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O A L S BULLETIN 11

AN ASSESSMENT OF THE IMPACT OF WATER IMPOUNDMENT AND DIVERSION STRUCTURES ON VEGETATION IN SOUTHERN ARIZONA

by

Jeffery S. Conn, David A. Mouat,

Robin B. Clark

A Report of Work Performed Under
NASA Grant No. NGL 03-002-313

In Cooperation with the
U.S. Soil Conservation Service
and the Arizona Water Commission

OFFICE OF ARID LANDS STUDIES
University of Arizona
Tucson, Arizona

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FOREWORD

This Bulletin is published in furtherance of the purposes of NASA grant NGL 03-002-313 entitled "Research for Applications of Remote Sensing to State and Local Governments." The purpose of the grant is to assist, with the use of NASA high-altitude photography and satellite imagery, governmental agencies whose responsibility lies in planning, zoning, and environmental monitoring and/or assessment.

This report is the eleventh in a series of publications designed to present information bearing on remote sensing research and applications in Arizona. In the present investigation NASA high-altitude color infrared photography was used to survey existing conditions, both upstream and downstream, from nineteen diversion structures in Southern Arizona to determine their effect upon vegetation health, vigor, and cover. A diversion structure is herein defined as a man/made feature constructed to control storm runoff. The results of this study will determine if the policy for future structure design should be altered from present standards.

INTRODUCTION

A common man-made feature in the Arid Southwest is the water impoundment or diversion structure. Constructed by private individuals, as well as by public agencies, these structures were built for a variety of purposes. The chief reason for their construction is protection of agricultural lands, urban developments, highways, and canals from the devastating effects of storm runoff. The structures may divert water away from those features or they may impound the water for slow release at a later time. Occasionally the structures concentrate sheet flow into flood control channels. A few structures were built to store water for municipal or livestock use.

The water impoundment or diversion structures were built at various times throughout the past 100 years. Most, however, were built rather recently - many of the larger ones being built in the last 10 years. They range in size from a few feet high and across to thirty - five feet high and many miles in length. Structures built since the early 1950's are under the jurisdiction of Federal Public Law 83-566 which provides assistance for planning, funding, and construction of water impoundment and diversion structures through the Soil Conservation Service.

The effects these structures may have on the distribution and vigor of riparian habitat have been the focus of recent attention. In order to better assess what effect, if any, these structures have had the Applied Remote Sensing Program (ARSP), University of Arizona, Office of Arid Lands Studies and the Arizona Water Commission held initial discussion on 1 April and 15 April 1975 to establish a cooperative effort between the two groups for the purpose of solving this ecological controversy of whether or not water impoundment or diversion structures affect riparian vegetation habitat.

ARSP agreed to undertake an analysis of nineteen of the structures. The structures are all located within the Sonoran Desert of Southwest Arizona as shown in Figure 1.

The project was jointly funded by the U. S. Soil Conservation Service and the Applied Remote Sensing Program which operates under NASA grant no. NGL 03-002-313.

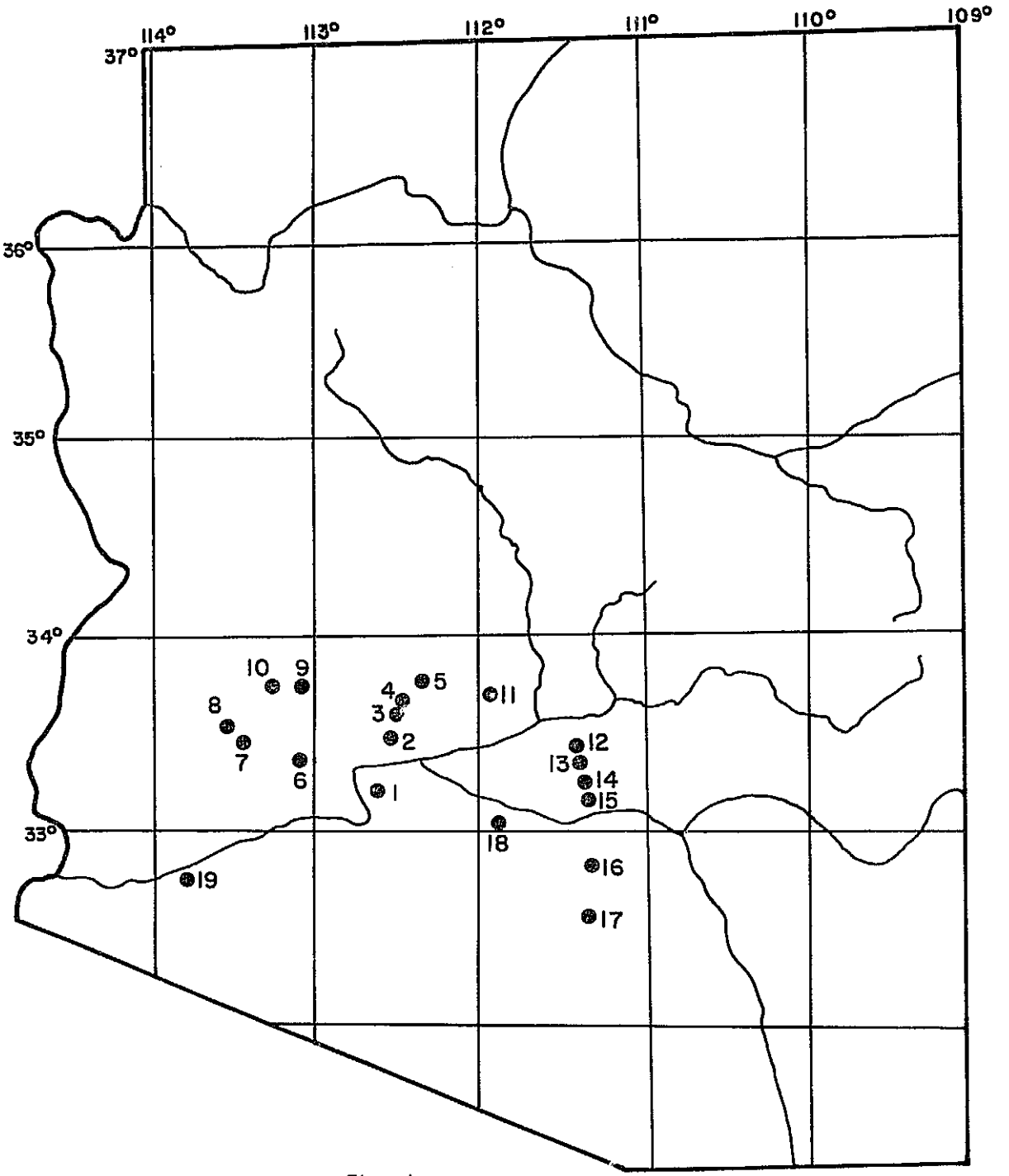


Figure 1. Location of Diversion Structures.

MATERIALS AND METHODS

Suitability of Diversion Structures for Analysis

Before detailed statistical analysis of each of the nineteen diversion structure sites was attempted, a study was made of the suitability of each of the sites for quantitative study. The analysis was made using NASA-supplied high altitude aircraft photography (see Table 1, a list of imagery used for each site) in conjunction with ground study. The criteria for suitability were:

1. Areal extent of natural vegetation upstream and downstream from the structure to enable comparisons to be made;
2. Absence of large nearby diversions upstream or downstream that might influence the vegetation that was to be compared;
3. Areal extent of riparian vegetation to make mapping and comparison feasible.

Diversion sites found not to be suitable were:

Site No. 1, The U. S. Highway 80 Diversion;
Site No. 2, White Tanks No. 1 Diversion;
Site No. 6, Interstate 10 - Harquahala Valley;
Site No. 7, B.L.M. Centennial Wash Waterspreaders;
Site No. 9, Unnamed Diversions - Aguila
Site No. 10, U. S. Highway 60 Diversions;
Site No. 17, Farm Road Dike
Site No. 19, Wellton - Mohawk Canal and Diversions.

Diversion Sites 1, 6, and 10 were unsuitable for quantitative study due to the small areal extent of riparian vegetation. The diversions at these sites produced very little change upstream and downstream. Vegetation for each of these sites is described and compared qualitatively however.

Table 1. High Altitude Imagery Employed in the Study

Site No.	Mission No.	Frame No.	Description	Date Taken
1	72-193	7432	Color Infrared	6 November 1972
2	72-193	7413	Color Infrared	6 November 1972
3	72-193	7413	Color Infrared	6 November 1972
4	72-193	7413	Color Infrared	6 November 1972
5	72-193	7413	Color Infrared	6 November 1972
6	155, R2	568	Color	18 January 1971
7	------	-----	orthophotoquad	----------
8	------	-----	orthophotoquad	----------
9	155, R2	572	Color	18 January 1971
10	155, R2	573	Color	18 January 1971
11	72-193	7409	Color Infrared	6 November 1972
12	72-193	7423	Color Infrared	6 November 1972
13	72-193	7424	Color Infrared	6 November 1972
14	72-193	7424	Color Infrared	6 November 1972
15	155, R19	731	Color	19 January 1971
16	101, R7	4641	Color Infrared	10 August 1969
17	101, R7	4692	Color Infrared	10 August 1969
18	101, R7	4636	Color Infrared	10 August 1969
19	72-192	7236, 7237	Color Infrared	1 November 1972

Sites 2, 17, and 19 were considered to be unsuitable for quantitative study because of the close proximity of agricultural fields downstream that make comparison of adjacent upstream and downstream vegetation impossible. These structures are not described further in this report.

Structures 7 and 9 are a network of diversions that were deemed unsuitable because each diversion in the series influences the next, making simple, upstream-downstream comparisons difficult. The sites are qualitatively described in the report.

Sites which met the suitability criteria were:

Site No. 3, White Tanks Proving Grounds Diversion;
Site No. 4, White Tanks No. 2 Diversion;
Site No. 5, Trilby Wash Detention Basin;
Site No. 8, B.L.M. Narrows Dam;
Site No. 11, Old Verde Canal;
Site No. 12, Powerline Dam;
Site No. 13, Vineyard Road Dam;
Site No. 14, Rittenhouse Dam;
Site No. 15, Magma Dam;
Site No. 16, Brady Wash Diversion
Site No. 18, South Side Canal and Diversions.

These sites were analyzed quantitatively and are reported in the Results section.

Methods of Quantitative Analysis

Statistical study of the eleven sites began with the enlargement of the NASA-supplied high altitude aircraft imagery listed in Table 1, to an approximate scale of 1:30,000. Delineations of different-appearing vegetation types one mile upstream and downstream of the sites were performed. Later, a low altitude aerial reconnaissance was made and color infrared photographs taken with hand held 35 mm single lens

reflex cameras. These photographs, taken in June 1975, were used to up-date the older NASA imagery. Identifications of vegetation types were made by field checking the delineations. Vegetation types were determined by matching the vegetation with the appropriate Brown and Lowe (1974) legend designation. In many instances it was necessary to amend the legend in order to more accurately describe the existing vegetation. Cover and vigor estimates were made through on-site inspection and image interpretation. These techniques have been shown to be valid by such plant ecologists as Braun - Blanquet (1964), and Poulton (1970). The vegetation types noted, as well as the cover and vigor classes used, are given in Figure 2.

Following the initial delineations and subsequent vegetation type identification, the maps were redrawn. Locations of culverts and other diversion flow-through points were added to the maps. Acreage determinations of the vegetation types including cover and vigor were then made using a polar planimeter. Data obtained from the vegetation maps were manipulated using the equations shown in Figure 3. The resulting statistics constitute the basis from which the results and summary for the eleven sites were made.

Figure 2. Classification of vegetation types, cover, and vigor used in the analysis.

Vegetation Types Occurring at Diversion Structure Sites (Modified from Brown and Lowe, op. cit.)

342.4	Riparian Scrub
342.43	Mixed Riparian Scrub Types
342.431	Tamarix/Seep Willow/Mesquite Type
342.432	Tamarix/Seep Willow/Mesquite Type, with annuals
342.433	Mesquite/Whitethorn Acacia/Catclaw Type
363	Sonoran Desert Scrub
363.11	Mixed Paloverde - Cacti Types
363.111	Foothill Paloverde/Triangle-Leaf Bursage Type
363.115	Mesquite Type
363.117	Creosote Bush/Triangle-Leaf Bursage/Foothill Paloverde Type
363.12	Creosote Bush - Bursage Types
363.121	Creosote Bush Type
363.122	Creosote Bush/White Bursage Type
363.125	Creosote Bush/Triangle-Leaf Bursage Type
363.126	Creosote Bush/Cholla Type
363.18	Riparian Desert Scrub Types
363.181	Mesquite Type
363.182	Tamarix Type
363.183	Tamarix/Mesquite Type
363.185	Blue Paloverde/Mesquite Type
363.186	Mesquite/Blue Paloverde/Ironwood Type
363.187	Foothill Paloverde/Ironwood Type
363.188	Ironwood/Mesquite Type
363.189	Ironwood/Mesquite/Foothill Paloverde Type

Cover Classes (half shrubs, shrubs, trees, and succulents)

1. 0 - 5%
2. 5 - 10%
3. 10 - 20%
4. 20 - 30%
5. 30 - 50%
6. 50 - 75%
7. 75 - 100%

S = scraped area

Vigor Classes

1. severely stressed
2. stressed
3. normal
4. moderately vigorous
5. highly vigorous

Figure 3. Vegetation measurement equations.

Total Vegetation Acreage (TVA) = total acreage covered by vegetation

Riparian Vegetation Acreage (RVA) = total acreage covered by riparian vegetation

Interfluvial Vegetation Acreage (IVA) = total acreage covered by interfluve vegetation

% Total Cover (C) = [TVA ÷ total acreage (soil + vegetation)] x 100

% Riparian Cover (C_r) = (RVA ÷ total acreage) 100

% Interfluvial Cover (C_i) = (IVA ÷ total acreage) 100

% Average Riparian Cover ($\overline{C}_r$) = [RVA ÷ total riparian acreage (soil + vegetation)] 100

% Average Interfluvial Cover ($\overline{C}_i$) = (IVA ÷ total interfluvial acreage) 100

Average Vigor ($\overline{V}$) = Σ (Vigor Class Constant x basal area for each vegetation type) ÷ TVA

Average Riparian Vigor ($\overline{V}_r$) = Σ (Vigor Class Constant x RVA for each type) ÷ RVA

Average Interfluvial Vigor ($\overline{V}_i$) = Σ (Vigor Class Constant x IVA for each type) ÷ IVA

RESULTS

I. U. S. Highway 80 Diversion Structure (#1)

The vegetation on both sides of the structure consists of the Creosote Bush/ Foothill Paloverde type with small amounts of brittle-bush, triangle-leaf bursage, and saguaro. Ironwood is common along the washes.

Vegetation cover is similar on both sides of the structure as can be seen in Figures 4 and 5 (ground truth photographs of vegetation upstream and downstream from the structure) and Figure 6 (an infrared photo of the diversion structure and adjacent upstream and downstream areas).

The vigor of the vegetation immediately downslope from the structure was lower than that of upslope vegetation and vegetation further downslope. However, the affected area extends only about 100 yards downslope from the structure. Creosote bush appears to suffer the greatest loss of vigor.

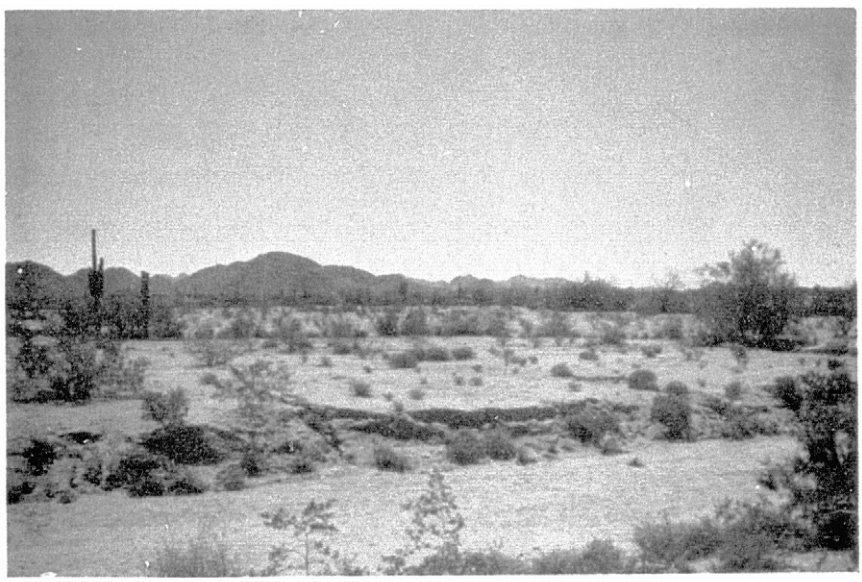


Figure 4. Ground truth photograph of upstream vegetation (Structure #1).

