigation but the area in question was completely surrounded by obviously irrigated agricultural fields, then it was assumed that the tilled field would be irrigated as well, once it was under cultivation. If there was no evidence of irrigation and/or the area in question was surrounded by large areas of agricultural fields that were obviously not irrigated, the area was coded as non-irrigated (2120).

6. If the photo signature appeared to be an active agricultural field but the field team observed successional vegetation types, the field was assumed to be fallow and the polygon was coded as either a 2110 or 2120 depending upon the surrounding agricultural fields and evidence of irrigation. If there was evidence of irrigation on-site, i.e. irrigation pipes, wells, stand-pipes, irrigation equipment storage areas, then the area was classed as 2110. If there was no evidence of irrigation but the area in question was completely surrounded by obviously irrigated agricultural fields, then it was assumed that the field would be irrigated as well, once it was under cultivation. If there was no evidence of irrigation and/or the area in question was

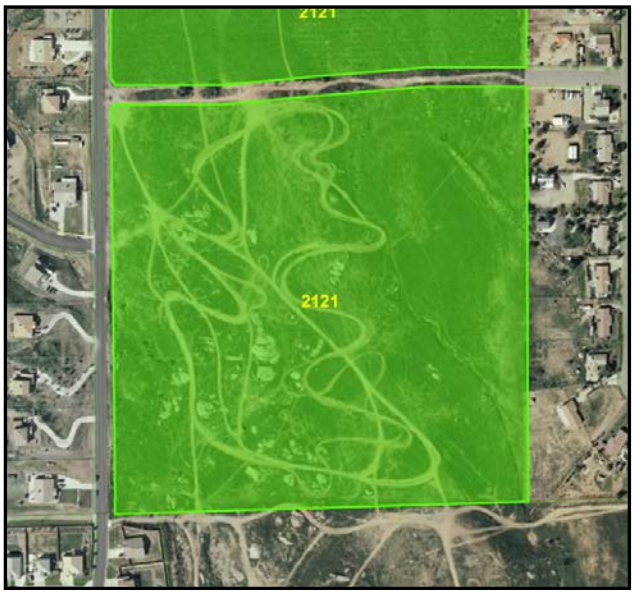
surrounded by large areas of agricultural fields that were obviously not irrigated, the area was coded as non-irrigated (2120).

7. If the photo signature appeared to be an active agricultural field but the field team observed obvious construction or development, the area was not captured as part of the AgLU dataset.

While the above criteria and project materials help the interpreters to consistently assign the three classes in question, the user needs to be aware that these agriculture types are subject to rapid conversion. Therefore the 2110 and 2120 AgLU features are not as "permanent" as other AgLU types such as dairies, citrus, poultry, etc., from one year to the next.

Vacant, Zoned Agriculture (2121)

Vacant land was not captured in the AgLU data with the exception of vacant land that had been zoned as agriculture (*2121 Vacant, Zoned Agriculture)*. The 2121 class was only mapped where the available city and county zoning maps showed areas designated as agricultural zones intersecting with vacant land on the aerial photos. In order for a parcel to contain a 2121 code, there must have been a minimum of 1 acre of "Vacant, Zoned Agriculture" within it.



AgLU with Zoning Data and Aerial Imagery

Even though the aerial photos show that the land is currently not being used (vacant), the presence of an agriculture zone designation indicates the potential for agricultural land use that might need to be included in the TMDL. By capturing the Vacant, Zoned Agriculture class, MSAR has the ability to individually assess each 2121 feature in the AgLU data to determine whether it qualifies for inclusion in the TMDL program.

Zoning Data

In order to map the aforementioned *2121 Vacant, Zoned Agriculture* AgLU types, current zoning data was required. AIS downloaded readily available zoning maps and/or data files from county/city websites as available. Most of the city information was only available as .jpg or .pdf files that needed to be georeferenced to ensure they displayed in the accurate location within the project area.

The agricultural zones for each map were identified by the zoning information shown on the individual county and city map legends. Specific Plans, special districts, and tabular documentation were not researched for the agricultural zone assessment, as this task was outside of the project scope of work.

Los Angeles and Orange counties zone maps were not used. It was determined that the small portion of these counties within the MSAR study area did not contain any relevant agricultural information.

Another problematic issue was the inconsistency of the zoning classifications from city to city and city to county. If SAWPA determines that a complete agricultural zoning assessment is needed for future AgLU updates, we recommend that sufficient funds and time be included in the project scope to provide for the creation of an accurate and comprehensive agricultural zoning layer that addresses the aforementioned issues.

Flood control channels (1437)

After the mapping was complete, a second look was given to flood control channel (FCC) features spanning the entire study area. Many FCC features are housed within their own parcels, but that is not always the case. Most of these parcels stop at roads and/or freeways, but not all of them. In an effort to standardize the FCC data capture, AIS came up with the following criteria:

1. FCC (1437) polygons were mapped whether there was a "Flood Control" parcel or not.

2. FCC (1437) features smaller than the project MMW of 90' were captured, as needed, in order to preserve the FCC network continuity.