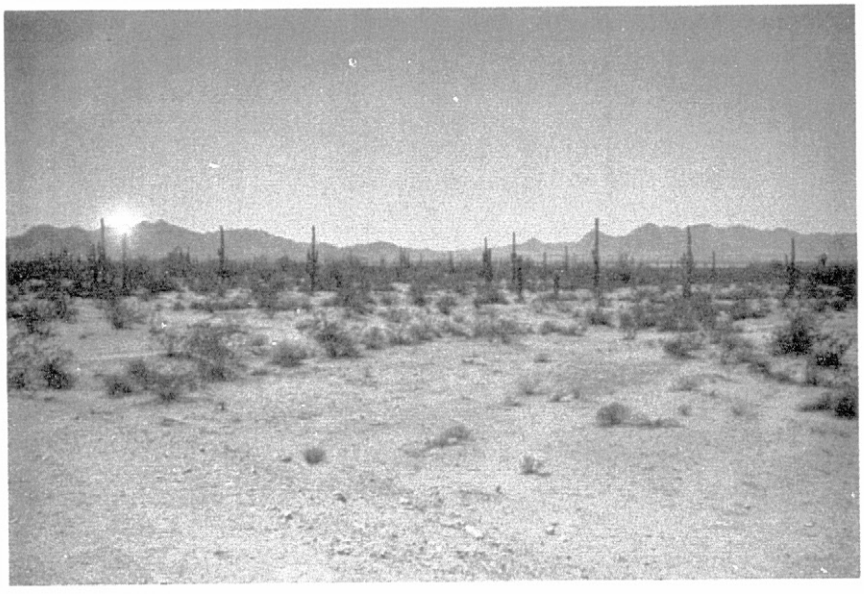


Figure 5. Ground truth photo of downstream vegetation (Structure #1).

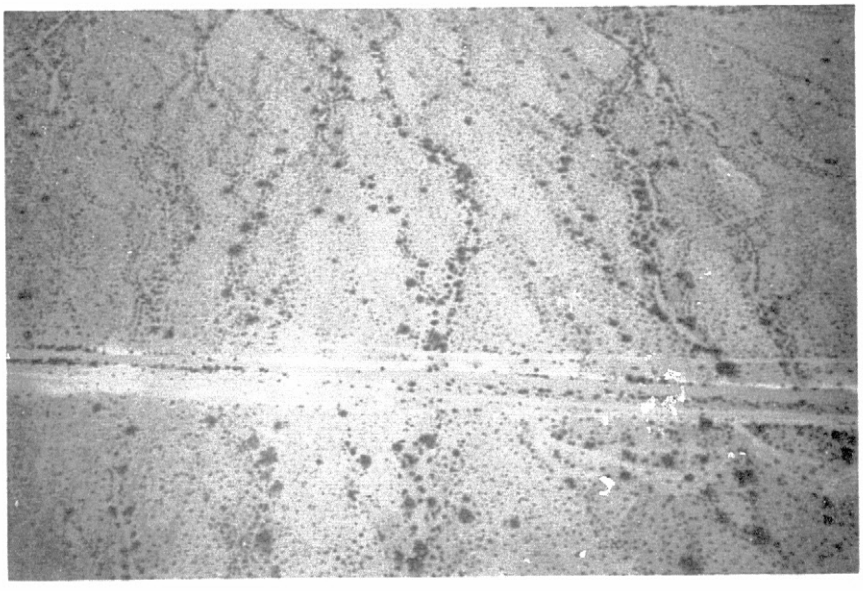


Figure 6. Infrared photo of the diversion structure and adjacent upstream and downstream areas (Structure #1).

Although its affect on vegetation has been minimal, the diversion structure has caused a major wash to exist which parallels the structure, just upstream from it. The new wash, which is approximately 15 feet wide, prevents water from accumulating behind the structure, preventing the occurrence of more luxuriant plant growth upstream.

II. White Tanks Proving Grounds Diversion (#3)

Qualitative Assessment

Species composition of the vegetation upslope and downslope from the diversion structure is the same: foothill paloverde, creosote bush, and triangle-leaf bursage on the interfluves, and mesquite, ironwood, and blue paloverde along the washes. Vegetation density and vigor are quite different for the two areas however. Figure 7 (a photo of the downslope vegetation) when compared to Figure 8 (a photo of upslope vegetation) illustrates this difference. The vegetation upslope appears to be much more luxuriant and vigorous than downslope.

On downslope interfluves, foothill paloverde is less dense and vigorous

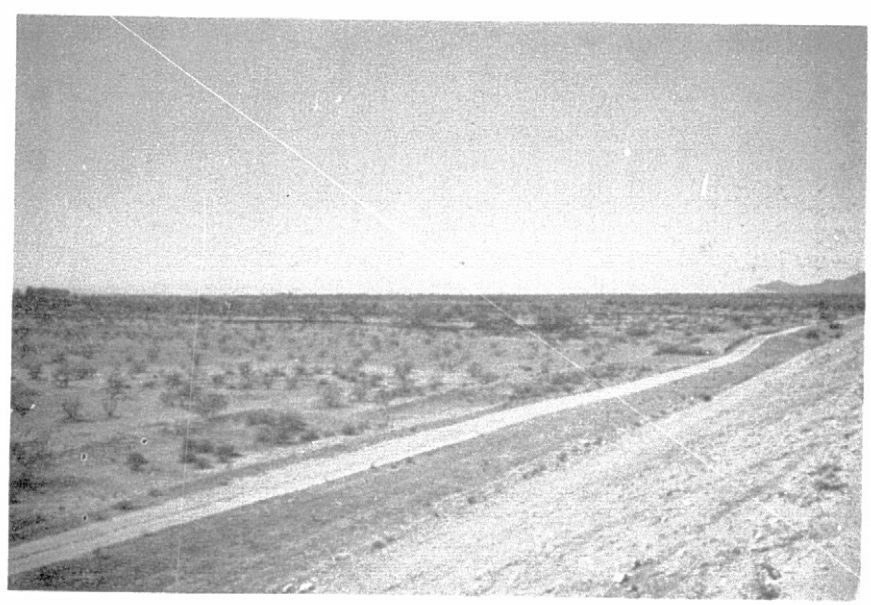


Figure 7. Ground truth photo of downslope vegetation (Structure #3).

Figure 8. Ground truth photo of upslope vegetation (Structure #3).

than on upslope interfluves, while creosote bush and triangle-leaf bursage are little-affected. Wash vegetation, in general, is also much less dense and vigorous downstream.

As shown in Figure 9, a vegetation map for this structure, the vegetation patterns appear to be unaffected by the structure.

Quantitative Assessment

The trends in vegetation discussed in the qualitative assessment are borne out by the quantitative results as shown in Appendix A.

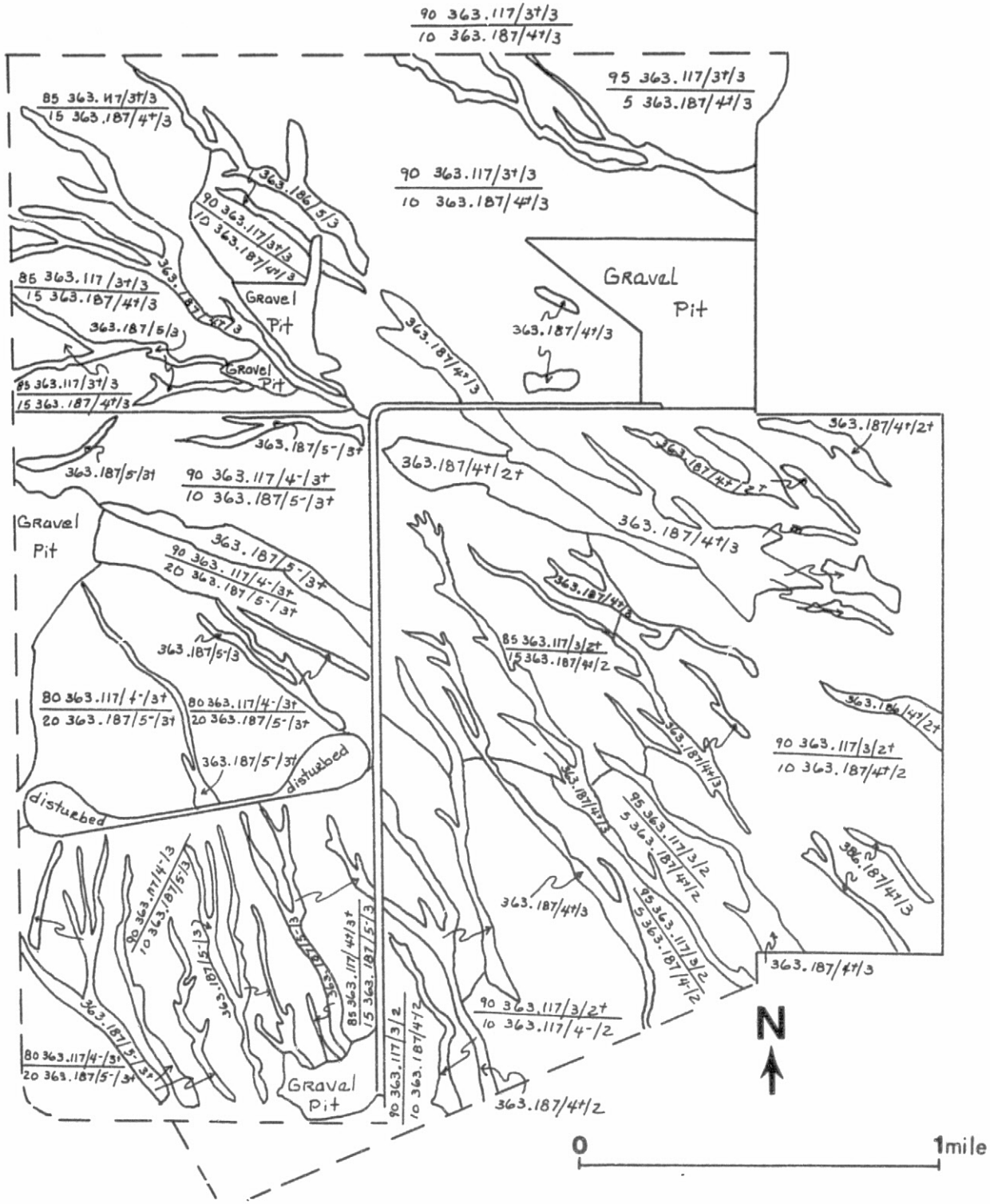


Figure 9. Vegetation map for White Tanks Proving Grounds Diversion (#3).

III. White Tanks No. 2 Structure (#4)

Qualitative Assessment

Vegetation upslope and downslope from this structure differs dramatically in species composition, cover, density, and vigor.

Upslope and adjacent to the structure (corresponding to the area of standing water) exists a very vigorous vegetation type consisting of tamarisk, seep-willow, and desert broom (shown in Figure 10). Further upslope, the interfluve vegetation consists of the Creosote Bush/Triangle-Leaf Bursage type with occasional foothill paloverde. Riparian vegetation is primarily foothill paloverde, blue paloverde, and ironwood. Downslope, interfluve vegetation consists of the Creosote Bush/Triangle-Leaf Bursage type with occasional foothill paloverde. Downslope, riparian vegetation is the Foothill Paloverde/Ironwood type.

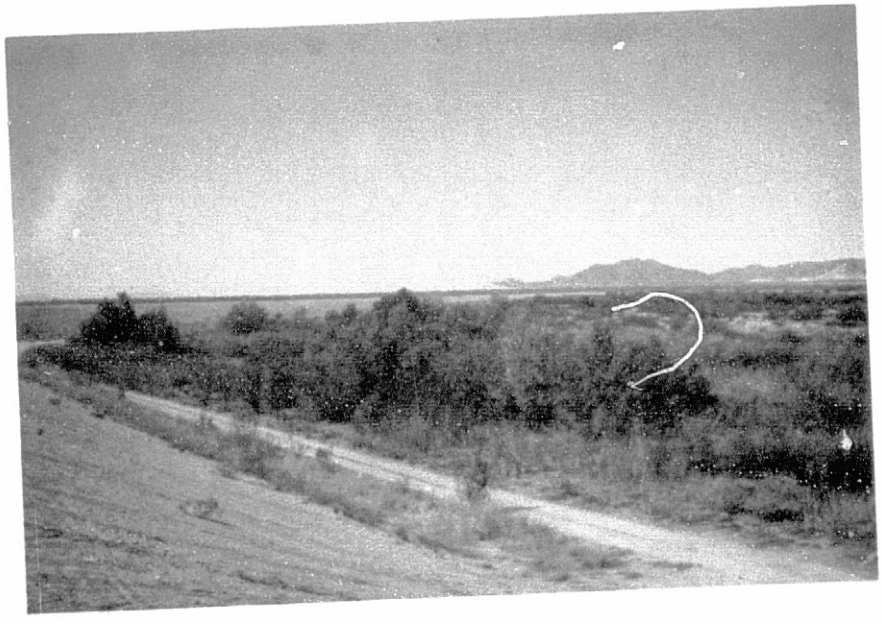


Figure 10. Vegetation upslope and adjacent to the structure (#4).

Associated with the riparian vegetation upstream is a high cover and density. Cover and density of downslope vegetation is quite low in comparison. Figures 10, 11, 12, and 13 (ground truth and infrared low-altitude photographs of the upslope and downslope areas) illustrate the upslope/downslope vegetation cover and density difference.

Upslope interfluve and riparian vegetation is much more vigorous than downslope vegetation. The riparian areas have a very marked difference: upslope riparian vegetation is very vigorous while downslope riparian vegetation is almost dead. Ironwood seems to be the most unfavorably affected plant downslope.

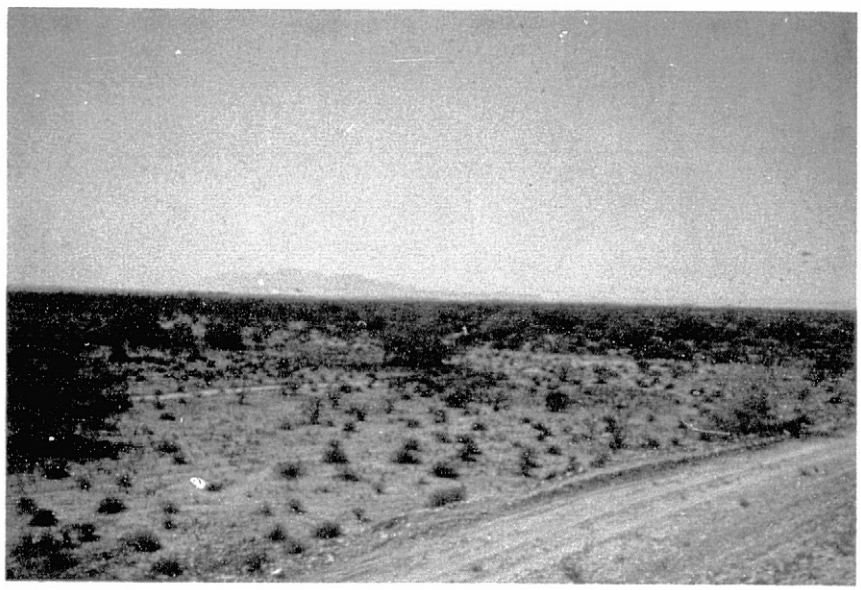


Figure 11. Ground truth photo of downstream vegetation (Structure #4).