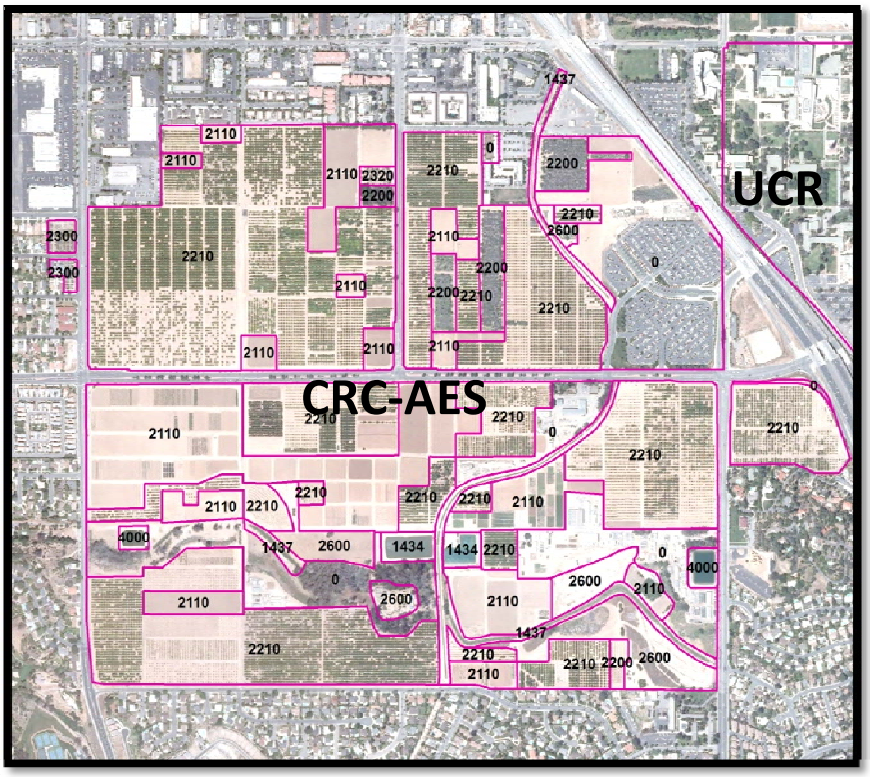
3. FCCs (1437s) were continued across roads, excepting freeways, regardless of whether the undercrossing was via bridge or culvert.

4. FCCs (1437s) were not mapped across freeways. The 1437 polygons were stopped at the outer edges of freeways.

5. Where an FCC extended across but the FCC parcel did not, the 1437 feature in the roadway was assigned an "ROW" (Right of Way) attribute in the Ag-parcel layer.

University of California at Riverside Agricultural Experiment Station

A 510 acre Citrus Research Center and Agricultural Experiment Station (CRC-AES) is located adjacent to the University of California at Riverside (UCR) campus. The area was mapped per the 2010 NAIP photo imagery base. However, the user of the data needs to be aware that due to the studies underway at this location, the configuration of agricultural use is continually changing.



University of California at Riverside (UCR) and Citrus Research Center and Agricultural Experiment Station (CRC-AES)

V. Analysis and Report Generation

AIS joined together the AgLU and Ag-parcel data layers to form a single layer. AIS staff linked tables in the county assessors' data to the layer using a series of key attributes common to both datasets. The initial link was performed using the parcel APN, while

subsequent links used other key fields depending upon the table attributes. This process extracted parcel attributes from the original county data and enabled AIS to link them to the correct spatial data. Examples of the parcel attributes extracted during this process include Assessee Last Name, Assessee First Name, Mailing Address, Situs Address, etc.

Once the spatial data had been populated with the appropriate parcel attribute information, AIS created an Excel file of the AgLU and Ag-parcel attribute data. The resulting tabular reports were delivered to SAWPA in both hardcopy and digital format.

SAWPA's primary interest was in owners whose total (aggregated) AgLU was 20 acres or more in size. AIS performed the analysis and created tabular files detailing the AgLU type and acreage by parcel owner with a listing of the mailing address and APN. SAWPA will use this information to assist in their TMDL fee assessment and collection procedures.

VI. Recommendations

The 2010 MSAR geodatabase forms a comprehensive dataset of AgLU and ag-owners to assist SAWPA in its TMDL fee assessment process and provides a baseline for monitoring future agricultural trends in the watershed over time.

To ensure the continued relevancy of the AgLU layer over time, we recommend that the AgLU and Ag-parcel layers continue to be updated on a three year cycle. Regular updates of the AgLU and Ag-parcel layers will ensure that the data layers are kept current thereby providing more accurate information for the TMDL process.

To enhance the usefulness of the geodatabase, we also recommend the creation of an urban land use and impervious surface layer, to match the IEUA portion of the MSAR study. The addition of non-agricultural land uses to the AgLU data will complete the land use mapping for the watershed and provide the end user with a comprehensive dataset for change analysis and other modeling applications. This project would also require the addition and adjustment of the remaining parcel data in the non-IEUA area to ensure comprehensive coverage of ownership information for the dataset.

Examples of other potential data layers include soil data, impervious surface, vegetation, general plan data, and monitoring well locations. With each additional layer, the power of the database is increased, creating a valuable tool for interested stakeholders within the watershed.

VII. Appendices

APPENDIX I

2010 MSAR Agricultural Land Use Classification

Derived from: A Land Use and Land Cover Classification System for Use with Remote Sensor Data,
U. S. Geological Survey Professional Paper 964, 1976

The MSAR AgLU classification follows the Western Riverside County Agriculture Coalition (WRCAC) classification developed by AIS for the WRCAC AgLU inventories in the San Jacinto River watershed. The WRCAC AgLU classification was based on the Southern California Association of Governments' (SCAG) land use classification, which in turn, follows the 1976 USGS Anderson, et al, Land Use Classification system. The Anderson system is in a hierarchical format with up to four levels of detail and has served as the standard classification for land use mapping in southern California.

Not all of the AgLU classes describe actual agricultural uses. For example, the 14XX classes, i.e. *Water Storage (1434), Water Transfer (1436), Flood Control (1437)*, and *Unimproved Flood Ways (1438)* describe land use types related to water control and distribution. However, since water quality is an important concern of SAWPA and other stakeholders, we felt it was important to include these classes in the AgLU inventory. Other non-agricultural land use classes include *Wildlife Refuge (1850),* and *Water (4000).* The full AgLU classification and descriptions follow below.

1434 Water Storage

This category includes most small water reservoirs and water tanks used for domestic water supply and irrigation purposes. Included are any associated facilities and dams. The reservoirs include all covered water storage facilities and water tanks. Open water bodies used for water storage are included if they are below 5 acres in area, otherwise they are mapped as Water (see code 4000). Water tanks typically appear on the photo as small round light colored structure. Covered reservoirs may be circular, oval, or rectangular in shape. Dams associated with water storage reservoirs are included. Dams associated with flood control are mapped as code 1437.

1436 Water Transfer

This category includes major above-ground water distribution channels, aqueducts, water treatment, filtration (non-sewage), reclamation (non-sewage), and pumping facilities. On the imagery, channels and aqueducts appear a linear features, with water flanked by light-toned concrete.