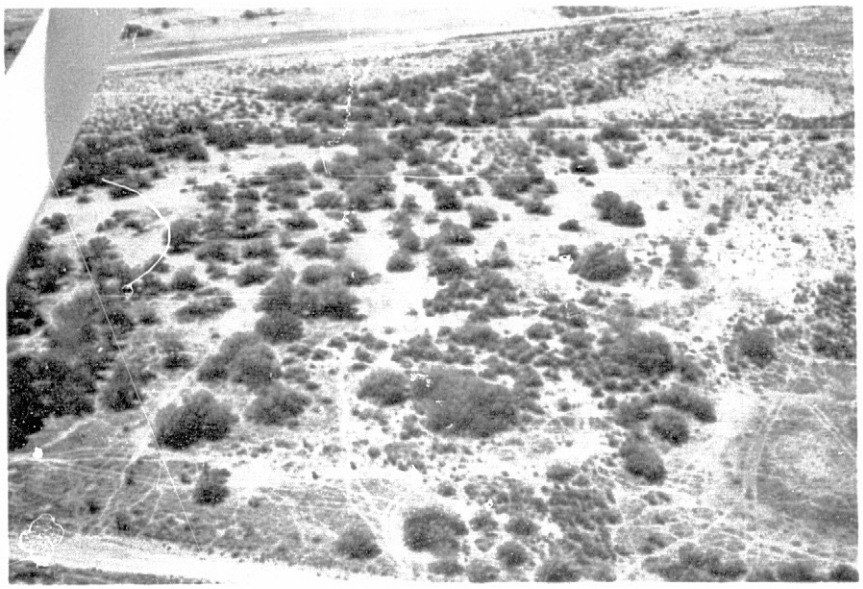


Figure 12. Infrared low-altitude photo of upslope vegetation (Structure #4).

Figure 13. Infrared low-altitude photo of upslope vegetation (Structure #4).

As can be seen from Figure 14 (the vegetation map for this site) vegetation patterns upstream and downstream of the structure remain unaltered.

Quantitative Assessment

In general, the statistics presented in Appendix A for this site support the observations listed in the qualitative assessment. Of interest, however, is that the greatest difference in density is between upslope and downslope interfluves and not between the riparian areas. It should also be noted that the greatest difference in vigor is between upslope and downslope riparian areas.

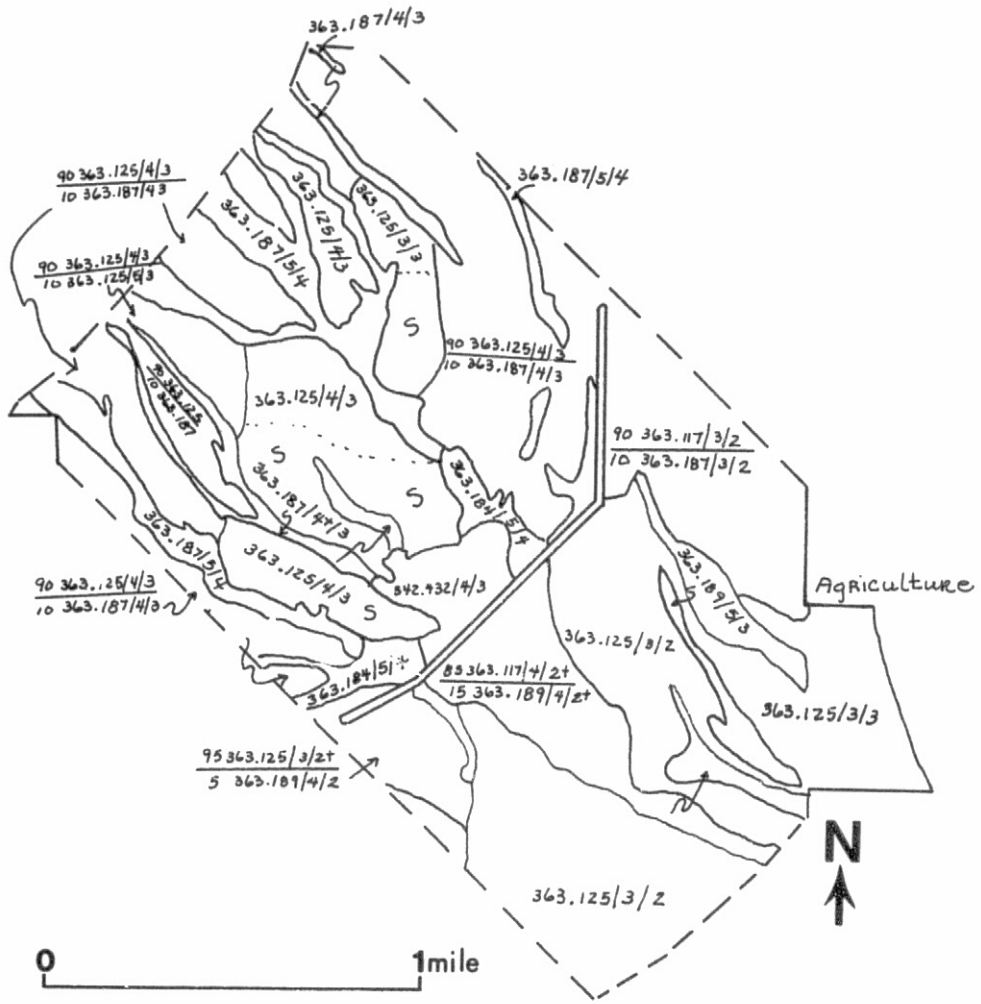


Figure 14. Vegetation map for White Tanks No. 2 (Structure #4).

IV. Trilby Wash Detention Basin (#5)

Qualitative Assessment

Observational assessment of vegetation upstream and downstream from this major diversion structure reveals marked differences in cover, density, vigor, and species composition between the upslope and downslope sides.

Upslope, in the areas of deepest seasonal standing water, there occurs a very dense stand of seep-willow (shown in Figure 15). Further upstream, wash vegetation is primarily the Mesquite/Blue Paloverde type as shown in Figure 16. Interfluve vegetation is the Triangle-Leaf Bursage/Creosote Bush type.

Downslope, seep-willow communities are absent. Wash vegetation consists of ironwood, mesquite, foothill paloverde, and blue paloverde.

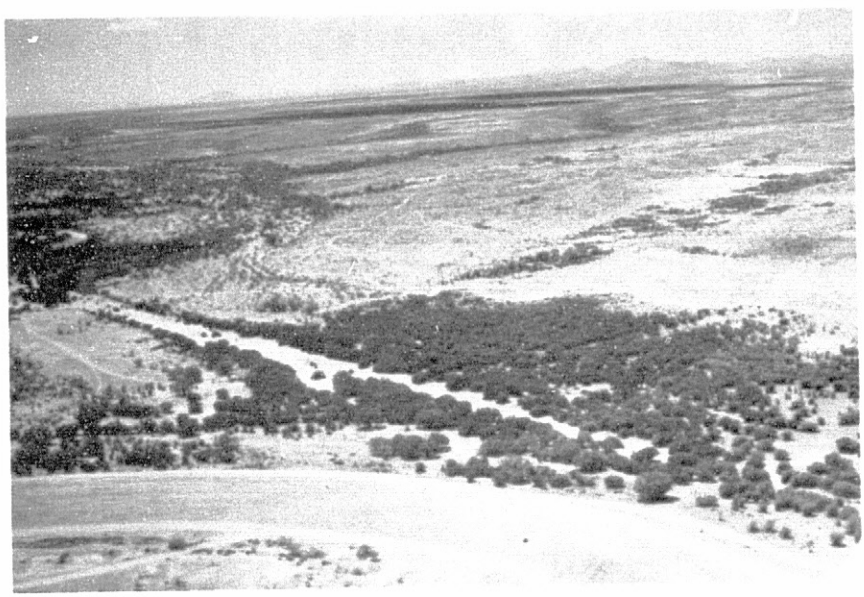


Figure 15. Dense stand of vegetation immediately upslope of structure (#5).

Figure 16. Mesquite/Blue Paloverde type upslope from the structure (#5).

Interfluve vegetation is the Triangle-leaf Bursage/Creosote Bush type with cholla, as is shown in Figure 17.

Cover, density, and vigor of upstream vegetation are much greater upslope than downslope as is shown by Figures 15 and 18. Blue paloverde seems to be the most severely stressed plant downstream.

Riparian vegetation patterns downslope are different from those upslope, especially for the northern 4/5 of the length of the diversion structure. Figure 19, the vegetation map for this site, shows that many of the large upslope riparian vegetation patterns end at the structure, with no correlate downslope. The changed vegetation patterns are most probably a direct result of the diversion structure.

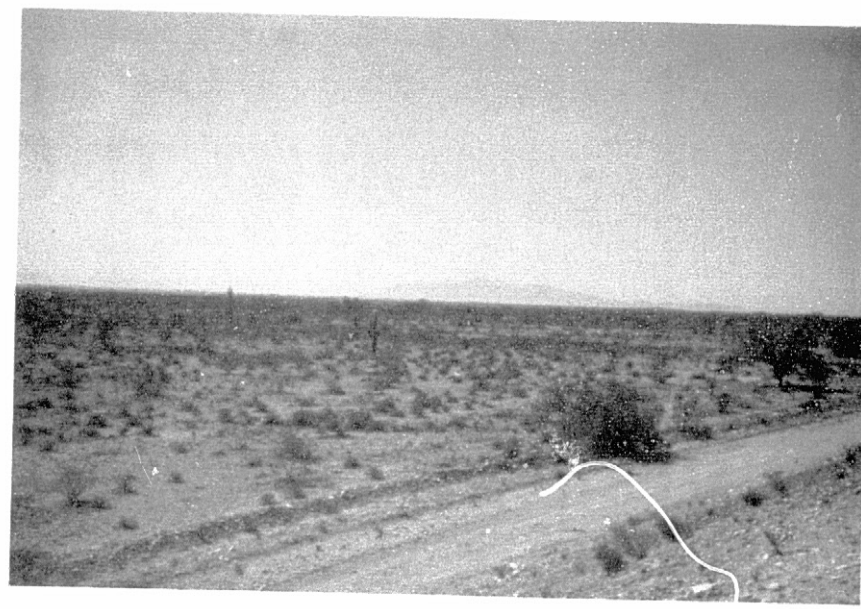


Figure 17. Downslope interfluve vegetation. The Triangle-leaf Bursage/ Creosote Bush type with cholla (Structure #5).

Figure 18. Infrared low-altitude photo of downstream vegetation (Structure #5).

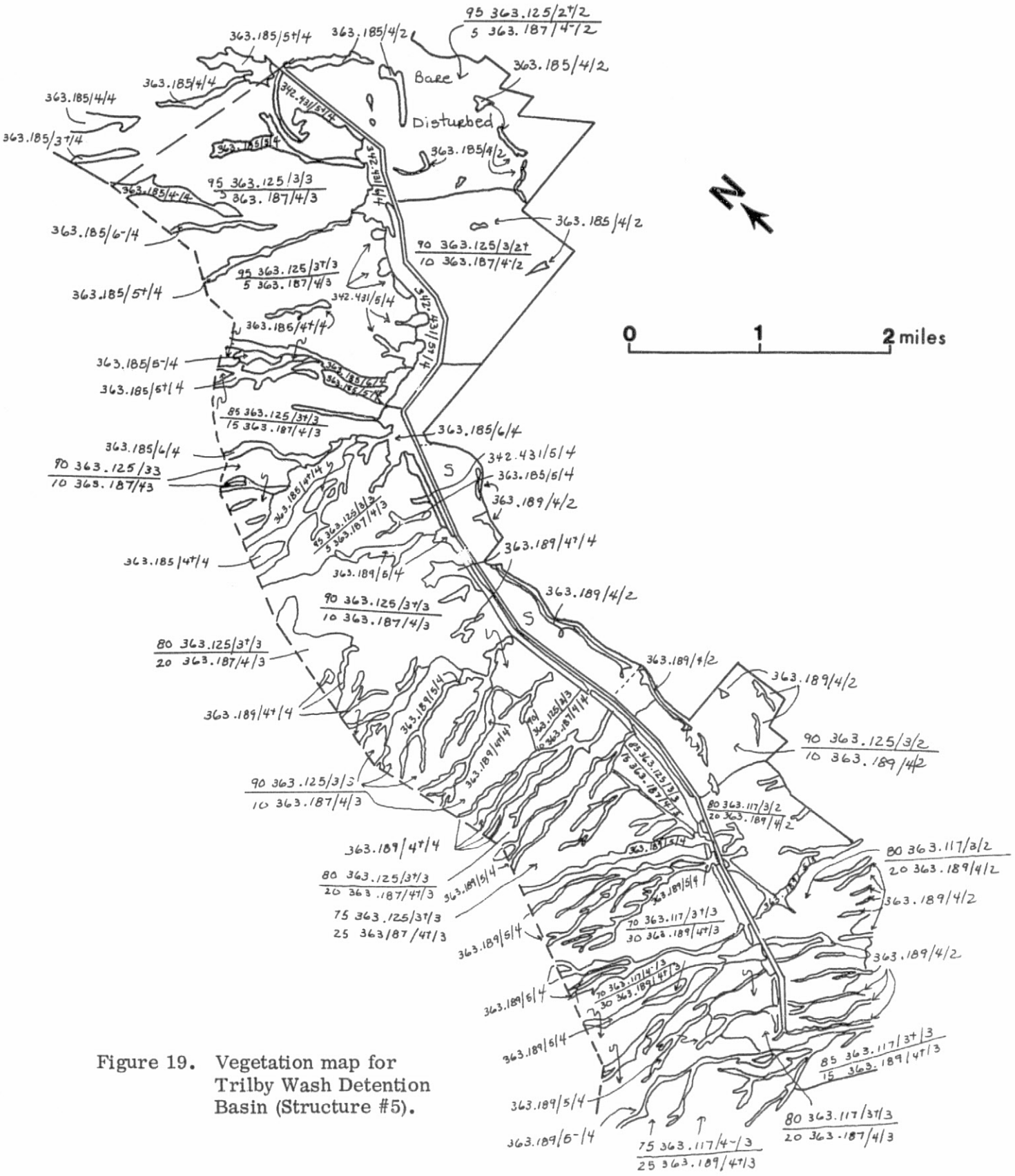


Figure 19. Vegetation map for Trilby Wash Detention Basin (Structure #5).

Quantitative Assessment

The statistics for this site, presented in Appendix A, support the general conclusions of the previous section. The statistics show a higher vigor, cover, and density upslope than downslope. Moreover, riparian vegetation seems to be much more affected both upslope and downslope, than is interfluve vegetation.

V. Interstate 10 - Harquahala Valley Structure (#6)

Introduction

The diversion structure is Interstate 10, approximately $\frac{1}{4}$ mile west of the Salome exit.

Qualitative Assessment

In general, downslope and upslope vegetation is the same in species composition, density, cover, and vigor. Upslope, however, there is an increase in the before-mentioned vegetation parameters immediately adjacent to the highway. Downslope, at culverts, the vegetation is locally luxuriant and vigorous. Figures 20 and 21 (photos of upslope and downslope vegetation) and Figure 22 (an aerial infrared photo of the highway and areas upslope and downslope) show the differences in vegetation

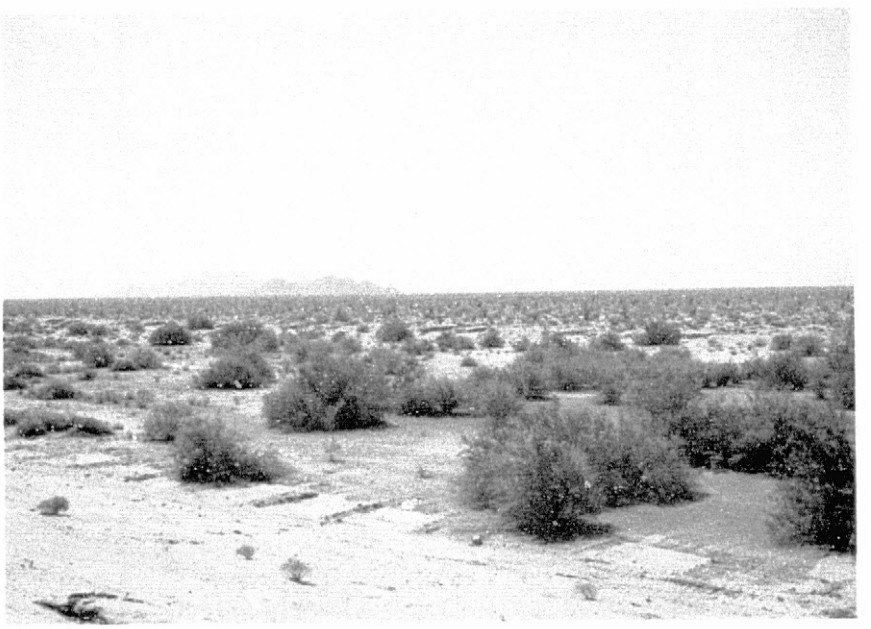


Figure 20. Ground truth photo of upslope vegetation (Structure #6).

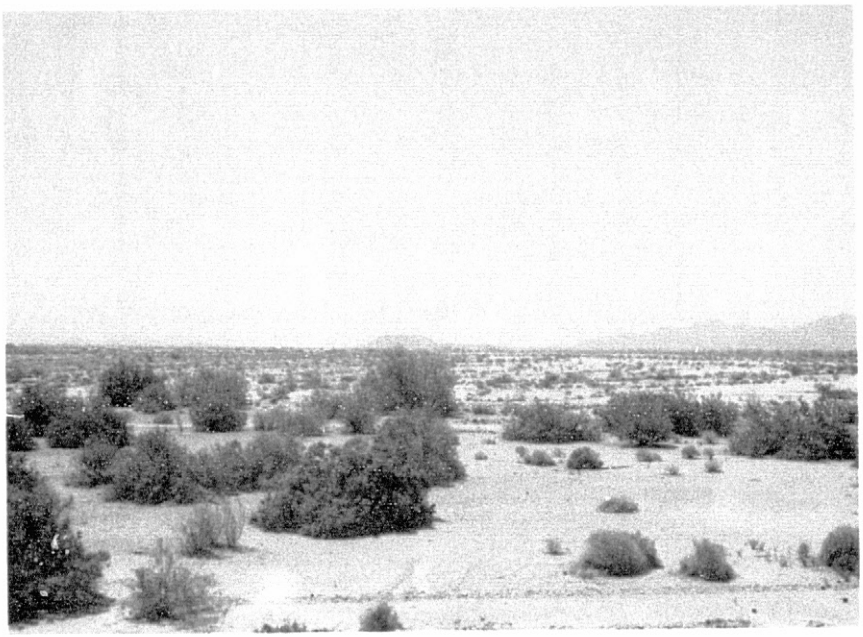


Figure 21. Ground truth photo of downslope vegetation (Structure #6).

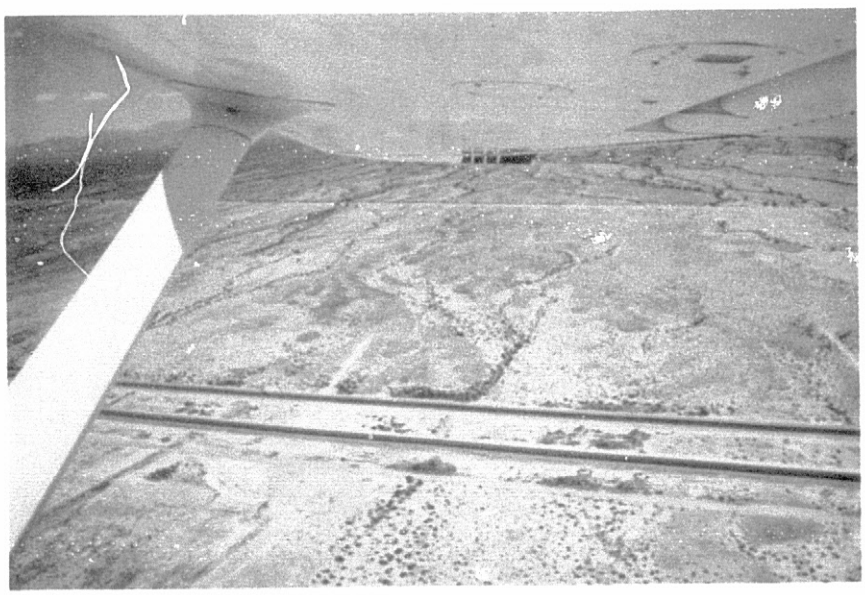


Figure 22. Infrared low-altitude photo of I-10 and areas upslope and downslope. (Structure #6).

upslope and downslope. The increases in vegetation were quite small and restricted, though, and mapping from high-altitude photography was not therefore feasible.

The vegetation of the entire area consists of the Creosote Bush type with foothill paloverde restricted to the washes. The cover of the Creosote Bush type was quite low (< 10%) throughout the area.

As can be seen from Figure 22, the vegetation patterns are essentially the same both upslope and downslope, although vegetation densities are somewhat locally higher upslope along the diversion.

VI. B.L.M. Centennial Wash Waterspreaders (#7)

Introduction

This site consists of a 3 mile-long series of diversion structures along Centennial Wash approximately 5 miles downstream from the BLM Narrows Dam.

Qualitative Assessment

Diversion structures at the upper end of the series have a higher vegetation cover upslope from the structures than do diversion structures at the lower end of the series. Figure 23 is a ground truth photo of one of the upstream structures and associated vegetation.

Figure 23. Ground truth photo of an upstream structure and associated vegetation (#7).

Figure 24 is an aerial view of the same structure. Figure 25, an aerial view of two diversion structures further downstream, when compared to Figure 24, illustrates the reduced impact on vegetation of structures furthest downstream in the series.

Upslope from these structures at the upper end of the series are dense bosque-like stands of mesquite. Vegetation cover, density, and vigor are extremely high. Immediately downslope from the structures the vegetation consists of the Creosote Bush type on the interfluves and the Mesquite/Catclaw type in the washes. Downslope, wash vegetation has a moderate cover (20%) but is extremely stressed. Downslope, interfluve vegetation cover (as well as vigor) is low (10%).

Further downstream, the vegetation upslope from the diversion structures consists of the Mesquite or Riparian Mixed Shrub types consisting of mesquite, whitethorn, and catclaw. Cover and density of those types is high and vigor is above average, but those characteristics are lower than those of the vegetation upslope from structures further upstream.

Downslope of each downstream structure, interfluve vegetation consists of the Creosote Bush type, while wash vegetation consists of the Riparian Mixed Shrub type. Cover, density, and vigor of the downslope vegetation is much higher than that downslope of structures further upstream.

As is shown by Figure 26, the vegetation map for the site, vegetation patterns are quite complex and are, quite certainly, a result of the diversion structures.

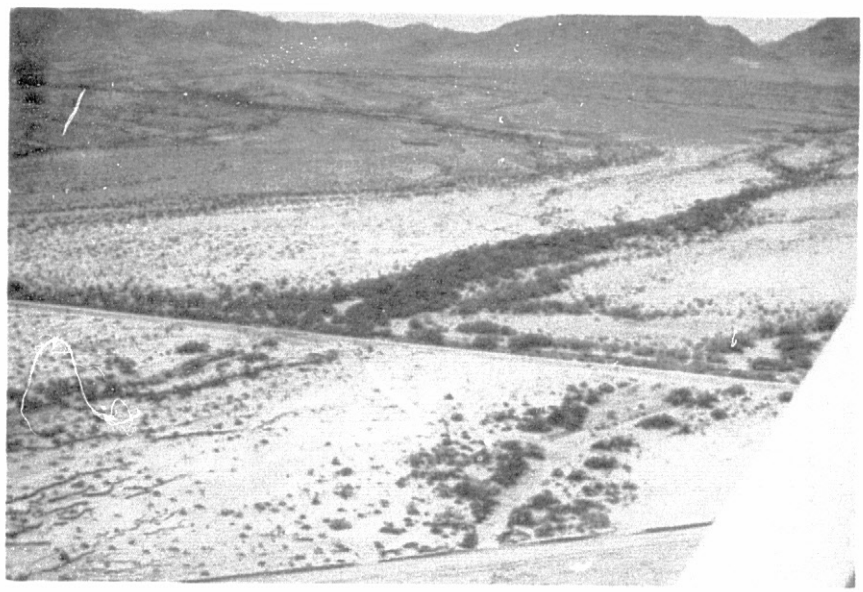


Figure 24. Infrared aerial photo of an upstream structure (#7).

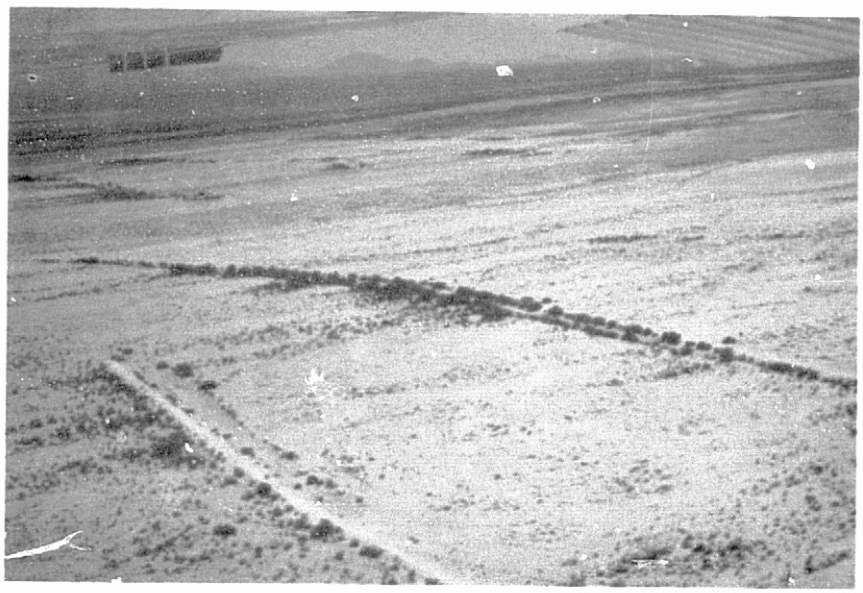


Figure 25. Infrared aerial photo of two downstream diversion structures (#7).

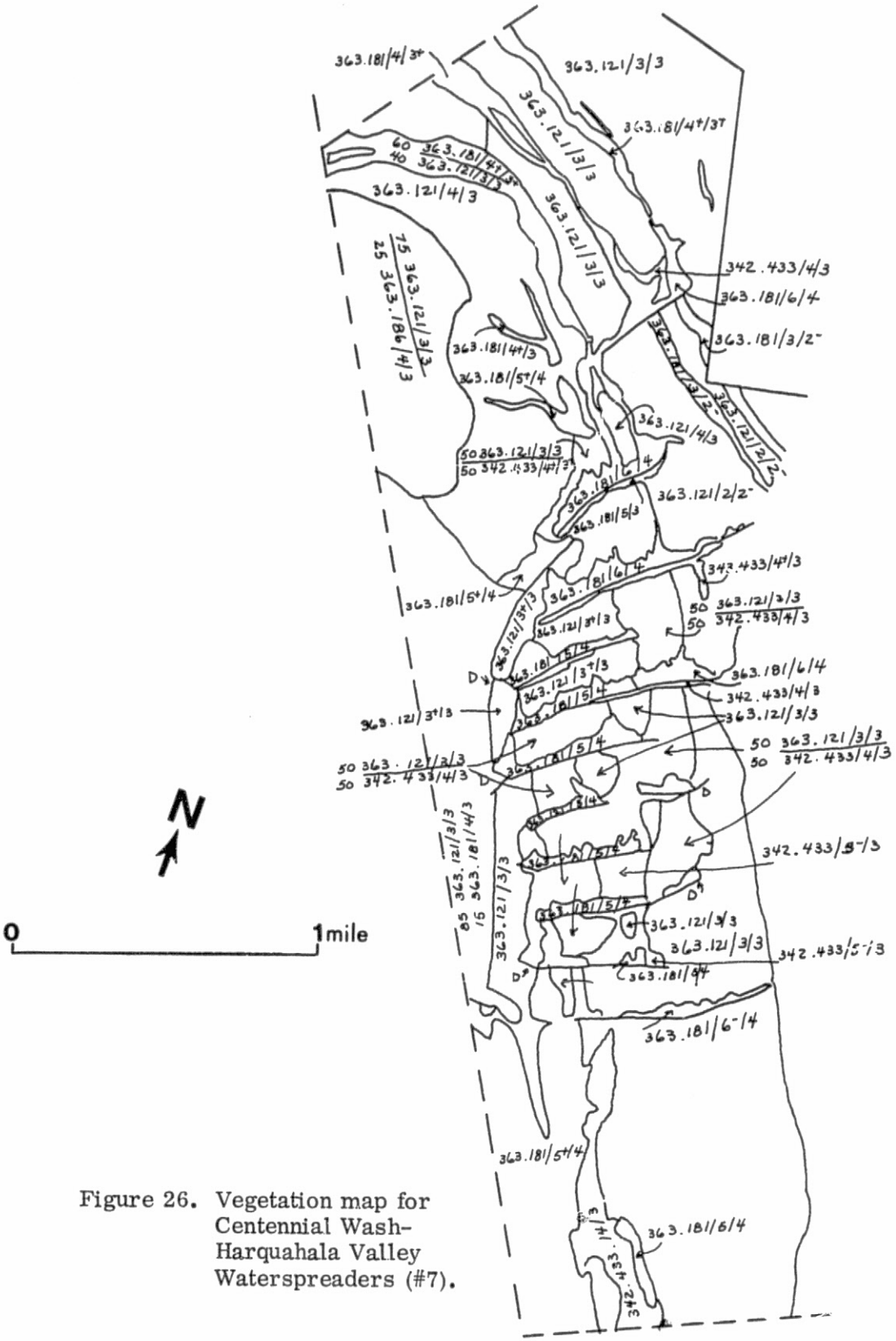


Figure 26. Vegetation map for Centennial Wash-Harquahala Valley Waterspreaders (#7).

VII. BLM Narrows Dam (#8)

Introduction

The BLM Narrows Dam is located on Centennial Wash adjacent to the Buckeye-Salome Road almost directly south of Waddell, Arizona. The dam is constructed at a narrows between the Little Harquahala Mountains and the Harquahala Mountains. Upstream from the structure is a small shallow pond.

Qualitative Assessment

Associated with the standing water upstream is a very dense and vigorous stand of tamarisk. Further upstream tamarisk grades into Mesquite Desert-scrub Associations also of high density and vigor. Figure 27, a ground photo of upslope vegetation, and Figure 28, an infrared aerial photo of upslope vegetation, document the nature of upslope vegetation.

Downslope, vegetation along the stream channel consists of the Mesquite/Blue Paloverde type with scattered cottonwoods. A vegetation type consisting of foothill paloverde, creosote bush, and triangle-leaf bursage occupies the non-riparian areas both downslope and upslope from the structure. This vegetation type does not appear to be stressed. Figures 29 and 30 illustrate the vegetation downslope from the structure.

Figure 31, the vegetation map of the site, shows the pattern of the vegetation types. As can be readily seen from the map, the vegetation patterns upstream are quite different from those downstream.

Quantitative Assessment

The trends discussed in the preceeding section are borne out by the statistics for the structure (shown in Appendix A). The density of upstream riparian

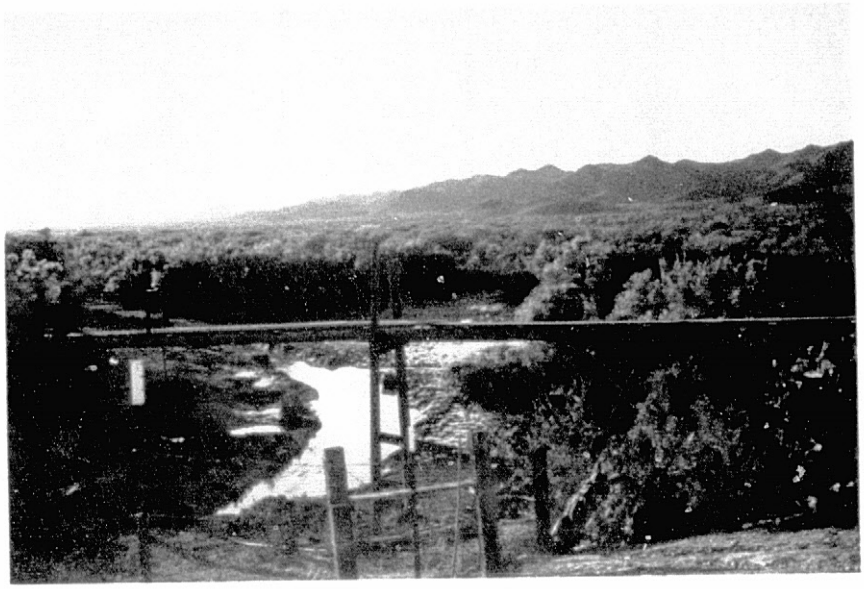


Figure 27. Ground truth photo of upslope vegetation (Structure #8).