1437 Flood Control

This category includes improved flood control channels and dams, detention ponds, percolation basins, and debris dams.

Most improved flood control channels are channelized and/or lined with concrete. The photo signature shows a white to off-white color representing the concrete lining. Percolation/flood control basins are typically located adjacent to a flood control channel, or next to urban developments. The inlets are often visible as small concrete lined culverts with evidence of water drainage. Debris dams are normally earthen, but may contain a concrete spillway. They are located at the mouth of canyons or downstream of the canyon, and contain a vegetated, though dry to intermittent back pond. Dams associated with water storage are mapped as code 1434.

1850 Wildlife Reserve

This category includes wildlife reserves, including both public land and private facilities, and developed areas devoted to the preservation of wildlife species and habitats. This class includes such uses as zoos, wild animal parks, duck ponds, exotic animal farms, etc. Most wildlife preserves and sanctuaries are identified on ancillary data sets. Undeveloped areas within national and state preserves and sanctuaries are considered vacant land and not mapped as part of the 1850 category.

2110 Irrigated Agriculture

This category includes all irrigated field and row cropland areas, and irrigated improved pasture land.

The majority of row crops in southern California are irrigated. The photo signature for active cropland will show one of several signatures. If the land is in field crop, the signature will show a uniform, smooth texture area, with a green color. Land that is in row crop will appear similar to field crop, except the individual rows can be distinguished as narrow parallel lines. Land that is being made ready for crop or has been recently harvested will appear as a uniform, smooth texture of off-white to tan color representing the just graded or plowed field. Fallow fields will appear similar to vacant lots or disturbed vacant land. The area will appear unkempt, with a non-uniform texture representing a mixture of shrubs and grasses in a successional state. Fallow land will typically occur in close proximity to in-crop areas.

2120 Non-Irrigated Agriculture

This category includes all non-irrigated cropland, including dry-farmed field crops.

Depending on the time of the aerial photography, the photo signature for non-irrigated field crops can vary between a dull green to mottled brown color with smooth, uniform texture or display a uniform green smooth texture. Furrows or plow marks may also be visible. Dry farmed areas may appear very similar to natural grass vegetation. Land that is being made ready for crop or has been harvested will appear as a uniform, smooth texture of off-white to tan color representing the just graded or plowed field. Fallow fields will appear similar to vacant lots or disturbed vacant land. The area will appear unkempt, with a non-uniform texture representing a mixture of shrubs and grasses in a successional state. Fallow land typically occurs in close proximity to in-crop areas.

2121 Vacant, Zoned Agriculture

This class requires existing zoning data in order to delineate the boundaries. Areas zoned as agriculture on the digital zoning data are compared to the aerial photo signature. Vacant (not fallow) areas as shown on the aerial photos that fall within the boundaries of an agricultural zone are classed as 2121.

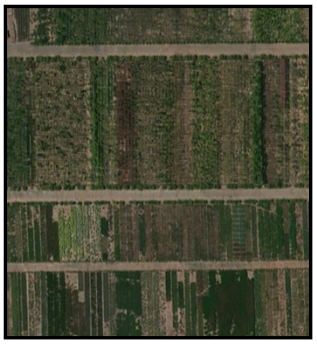
2200 Orchards/Vineyards Undifferentiated

This category includes commercially productive non-citrus fruit trees, bush crops, and vineyards.

Non-citrus fruit orchards, i.e. avocado, nuts, apples, cherries, etc., are typically aligned in a matrix form, with crowns abutting each other. Bush crops are similar to orchards, however, they may be configured in rows rather than a matrix, and are much shorter in height. The photo signature for vineyards will appear as dark green, coarse-textured, thin linear rows that, when measured, will be approximately five to ten feet apart. The height of vineyards is shorter than orchards. The orchard and vineyard areas will be neat and uniform.

2210 Citrus

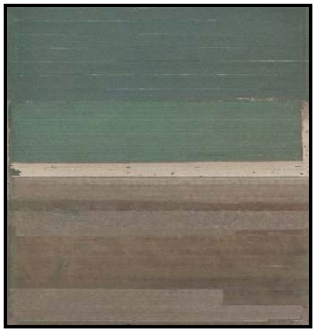
The photo signature for citrus orchards is typically a dark green, coarse-textured area, where the individual trees are distinguishable. The trees are aligned in a matrix form, with crowns appearing to abut each other.



2300 Nurseries Undifferentiated

This category includes land managed for the production of ornamental trees, plants and flowers, vegetable seedlings, seed farms, and wholesale greenhouses. It also includes vegetable crops using drip irrigation within temporary field greenhouses.

Planted nursery crop can appear similar to row crops in configuration. The photo signature, however, reveals that it is an area of non-uniformity, where a few rows appear similar but the next few rows are of a different type of plant, and so on. Trees may occur in some rows, then plants in the next section. Greenhouses or hot houses may also occur in some row areas, or in separate areas altogether. Greenhouses typically appear as long narrow structures abutting each other with steeply pitched or rounded roofs. Potted plants, i.e. palms, other landscape plants, are also classified as 2300. Nurseries are often found within electrical transmission line rights-of-way.



2310 Turf Farms

On the aerial photo, turf farms appear similar to pasture or field crop; therefore, some field verification is necessary. Actively growing turf usually appears as an extremely smooth uniform green signature with occasional strips of bare ground showing where the turf has been harvested.

2320 Christmas Tree Farms

Christmas tree farms often appear on the imagery as unevenly planted groves containing plants of various sized crowns and separated by varying amounts of open space. This effect is created by differences in the planting and harvest cycle over time.

2411 Dairies – Intensive

This class describes the main operating area of the dairy, including confined feeding area and corrals, typified by a dark, wet looking, earthen signature. Large numbers of cows are often visible. Feeding troughs, hay storage, and shelters are usually present. Intensive areas of the dairy usually contain simple rectangular shade structures that are evenly and widely spaced over the area. Structures for protecting stored hay bales may be present, in addition to structures used for milking. All dairies should have at least one area defined as intensive. Manure piles visible on dairies are not mapped separately.