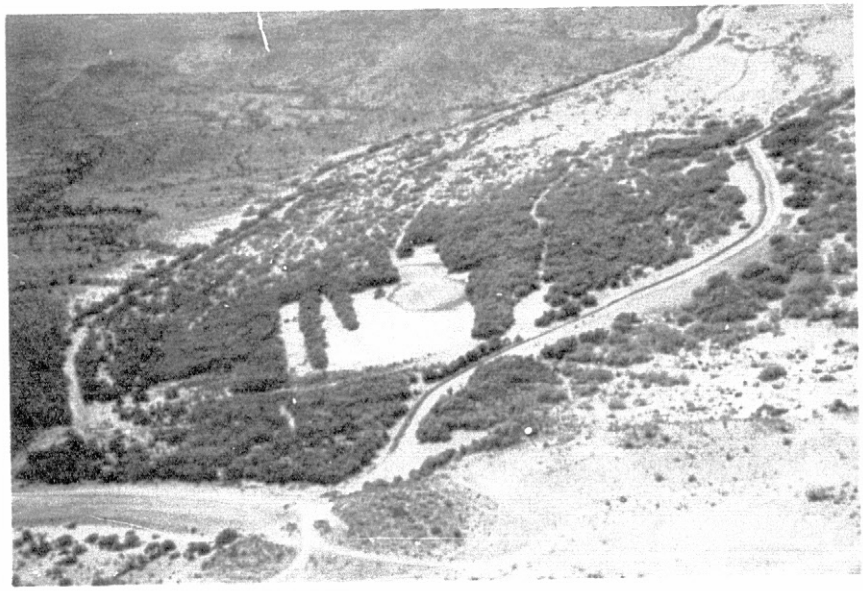


Figure 28. Infrared low-altitude photo of upslope vegetation. (Structure #8).

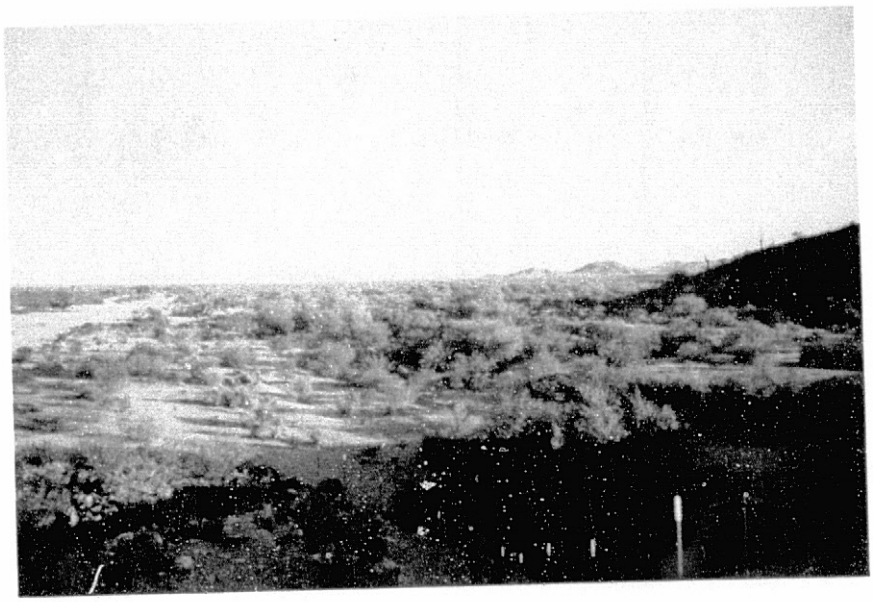


Figure 29. Ground truth photo of downslope vegetation (Structure #8).

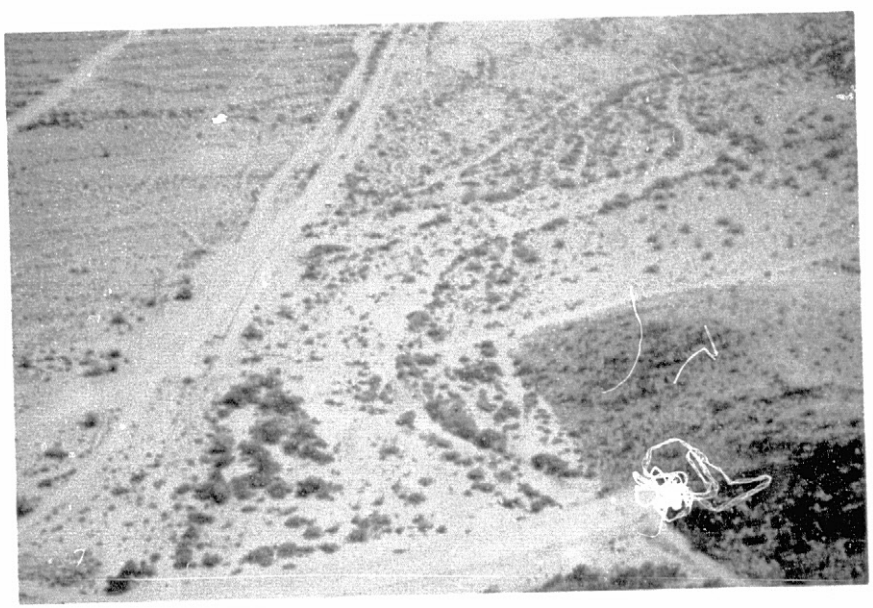


Figure 30. Infrared aerial photo of downslope vegetation (Structure #8).

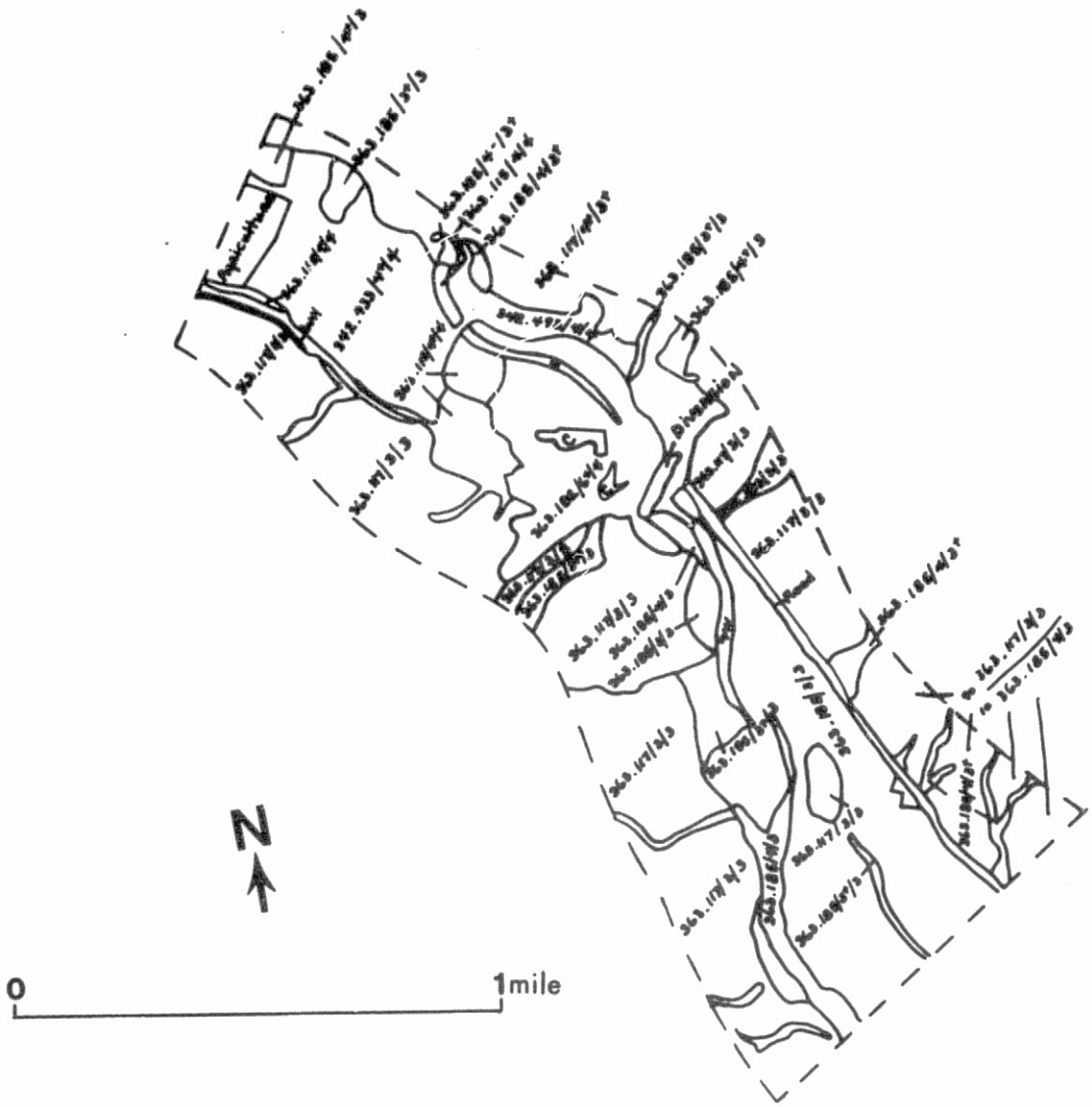


Figure 31. Vegetation map for BLM Narrows Dam (#8).

vegetation is over two times that of downstream riparian vegetation. Interfluvial vegetation density is similar for upslope and downslope areas. In general, the vigor of upslope vegetation is higher than downslope vegetation.

VIII. Unnamed Diversions - Aguila (#9)

Introduction

The Aguila diversions are a series of structures located approximately 5 miles southeast of Aguila, Arizona. These structures intercept runoff from the Vulture Mountains southeast of the structures.

Qualitative Assessment

Figure 32, a low-altitude color infrared oblique photograph of the structures, shows a high vegetation density upslope from each structure and lower density downslope. Upslope vegetation adjacent to the diversions consists of the Mesquite/Snakeweed type of relatively high cover (30-40%) and vigor.

Figure 32. Low-altitude infrared oblique photo of the diversion structure network (Structure #9).

Further upstream from the structures and downslope from them, the vegetation type is Creosote Bush. Downslope, creosote bush seems to be less dense and vigorous that it is upslope.

Diversion structures furthest downstream in the series have smaller differences between upslope and downslope vegetation than do structures further upstream.

IX. U. S. Highway 60 (#10)

Introduction

The U. S. Highway 60 site is located 4 miles southwest of Aguila, Arizona, on Highway 60. It consists of a number of low diversion structures (< 4 feet high) which channel runoff from the Harquahala Mountains into highway culverts.

Qualitative Assessment

Vegetation both upslope and downslope from the structures consists of the Creosote Bush type with scattered mesquite and cholla. Mesquite is abundant along the upslope edge of the diversions. Cover and vigor of vegetation upslope and downslope from the structures has been little affected. Figure 33, an aerial photo of one of the structures, shows how it has possibly affected the alteration of water courses.

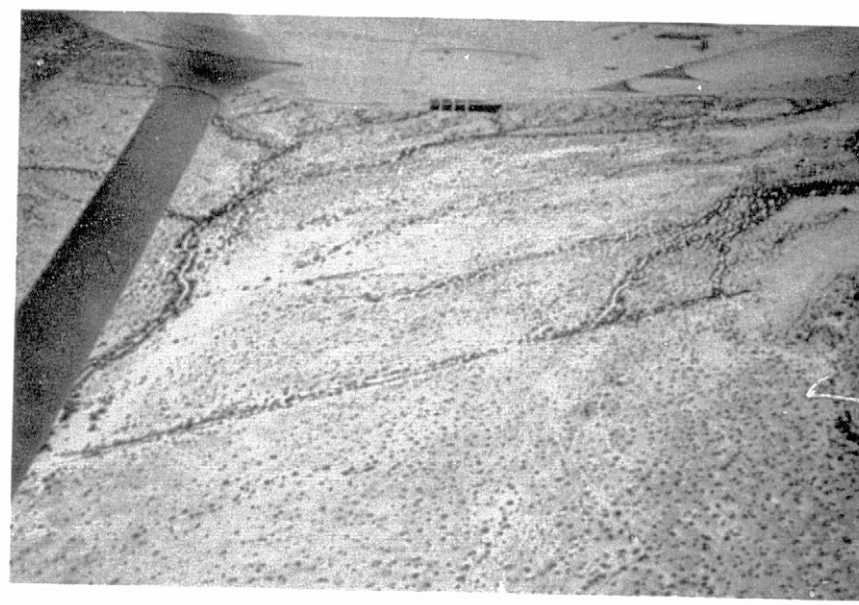


Figure 33. Infrared aerial photo of one of the structures (#10).

The alteration of stream courses and enhancement of vegetation cover immediately upslope appears to be the main effects of the structures.

X. Old Verde Canal (#11)

Introduction

The Old Verde Canal is a long structure, extending from the foothills of the McDowell Mountains, northeast of Phoenix, to the Union Hills of extreme Northwestern Phoenix; however, at the time of this study, the Old Verde Canal Diversion, west of Scottsdale Airport, was not suitable for study of upslope-downslope vegetation due to the construction of a new diversion structure immediately downslope. Construction of the new structure resulted in the loss of most vegetation immediately downslope from the old structure. For this reason, the area chosen for sampling was located at the extreme eastern end of the canal, just northeast of the Scottsdale Airport.

Qualitative Assessment

Along most of the length of the canal, the structure has been breached by major washes. It is probably for this reason that upstream and downstream vegetation is very similar with respect to species composition, cover, density, and vigor.

Upslope and downslope interfluve vegetation consists of the Creosote Bush/Triangle-Leaf Bursage/Foothill Paloverde type with some cholla. Vegetation cover is lower downslope, adjacent to the structure, than further downslope or immediately upslope from the structure. Vigor is somewhat decreased adjacent to the structure downslope.

Riparian vegetation both upslope and downslope consists of the Ironwood/Mesquite/Blue Paloverde type. Cover and vigor are identical upstream and downstream except for a slight increase in cover upslope, adjacent to the structure.

As is shown by Figure 34 (an aerial photo of the site) and Figure 35 (the vegetation map of the site) vegetation patterns are similar upslope and downslope, except for a narrow band of dense vegetation immediately upslope from the structure.

Quantitative Assessment

The trends discussed above are borne out by the vegetation statistics for this structure, shown in Appendix A.

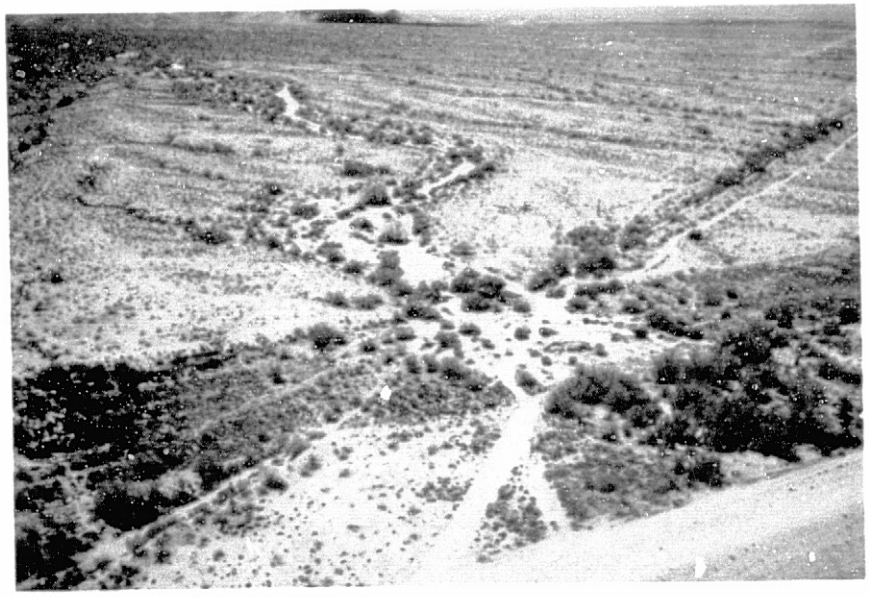


Figure 34. Infrared low-altitude photo of the diversion structure and upslope-downslope vegetation (Structure #11).