Livestock feedlots and dairies appear similar in that both contain a series of small fenced areas with a very high concentration of animals. Both feedlot and dairies contain fenced areas with a very dark to black photo signature representing dung piles. Pasture and field crop adjacent to and associated with dairies are mapped as 2412.

2412 Dairies – Non-Intensive

This class describes the pasture area and other non-livestock intensive areas of dairy operations. The photo signature usually includes large fields adjacent to the main operating area of the dairy. The fields often look vaguely plowed and can include irregular shaped areas of water and larger fenced pastures. Not all dairies will have a non-intensive area.

2413 Abandoned Dairies

This class describes dairies that have obviously been abandoned but have not yet been converted to other uses or gone back to vacant land. The photo signature will typically show building footprints and sometimes even standing structures. There is usually no evidence of active animal husbandry. Associated ponds are usually dry and surrounding pastures exhibit an unkempt appearance.

2420 Other Livestock

This category includes large, specialized livestock and other specialty farms. These areas have a high concentration of animal population in a relatively small area. This class includes pig, goat, llama and other non-cow livestock farm uses. It also includes areas where there is evidence of livestock in a non-intensive setting, e.g. fenced pastures, corrals, shelters, but very few to no animals visible.

2500 Poultry

This category includes poultry operations such as chicken, turkey, and egg farms. Poultry farms typically contain a series of long, narrow enclosed structures in a parallel, side-by-side configuration. The photo signature shows each structure as having a white pitched roof, typically with air conditioning units. Grain feed storage structures may be located at the ends of the building. One to ten structures may occur in each group. Smaller poultry manure spreading grounds are included in the 2500 class. Major poultry manure spreading grounds are coded 2610.

2600 Other Ag Undifferentiated

This category includes other miscellaneous agricultural facilities not described in the agricultural categories above. These facilities include storage facilities, hydroponic farms, fish hatcheries, apiaries, and worm farms.
Storage facilities can include isolated barns, or other structures located in, or adjacent to an agricultural area. Also included are small plots of land where heavy equipment or machinery is stored within the agricultural field area. Track ovals not associated with an equestrian facility (2700) are coded 2600.

2610 Manure and Compost Piles

This category includes all manure piles located outside of dairy farms, including areas identified as potential unauthorized dumping grounds. Compost and green-waste piles are also included in this category.

The classic photo signature for manure are large piles of dark brown to black colored organic looking material; multiple piles are often arranged in a linear fashion, similar to the photo signature for green-waste recycling land uses. Compost and green-waste piles are usually less uniform in color and show a greater range of texture due to the presence of vegetation and other organic material.

Areas of unauthorized manure dumping typically do not reflect the classic manure photo signature due to the temporary nature of the piles, as the operators quickly disperse the piles in order to avoid detection. On-site field observation is required and then the interpreters can back-track the known location to a potential photo signature. On the photos, manure spreading areas can look like fields that are being prepped for imminent agricultural planting due to the dark, freshly tilled look of the soil.

2620 Backyard Livestock

This class is intended for areas that are predominantly residential – typically suburban and semi-rural locations. For situations where animals are observed in a non-residential setting, the *2420 Other Livestock* class was used.

Backyard agriculture may include improved pastures, barns, and/or corrals. This class is mapped for contiguous areas of backyard animals, including horses, goats, pigs, chickens, etc. In the Norco and Hemet areas, many of the lots are 10, 5, and 2.5 acres. Small isolated residences are not important, but a concentration of houses, each with backyard livestock, can have a significant impact in terms of run-off water quality.

2700 Horses

This category includes commercial and non-commercial horse ranches, stables, tracks, barns, and corral areas, and improved pastureland. Commercial horse racing track facilities are not mapped as part of the AgLU.

Stables appear as one or more long, narrow buildings within a farm complex, adjacent to pastures (irrigated pastures are coded as 2110). Horse tracks are large dirt oval tracks located at the horse ranches. Track ovals not associated with a horse ranch are coded 2600. Corral areas, included horse corrals associated with residential areas, are coded 2700. Improved pasture areas are fenced, containing water troughs, and possibly shade structures or enclosures. Improved pastures differ from fenced rangeland in that pasture contains smaller fenced areas, typically with individual enclosures of less than one hundred acres. Horse ranches may also occur within electrical transmission line rights-of-way.

In general, irrigated agricultural fields within the horse farm area are mapped as 2700. However, extremely large areas of irrigated agriculture within the farm will be mapped are captured as 2110.

3200 Abandoned Orchards/Vineyards

This category includes formerly productive orchards and vineyards that are now abandoned and not in commercial production.

Abandoned orchards and vineyards may contain successional or weedy vegetation between the rows. The photo signature may show and the field check may verify an unkempt condition. Many trees or vine plants may be dead, or totally removed. If a significant number of trees remain on the lot, then the polygon is coded 3200. If most trees have been removed, then the polygon is considered vacant and is not captured as part of the AgLU.

4000 Water

This category includes all perennial open water bodies greater than 1 acre in area not associated with water storage; and all water bodies associated with water storage that are greater than 5 acres in size. Included in this class are oceans, lakes, reservoirs, golf course ponds, rivers, estuaries, and channels.

Water body delineations follow the "high water" line as seen on the project imagery, or follow the configuration of water as shown on the 7.5 minute U.S.G.S. topographic quadrangles, unless the configuration of the water body has changed significantly. Water bodies at low water levels are typically mapped at their normal levels to account for drought years. The photo signature for water is blue to dark blue.

APPENDIX II

Glossary

The following are definitions of common terms used in the final report.

Agricultural Land Use (AgLU)
This term refers to the classes in the Land Use classification that pertain to any agricultural uses.

APN
Assessor's parcel number

Below Resolution (BR)
This term describes AgLU features that are smaller than the minimum mapping unit. Below resolution features are not mapped for their specific AgLU class but are aggregated into an adjacent above resolution AgLU polygon when possible. If not possible, the BR feature was not mapped.

Direct Digital Capture/(Heads-up Digitizing)
The process of using GIS tools to delineate and code features while viewing the data on-screen.

Feature
The term used to describe point, line, or polygon data item residing in the GIS dataset.

GIS
Geographic Information Systems (GIS) is the generic name for computer software programs that provide for the creation and analysis of multiple datasets, in point, line, or polygon formats, that are tied to specific map projections and real-world coordinate systems. In this report, the term GIS specifically refers to Environmental Systems Research Institute's (Esri) ArcGIS software program.

IEUA
Inland Empire Utilities Agency

Layer
The term used to describe the location of the GIS features. For example, the AgLU layer contains the AgLU polygons and attributes while the Ag-parcel layer contains the Ag-parcel polygons and attributes.

MMU (Minimum Mapping Unit)
The smallest polygon size (total area) mapped for each AgLU class.

MMW (Minimum Mapping Width)
The smallest polygon width mapped for each AgLU class.

MSAR
Middle Santa Ana River

NAIP
National Agriculture Imagery Program

Polygon
The GIS unit that defines the boundary of the mapped data features.

Photo Interpretation
The process of viewing aerial photos to identify land based features. The features are mapped per the specifications of the project classification. Photo interpretation can be performed using either a manual (pen, paper, mylar) or digital (on-screen) process depending upon the format of the project imagery.

SAWPA
Santa Ana Watershed Project Authority

Specific Plan
A zoning term used to identify areas of more detailed zoning within the Specific Plan (SP) area. The full SP descriptions and maps are usually located within the comprehensive zoning documents and are not displayed on the general city- and/or county-wide zone maps. Significant research of the individual zone documents is usually required to identify the details of the SP designations.

TMDL
Total Maximum Daily Load

USGS
United States Geological Survey

WRCAC
Western Riverside County Agriculture Coalition

APPENDIX III

GENERAL PRINCIPLES OF AERIAL LAND USE INTERPRETATION

Most land use features can be recognized by photo signature; i.e. characteristics unique to that feature as depicted on aerial photos. These signatures are defined by color, texture, pattern, and tonal qualities on the imagery. By observing the extent of the photo signatures associated with specific land use types, the photo interpreter is able to identify and delineate the boundaries of the land use features.

When the same photo signature exists for one or more land use type, the surrounding physical environment, or "context", is an important tool in determining the appropriate land use class. An understanding of development patterns, both current and historic, results in more accurate interpretations. For example, a large rectangular building viewed on the photo can represent either commercial or industrial land use. Knowing that industrial uses are often located next to rail corridors and away from high traffic areas while commercial uses are usually located along major traffic corridors and intersections, the interpreter can review the surrounding environment of the building signature for those types of features.

Collateral sources are useful to the photo interpreter as they can aid in the identification of land use features and provide a background context against which the photo signatures can be compared. Open source programs such as Google Earth and internet websites, i.e. Google Maps, Bing, Yahoo, etc., are important sources of additional information. They have all but replaced traditional hard-copy collateral sources such as county and city street maps and USGS topographic maps. The usefulness of any collateral source is directly related to the detail, accuracy, and timeliness of the information they provide.

If the above sources are not sufficient for the interpreter to confidently assign a land use class, on-site field visits are required. In addition to answering polygon-specific questions flagged during the photo interpretation effort, on-site field surveys serve to verify correlations previously established between photo signatures and land use types, ensuring that the interpretations are as error-free as possible.

APPENDIX IV

SUMMARY TABLES, FIGURES, and MAP

Santa Ana River Watershed Project Authority
Middle Santa Ana River

All Mapped Land Use Classes **Table 1**

Ag Land Use Code	Ag Land Use Code Descriptions	Total Area (ac.)	% of Total Area
1434	Water Storage	253.4	0.6%
1436	Water Transfer	509.8	1.2%
1437	Flood Control	5,646.3	13.1%
1850	Wildlife Reserve	638.7	1.5%
2110	Irrigated Agriculture	6,314.7	14.6%
2120	Non-Irrigated Agriculture	252.6	0.6%
2121	Vacant, Zoned Agriculture	8,516.9	19.7%
2200	Orchard/Vineyards, Undifferentiated	1,182.1	2.7%
2210	Citrus	2,738.2	6.3%
2300	Nurseries, Undifferentiated	2,781.2	6.4%
2310	Turf Farms	185.8	0.4%
2320	Christmas Tree Farms	81.0	0.2%
2411	Dairies - Intensive	3,349.3	7.8%
2412	Dairies - Non-Intensive	1,627.5	3.8%
2413	Abandoned Dairies	1,658.3	3.8%
2420	Other Livestock	48.4	0.1%
2500	Poultry	121.7	0.3%
2600	Other Agriculture, Undifferentiated	378.6	0.9%
2610	Manure and Compost Piles	227.3	0.5%
2620	Backyard Livestock	2,348.2	5.4%
2700	Horses	835.6	1.9%
3200	Abandoned Orchards/Vineyards	371.3	0.9%
4000	Water	3,107.1	7.2%
Grand Total		**43,174.0**	**100.0%**

Santa Ana River Watershed Project Authority
Middle Santa Ana River

Table 2

All Mapped Land Use Classes

Ag Land Use Code	Ag Land Use Code Descriptions	Los Angeles	Riverside	San Bernardino	Grand Total
1434	Water Storage	2.2	182.4	68.8	253.4
1436	Water Transfer	19.6	235.4	254.7	509.8
1437	Flood Control	133.2	1,522.6	3,990.5	5,646.3
1850	Wildlife Reserve		638.7		638.7
2110	Irrigated Agriculture		1,256.1	5,058.6	6,314.7
2120	Non-Irrigated Agriculture		30.1	222.5	252.6
2121	Vacant, Zoned Agriculture		7,047.8	1,469.0	8,516.9
2200	Orchard/Vineyards, Undifferentiated	1.3	433.3	747.5	1,182.1
2210	Citrus	1.8	2,630.4	106.0	2,738.2
2300	Nurseries, Undifferentiated	5.9	2,003.0	772.4	2,781.2
2310	Turf Farms			185.8	185.8
2320	Christmas Tree Farms		38.6	42.4	81.0
2411	Dairies - Intensive		331.4	3,017.9	3,349.3
2412	Dairies - Non-Intensive		305.1	1,322.4	1,627.5
2413	Abandoned Dairies		396.8	1,261.5	1,658.3
2420	Other Livestock		2.4	46.0	48.4
2500	Poultry		36.0	85.8	121.7
2600	Other Agriculture, Undifferentiated		182.0	196.6	378.6
2610	Manure and Compost Piles		7.3	220.1	227.3
2620	Backyard Livestock	3.5	1,972.4	372.4	2,348.2
2700	Horses		534.0	301.6	835.6
3200	Abandoned Orchards/Vineyards		215.5	155.8	371.3
4000	Water	0.9	3,082.4	23.8	3,107.1
Grand Total		**168.2**	**23,083.7**	**19,922.1**	**43,174.0**