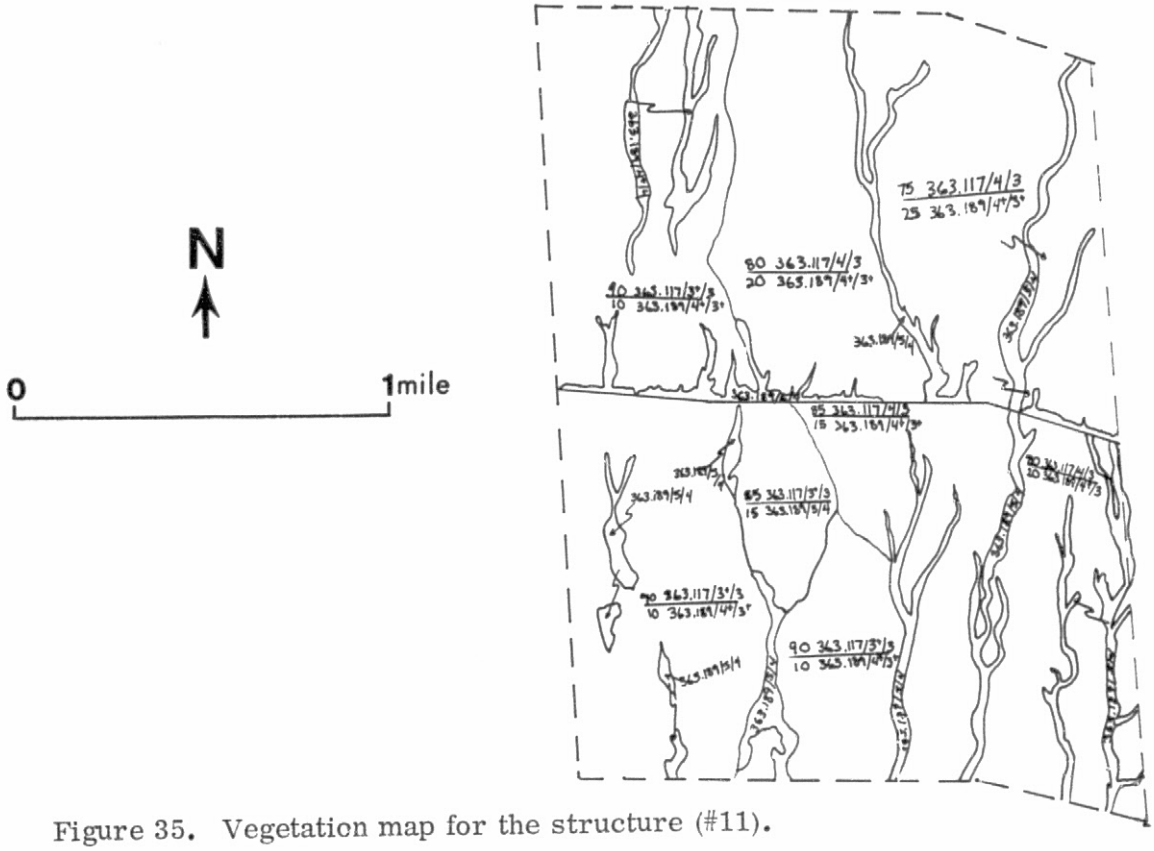


Figure 35. Vegetation map for the structure (#11).

XI. Powerline Dam (#12)

Introduction

Powerline Dam is located approximately $2\frac{1}{2}$ miles south of Apache Junction, Arizona. The structure intersects Siphon Draw, a major wash originating in the Superstition Mountains. An area extending approximately 100 yards upstream from the diversion along its entire length, has been scraped. The scraped area is about 4 feet lower than grade.

Qualitative Assessment

The vegetation upslope consists of the Creosote Bush type on the interfluves; the Foothill Paloverde-Ironwood type in the small washes; and the Mesquite types along the major washes.

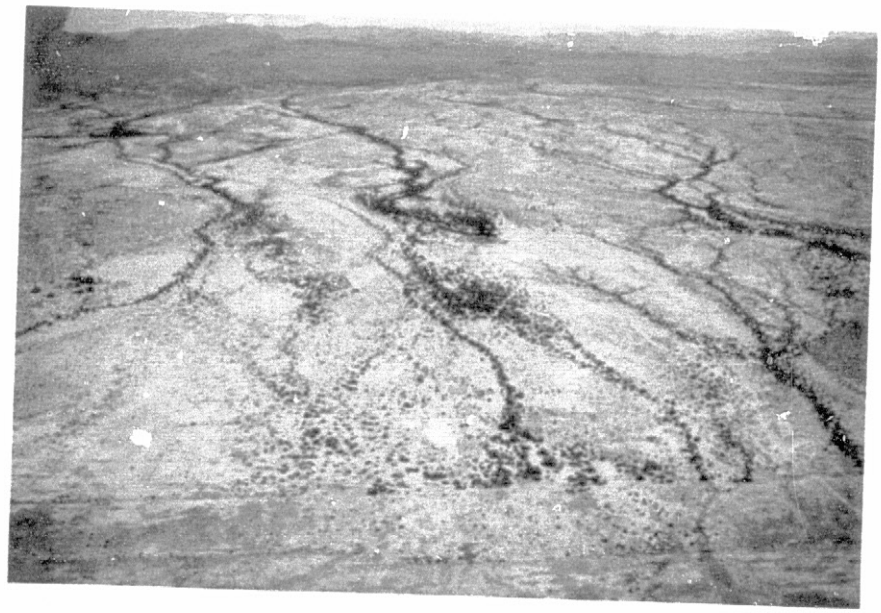


Figure 36. Low-altitude infrared photo of upstream vegetation showing high vegetation cover along washes (Structure #12).

As can be seen in Figure 36, the vegetation cover along the major washes is quite high. Interfluve vegetal cover is intermediate. Vegetation vigor is average on the interfluves, and from moderately high to very high along the washes.

Downslope vegetation is the same as upslope vegetation with respect to species composition and distribution. Cover and vigor are much decreased downslope, however. Wash vegetation is especially affected, as is illustrated by the comparison of aerial photos of downslope and upslope vegetation (Figures 37 and 36, respectively).

Vegetation patterns are quite different on either side of the structure as is shown by Figure 38, the vegetation map for the site. In general, riparian vegetation is denser immediately behind the structure and along the washes up to a mile upslope from the structure.

Vegetation along the wash which emanates from the dam spillway has greater cover and vigor than other downslope wash vegetation. Washes downslope from the structure are more deeply eroded than those upslope. Figure 39 illustrates the effects of erosion downslope.

Quantitative Assessement

Shown in Appendix A are the vegetation statistics for this site. Of interest is the greater amount of vegetation cover, density, and vigor upstream than downstream. There is an especially large difference in the vegetation parameters for riparian vegetation both upslope and downslope. It should be noted that the upslope measurements include the scraped area. Vegetation statistics based on the upslope area excluding the scraped area would have higher values.

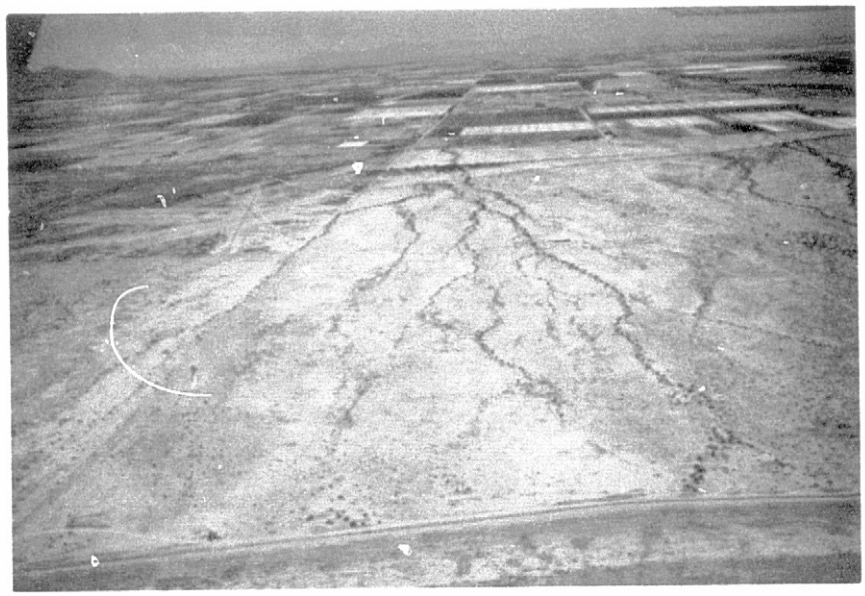


Figure 37. Low-altitude infrared photo showing downslope vegetation.

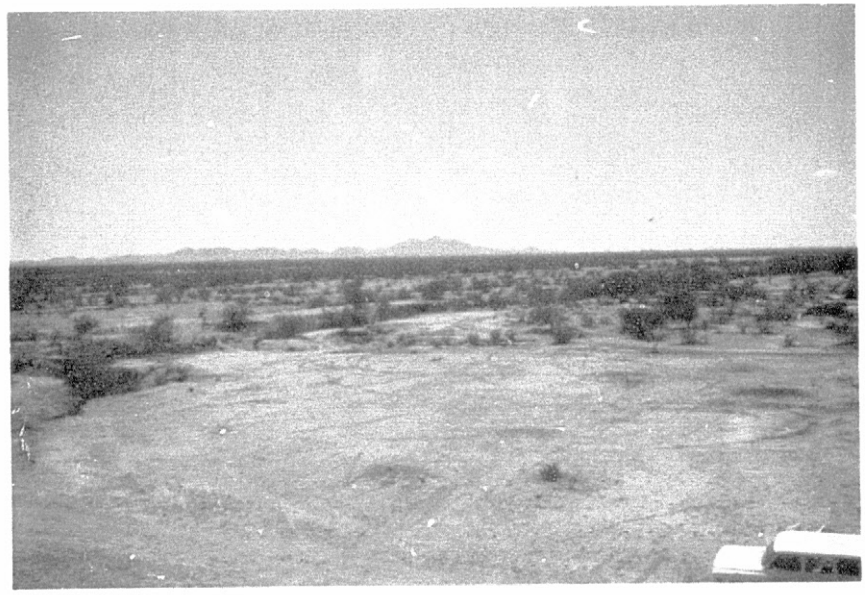


Figure 39. Ground truth photo illustrating erosion downstream from "flow-through" points (Structure #12).

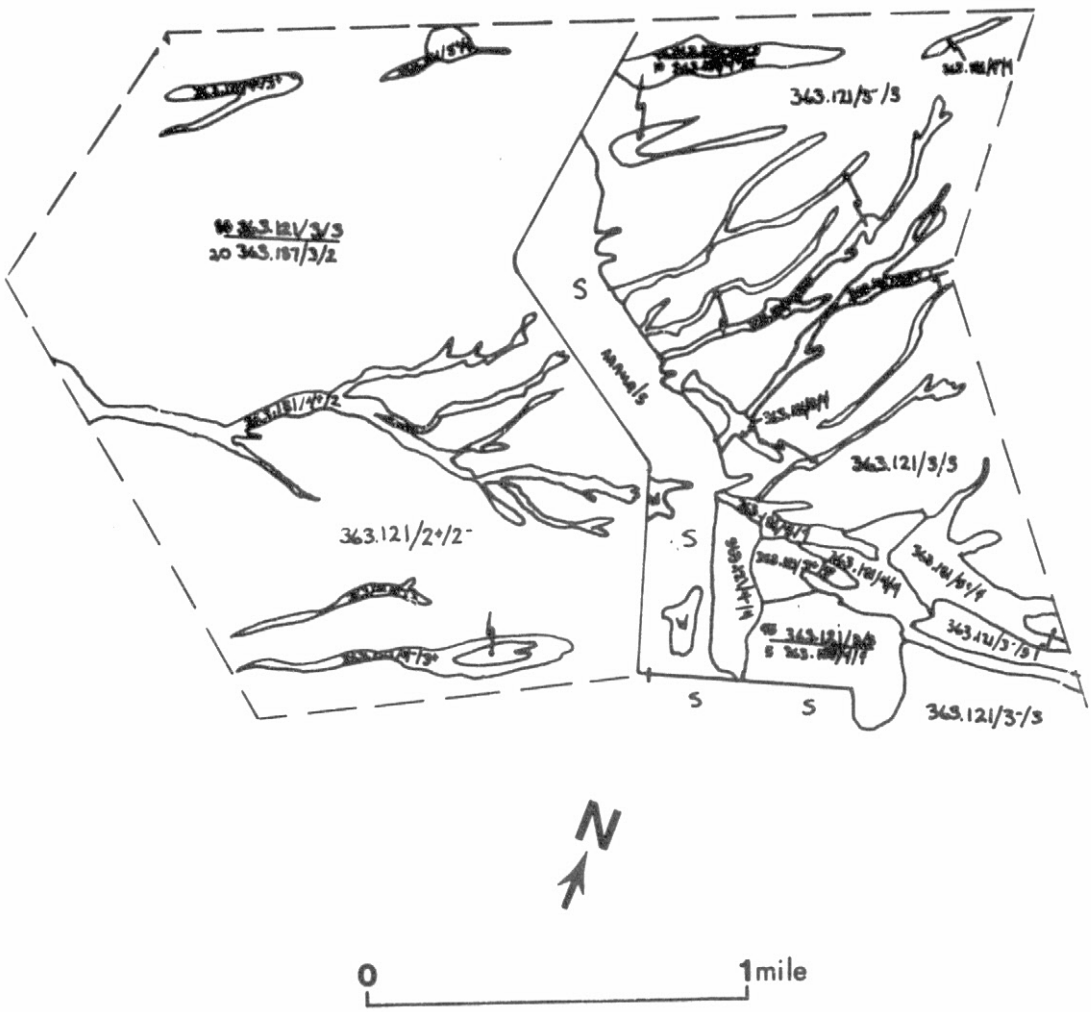


Figure 38. Vegetation map for Powerline Dam (#12).

XII. Vineyard Road Dam (#13)

Introduction

Vineyard Road Dam is located immediately south of Powerline Dam. Like the structure to the north, Vineyard Dam is approximately 25-30 feet high at its highest point. The structure intersects several major watercourses emanating from the western slopes of the Superstition Mountains. Immediately upslope from the structure there is a depressed scraped area approximately 100 yards wide.

Qualitative Assessment

The vegetation upslope and downslope from the structure consists of the Creosote Bush type on the interfluves and the Mesquite type along the washes. Generally, the vegetation upslope is more vigorous and has higher cover than the vegetation downslope. As is illustrated by the comparison of Figure 40 (infrared aerial photo of downslope vegetation) to Figure 41 (infrared aerial photo of upslope vegetation), riparian vegetation upslope is much more dense and vigorous than downslope vegetation. Some of the riparian stands upstream are bosque-like in character while most riparian vegetation downstream is sparse and impoverished. Interfluve vegetation exhibits a smaller upslope-downslope difference in the aforementioned parameters than does riparian vegetation.

Vegetation patterns upslope and downslope of the structure are shown in Figure 42, the vegetation map for the site. As can be seen from the map, riparian vegetation patterns seem to be unaltered where there are flow-through points (shown as cross hatches on the diversion structure in the

Figure 40. Infrared aerial photo of downslope vegetation (Structure #13).

Figure 41. Infrared aerial photo of upslope vegetation (Structure #13).

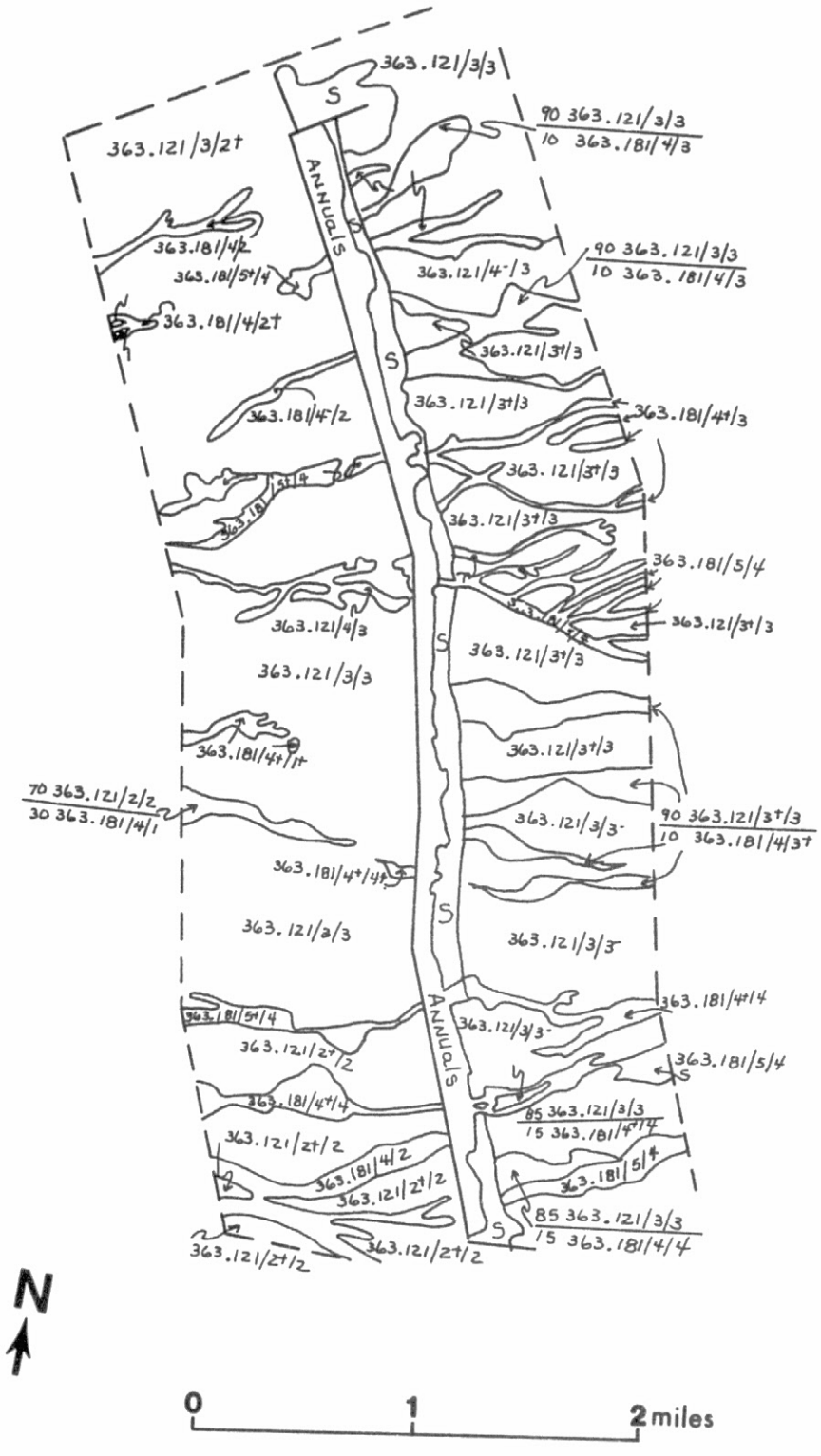


Figure 42. Vegetation map for Vineyard Road Dam (#13).

vegetation map) in the structure. Upslope, wash vegetation, not in the vicinity of flow through points, is more "spread out" than the complement wash vegetation downstream.

Riparian vegetation downstream from the flow-through points has more vigor and cover than downslope riparian vegetation not associated with the flow-through points.

Quantitative Assessment

As can be seen from the statistics for this site (presented in Appendix A) interfluve cover and density are quite similar upslope and downslope. Cover and density of riparian vegetation is somewhat higher upslope than downslope. The difference between upslope and downslope riparian vegetation is not as pronounced as in Site 12 however, perhaps because of the greater number of flow through points associated with this structure.

Vegetation vigor is higher upslope than it is downslope. The difference in upslope-downslope vigor is especially pronounced for riparian vegetation.

XIII. Rittenhouse Dam Structure (#14)

Introduction

Rittenhouse Dam is immediately south of the Vineyard Road Dam and is quite similar to the latter structure with respect to construction and orientation. The Rittenhouse structure intersects two major washes emanating from the Superstition Mountains. Queens Creek flows just to the south of the diversion structure. A depressed scraped area, approximately 100 yards wide extends along the entire length of the structure immediately upslope.

Qualitative Assessment

The vegetation upslope and downslope from the structure consists of the Creosote Bush type on interfluves and the Mesquite or Mesquite/Ironwood type along watercourses. The cover and vigor of the upslope vegetation is higher than that of downslope vegetation. Riparian vegetation downslope is severely stressed, while upslope it is quite vigorous. Figures 43 and 44 (color-infrared aerial photos of upslope and downslope vegetation, respectively) show the difference between upslope and downslope vegetation.

Figure 45, a vegetation map of the site, shows vegetation patterns upslope and downslope from the structure. There is a general buildup of riparian vegetation behind the structure and along incoming watercourses, although the overall patterns are the same on both sides of the structure.

Riparian vegetation, downstream from the only flow-through point, appears to be faring quite well when compared to other riparian vegetation downslope from the structure.

Figure 43. Infrared low-altitude photos of upslope vegetation (Structure #14).

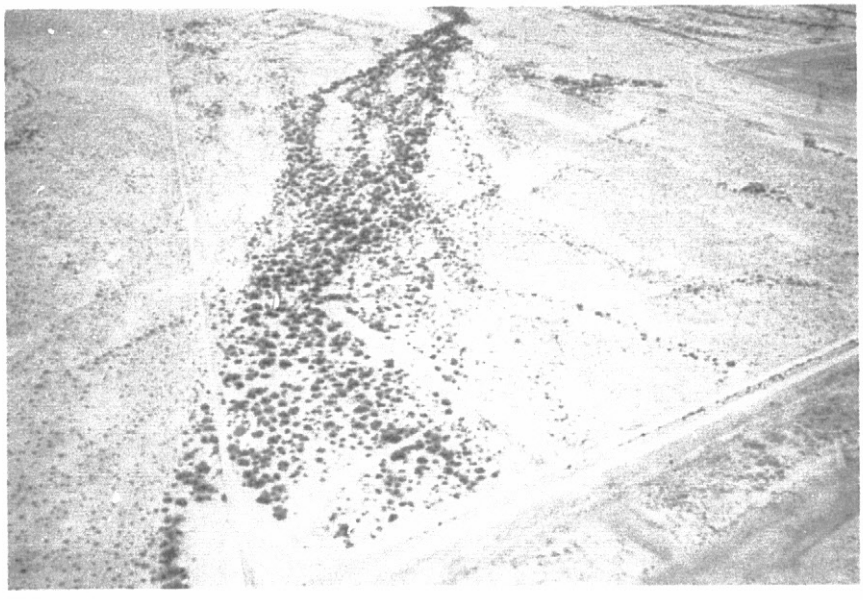


Figure 44. Infrared low-altitude photo of downslope vegetation (Structure #14).

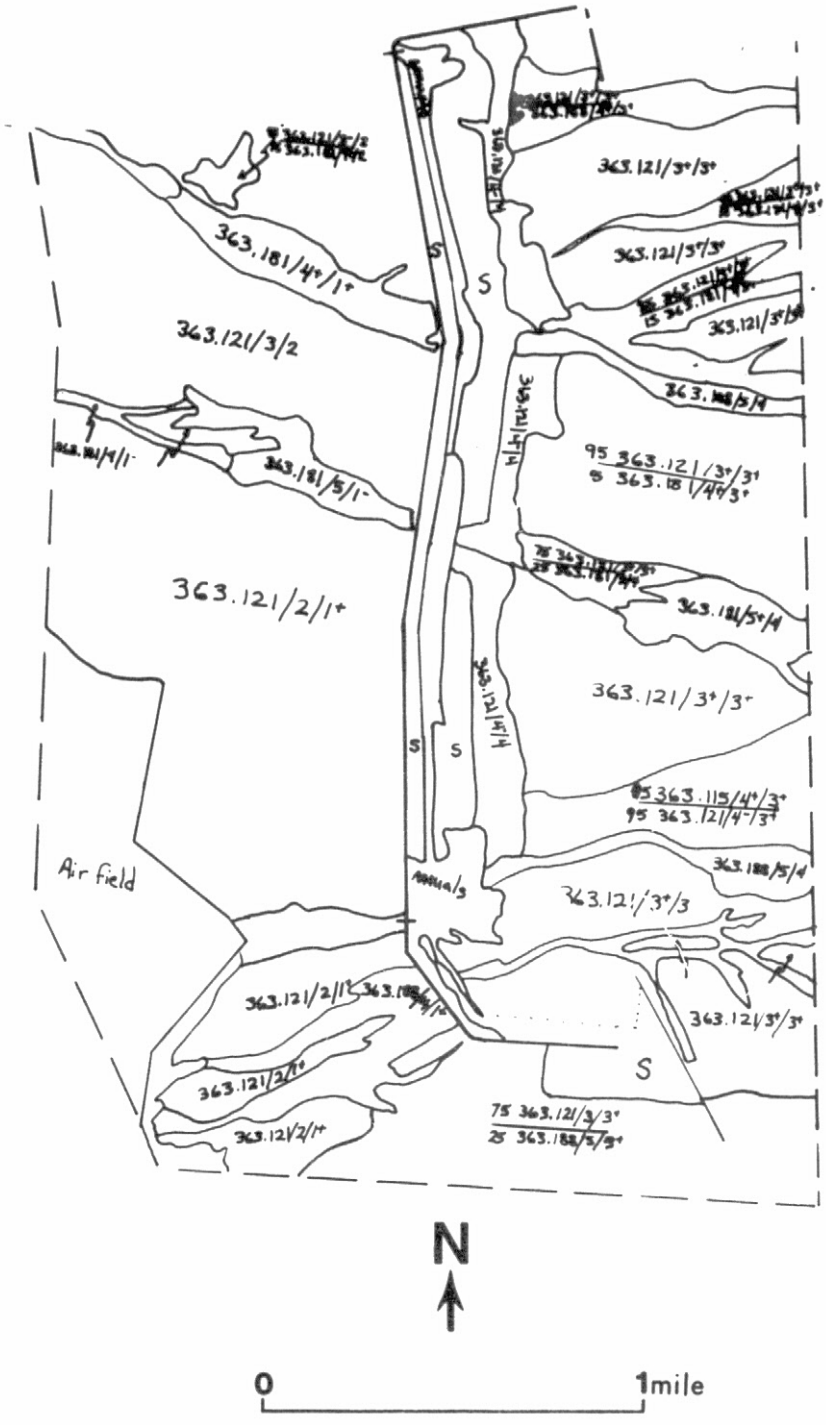


Figure 45. Vegetation map for Rittenhouse Dam (#14).

Quantitative Assessment

As is shown in Appendix A, riparian cover is about the same upslope and downslope although riparian density and vigor are much increased upslope. Interfluve vegetation has a higher cover, density, and vigor upslope than downslope. These differences are more pronounced for riparian than for interfluve vegetation.

Since the scraped areas were included in calculation of upslope vegetation statistics, those figures are probably lower then they should be.

XIV. Magma Dam Structure (#15)

Introduction

Magma Dam is located just north of Arizona Farms Road, 5.5 miles north of Florence, Arizona. The structure is constructed in a fashion similar to Rittenhouse, Powerline, and Vineyard Road Dams. It intercepts runoff from the Superstition Mountains, located east of the diversion, protecting agricultural fields immediately downslope.

Qualitative Assessment

Upslope, interfluve vegetation consists of the Creosote Bush type with scattered cholla. Cover and vigor are "normal." Riparian vegetation consists primarily of the mesquite vegetation type along the major watercourses and the Mesquite/Ironwood/Blue Paloverde type or Ironwood/Foothill Paloverde type along minor watercourses. Cover and vigor are quite high along the major washes.

Downslope, interfluve vegetation also consists of the Creosote Bush with cholla type; however, vegetation cover and vigor are much reduced. In some areas creosote bush appears to be almost dead. Downslope riparian vegetation consists of the Mesquite type or the Ironwood/Foothill Paloverde type. Vigor and cover of downslope wash vegetation is much lower than that of upslope wash vegetation. Figures 46, 47, and 48 (ground photos of upslope and downslope vegetation, and an aerial photo of the structure and upslope-downslope vegetation, respectively) illustrate the differences between upslope and downslope vegetation.

Figure 49, the vegetation map of the site, shows the difference in upslope and downslope vegetation patterns. Upslope, riparian patterns are quite spread out, suggesting that water "backs up" behind the structure. Downslope, riparian

Figure 46. Ground truth photo of upslope vegetation (Structure #15).

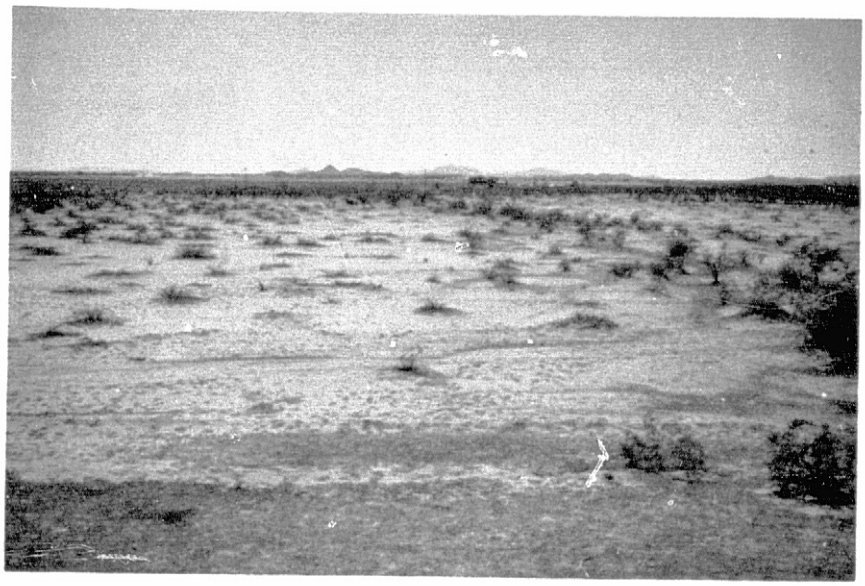


Figure 47. Ground truth photo of downslope vegetation (Structure #15).

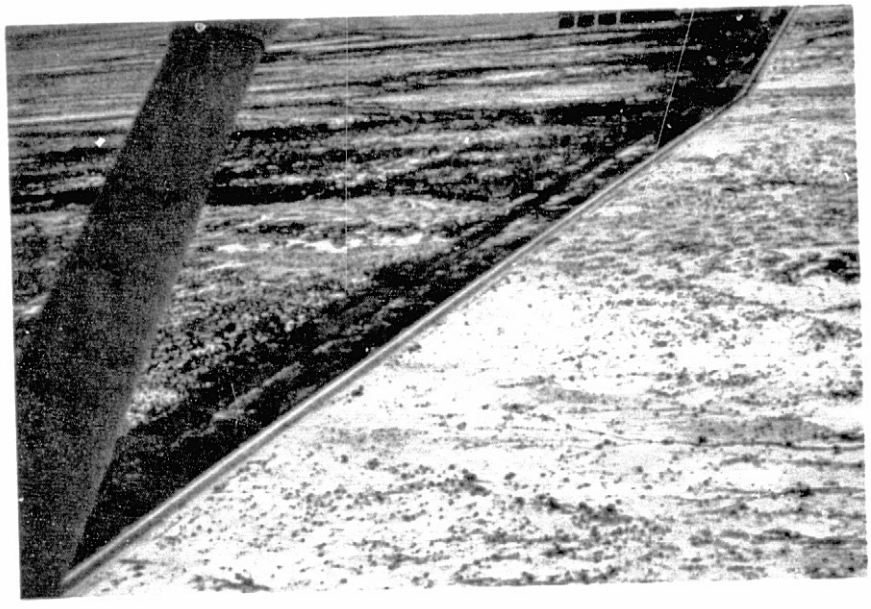


Figure 48. Infrared aerial photo of the structure and upslope-downslope vegetation (Structure #15).

patterns are much more narrow, the vegetation being restricted to wash edges. It should be noted that the Magma Dam has only one flow-through point. Wash vegetation immediately downstream from this point is similar in vigor and cover to wash vegetation upslope.