Santa Ana River Watershed Project Authority
Middle Santa Ana River

Table 3

Agriculture Land Use Classes

Ag Land Use Code	Ag Land Use Code Descriptions	Total Area (ac.)	% of Total Area
2110	Irrigated Agriculture	6,314.7	19.3%
2120	Non-Irrigated Agriculture	252.6	0.8%
2121	Vacant, Zoned Agriculture	8,516.9	26.1%
2200	Orchard/Vineyards, Undifferentiated	1,182.1	3.6%
2210	Citrus	2,738.2	8.4%
2300	Nurseries, Undifferentiated	2,781.2	8.5%
2310	Turf Farms	185.8	0.6%
2320	Christmas Tree Farms	81.0	0.2%
2411	Dairies - Intensive	3,349.3	10.3%
2412	Dairies - Non-Intensive	1,627.5	5.0%
2413	Abandoned Dairies	1,658.3	5.1%
2420	Other Livestock	48.4	0.1%
2500	Poultry	121.7	0.4%
2600	Other Agriculture, Undifferentiated	378.6	1.2%
2610	Manure and Compost Piles	227.3	0.7%
2620	Backyard Livestock	2,348.2	7.2%
2700	Horses	835.6	2.6%
	Totals	**32,647.6**	**100.0%**

Santa Ana River Watershed Project Authority
Middle Santa Ana River

Table 4

Agriculture Land Uses for Operators with Greater than 20 acres

Agriculture Land Use Code	Agriculture Land Use Code Descriptions	Total Agriculture Area (ac.)
2110	Irrigated Agriculture	5,890.08
2120	Non-Irrigated Agriculture	233.36
2121	Vacant, Zoned Agriculture	6,843.44
2200	Orchard/Vineyards, Undifferentiated	899.89
2210	Citrus	1,507.27
2300	Nurseries, Undifferentiated	1,746.07
2310	Turf Farms	185.76
2320	Christmas Tree Farms	63.69
2411	Dairies - Intensive	2,952.25
2412	Dairies - Non-Intensive	1,453.68
2413	Abandoned Dairies	1,617.13
2420	Other Livestock	15.46
2500	Poultry	61.43
2600	Other Agriculture, Undifferentiated	224.93
2610	Manure and Compost Piles	172.46
2620	Backyard Livestock	287.85
2700	Horses	245.14
Total		24,399.89
Total Agriculture minus 2121, 2411, 2412, & 2413		11,533.4

Figure 1:

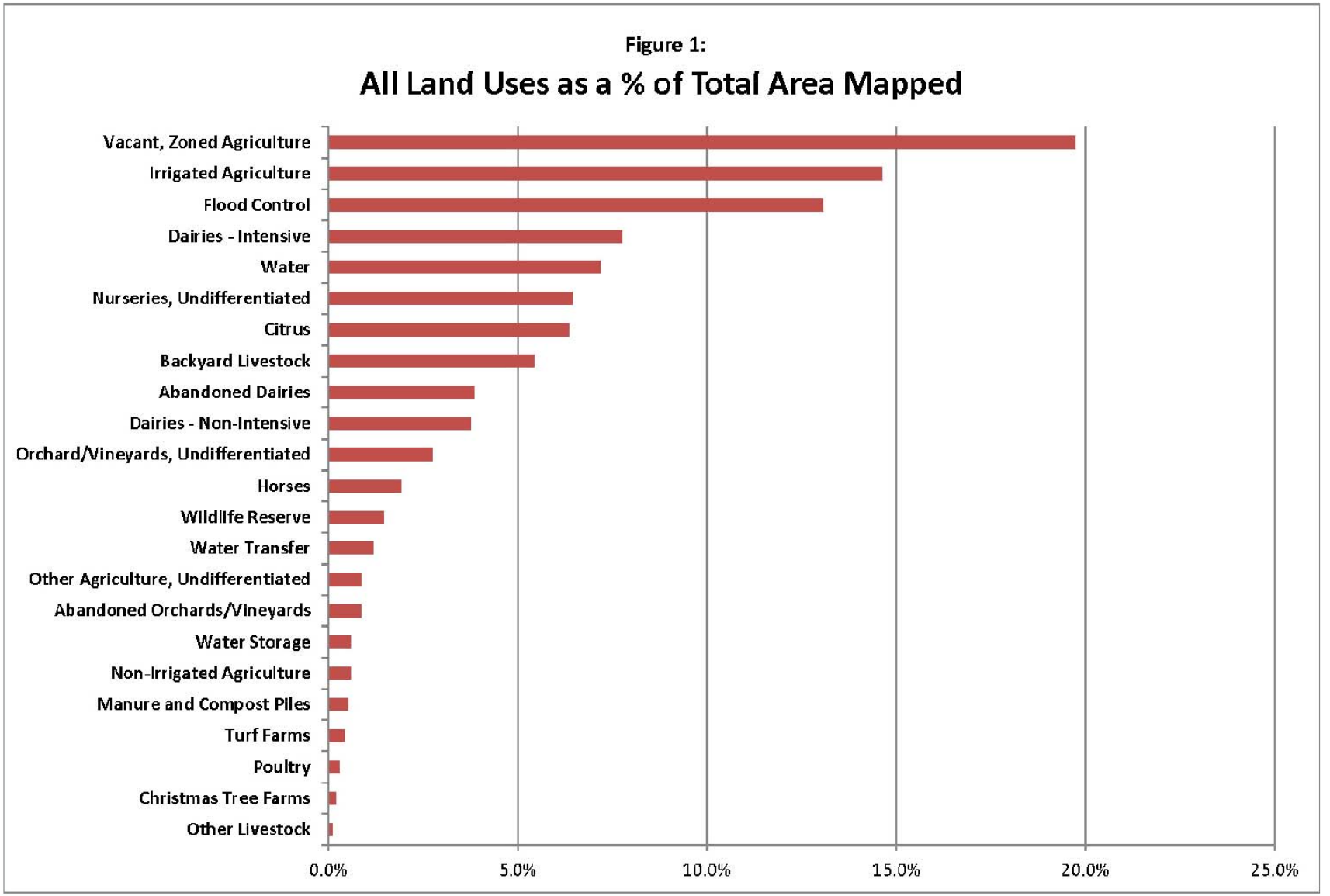
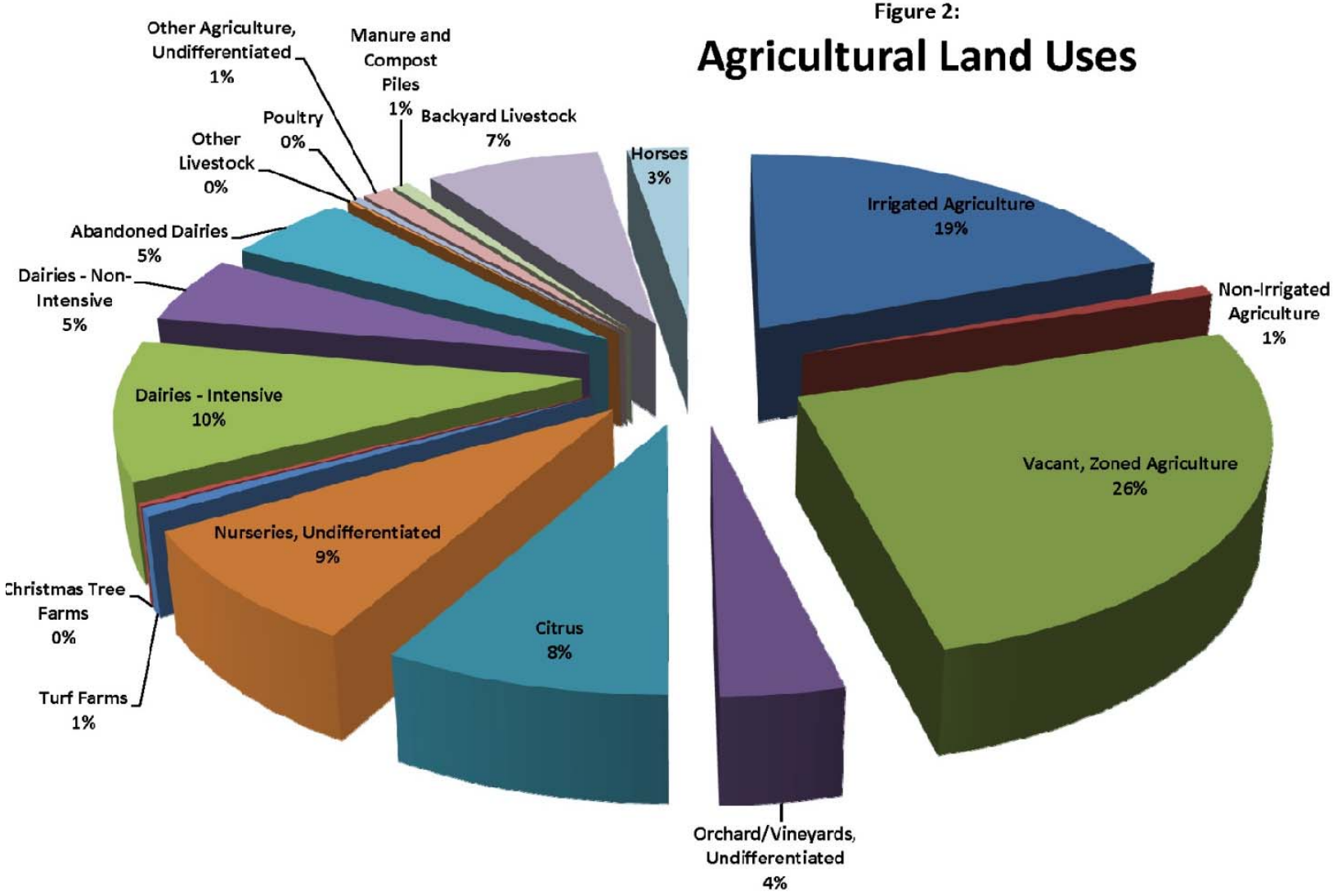
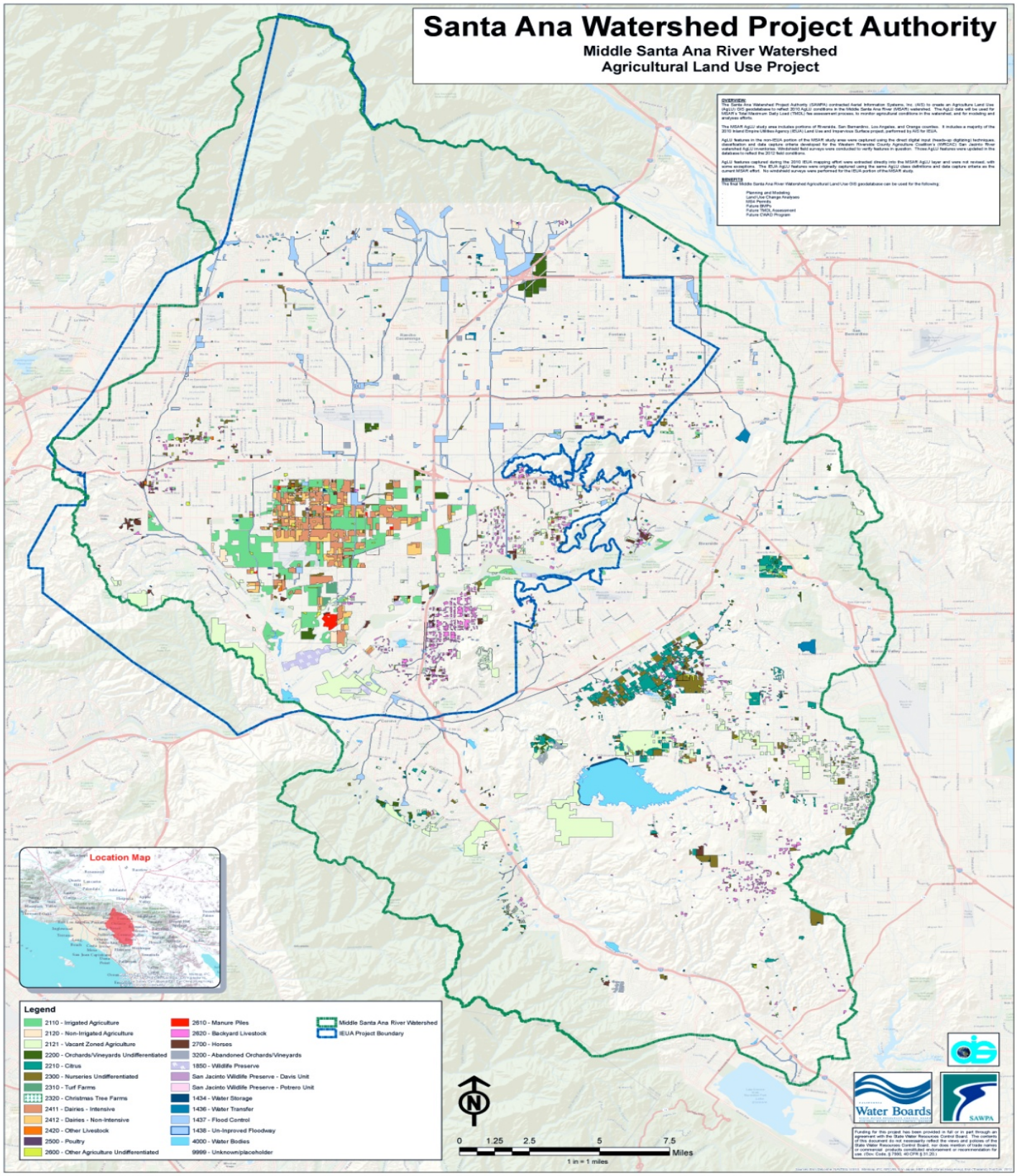

All Land Uses as a % of Total Area Mapped
Vacant, Zoned Agriculture
Irrigated Agriculture
Flood Control
Dairies - Intensive
Water
Nurseries, Undifferentiated
Citrus
Backyard Livestock
Abandoned Dairies
Dairies - Non-Intensive
Orchard/Vineyards, Undifferentiated
Horses
Wildlife Reserve
Water Transfer
Other Agriculture, Undifferentiated
Abandoned Orchards/Vineyards
Water Storage
Non-Irrigated Agriculture
Manure and Compost Piles
Turf Farms
Poultry
Christmas Tree Farms
Other Livestock
0.0%
5.0%
10.0%
15.0%
20.0%
25.0%

Figure 2:

Agricultural Land Uses




Santa Ana Watershed Project Authority
Middle Santa Ana River Watershed
Agricultural Land Use Project
OVERVIEW:
The Santa Ana Watershed Project Authority (SAWPA) contracted Aerial Information Systems, Inc. (AIS) to create an Agriculture Land Use (AgLU) GIS geodatabase to reflect 2010 AgLU conditions in the Middle Santa Ana River (MSAR) watershed. The AgLU data will be used for SAWPA's Total Maximum Daily Load (TMDL) flex assessment process, to monitor agricultural conditions in the watershed, and for modeling and analyses efforts.
The MSAR AgLU study area includes portions of Riverside, San Bernardino, Los Angeles, and Orange counties. It includes a majority of the 2010 Inland Empire Utilities Agency (IEUA) Land Use and Impervious Surface project, performed by AIS for IEUA.
AgLU features in the non-IEUA portion of the MSAR study area were captured using the direct digital input (heads-up digitizing) techniques, classification and data capture criteria developed for the Western Riverside County Agriculture Coalition's (WRCAC) San Jacinto River watershed AgLU inventories. Windshield field surveys were conducted to verify features in question. Those AgLU features were updated in the database to reflect the 2012 field conditions.
AgLU features captured during the 2010 IEUA mapping effort were extracted directly into the MSAR AgLU layer and were not revised, with some exceptions. The IEUA AgLU features were originally captured using the same AgLU class definitions and data capture criteria as the current MSAR effort. No windshield surveys were performed for the IEUA portion of the MSAR study.
BENEFITS
The final Middle Santa Ana River Watershed Agricultural Land Use GIS geodatabase can be used for the following:
Planning and Modeling
Land Use Change Analyses
MS4 Permits
Future BMPs
Future TMDL Assessment
Future CWAD Program
Location Map
Legend
2110 - Irrigated Agriculture
2120 - Non-Irrigated Agriculture
2121 - Vacant Zoned Agriculture
2200 - Orchards/Vineyards Undifferentiated
2210 - Citrus
2300 - Nurseries Undifferentiated
2310 - Turf Farms
2320 - Christmas Tree Farms
2411 - Dairies - Intensive
2412 - Dairies - Non-Intensive
2420 - Other Livestock
2500 - Poultry
2600 - Other Agriculture Undifferentiated
2610 - Manure Piles
2620 - Backyard Livestock
2700 - Horses
3200 - Abandoned Orchards/Vineyards
1850 - Wildlife Preserve
San Jacinto Wildlife Preserve - Davis Unit
San Jacinto Wildlife Preserve - Potrero Unit
1434 - Water Storage
1436 - Water Transfer
1437 - Flood Control
1438 - Un-Inproved Floodway
4000 - Water Bodies
9999 - Unknown/placeholder
Middle Santa Ana River Watershed
IEUA Project Boundary
N
0 1.25 2.5 5 7.5
Miles
1 in = 1 miles
Water Boards
SAWPA
Funding for this project has been provided in full or in part through an agreement with the State Water Resources Control Board. The contents of this document do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. (Gov. Code, § 7569, 40 CFR § 31.20.)