Quantitative Assessment

The trends discussed above are generally supported by the site statistics shown in Appendix A. Of interest however, is the low upslope interfluve cover.

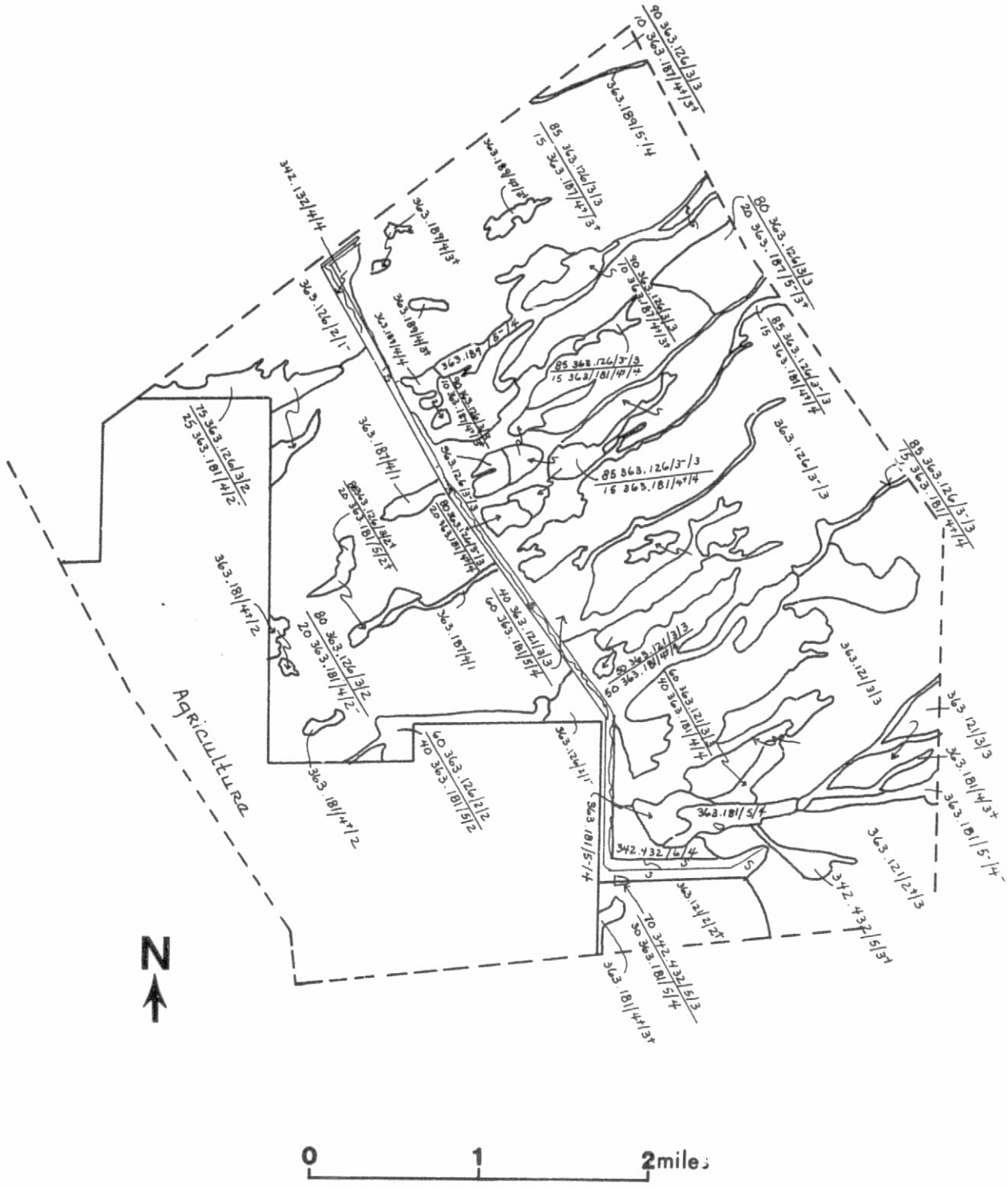


Figure 49. Vegetation map for Magma Dam (#15).

XV. Brady Wash Structure (#16)

Introduction

The Brady Wash Diversion is located approximately 6 miles downstream from the intersection of Tom Mix and Brady Washes. The structure is just north of an EL PASO NATURAL GAS pipeline road which intersects Highway 89, about 54 miles north of Tucson.

Water that previously continued down Brady Wash is now diverted to the north by the Brady Wash structure. The diversion, which has no flow-through points, is approximately 12 feet tall.

Qualitative Assessment

Vegetation upslope from the diversion consists of the Blue Paloverde/Mesquite type along the washes and the Foothill Paloverde/Triangle-leaf Bursage or Creosote Bush/Triangle-leaf Bursage (with or without foothill paloverde) types on the interfluves. Vegetation along Brady Wash upstream from the diversion is quite luxurious and vigorous. The vegetation on interfluves also has above average vigor and cover.

Species composition of downstream vegetation is the same as that upstream with the exception of triangle-leaf bursage, which is absent downstream. Figures 50 and 51 (aerial photos of upstream and downstream vegetation, respectively) illustrate the difference in vigor and cover of upslope and downslope vegetation. Downstream riparian vegetation appears to be more affected by the reduced waterflow than does interfluve vegetation. Downslope, interfluve vegetation is similar to that upslope with respect to cover and vigor. Vigor and cover of downstream riparian vegetation, however, is very much reduced.

Figure 50. Infrared low-altitude photo of upslope vegetation (Structure #16).

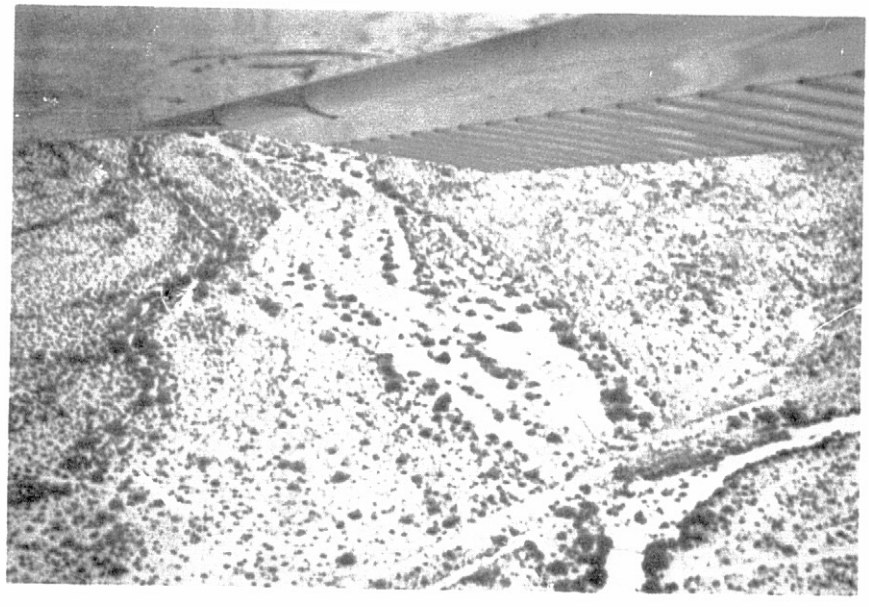


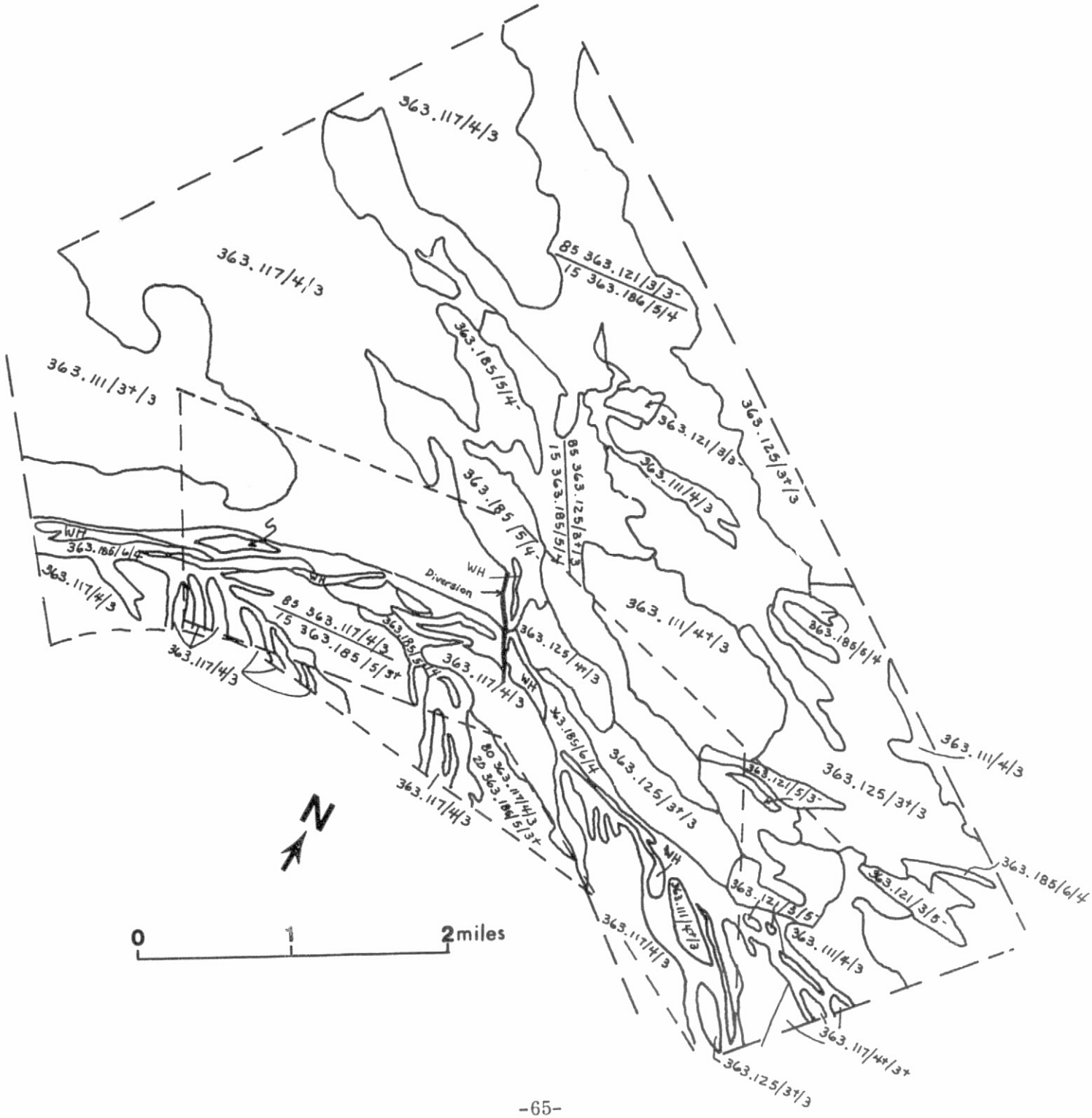
Figure 51. Infrared low-altitude photo of downslope vegetation (Structure #16).

Figure 52, the vegetation map of the site, shows the diversion-caused altered vegetation pattern. While the old vegetation patterns persist, a large new area of riparian vegetation now occurs north of the structure in response to diverted water.

Quantitative Assessment

The above comparisons of upstream and downstream vegetation are supported by the statistics presented in Appendix A.

Figure 52. Vegetation map for Brady Wash Structure (#16).



XVI. South Side Canal (#18)

Introduction

Located south of South Side Canal, the South Side Canal Diversion Structure intercepts runoff from the Sacaton Mountains and Bajada to the north. The portion of the diversion of interest extends from the intersection of South Side Canal and the western boundary of the Gila River Indian Reservation, east to Agency Peak just south of Sacaton, Arizona. The diversion structure has no flow through points.

Since it was not feasible to study the vegetation along the entire length of the diversion, three sites representative of major vegetation types were choosen for intensive study. The three sites were:

1) West Sacaton Mountains Site: located directly south of Sacaton Butte on the northwest-facing slopes of the Sacaton Mountains (Sections 30 and 31, RSE, T4S).

2) Interstate 10 Site: located north of the Sacaton Mountains, just west of the intersection of I-10 and South Side Canal.

3) Agency Peak Site: located one mile west of Agency Peak on the north-facing slopes of the Sacaton Mountains.

A. West Sacaton Mountain Site

Qualitative Assessment

Vegetation upslope and downslope from the structure consists of the Foothill Paloverde/Ironwood type along the washes and the Creosote Bush type on the interfluves. Adjacent and upslope from the structure, the vegetation consists of the Ironwood/Mesquite/Blue Paloverde type as is shown in Figure 53. The vegetation adjacent and upslope from the diversion and in the canal consists of the Tamarisk/Mesquite type.

Figure 53. Ironwood/Mesquite/Blue Paloverde type adjacent and upslope from the structure (#1a).

Except for the areas just upslope from the diversion structure and canal, upslope and downslope vegetation have similar cover and vigor. The vegetation in the canal, upslope from the canal, and immediately upslope from the diversion structure, is quite dense and vigorous. Figure 54, an aerial color-infrared photo of the site, illustrates the differences in vegetation vigor and cover.

Overall vegetation patterns are relatively undisturbed by the structures. Figure 55, the vegetation map of the site, shows the main effect of the structure: an increase in vegetation cover and vigor upslope, and an interruption of riparian vegetation patterns for a short distance downslope.

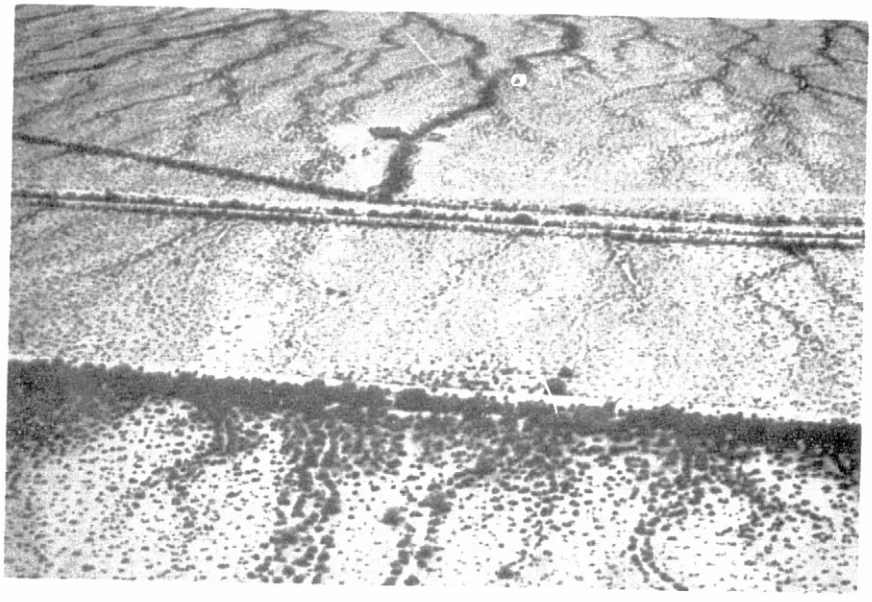


Figure 54. Aerial infrared photo of the structure and associated vegetation (Structure #18).

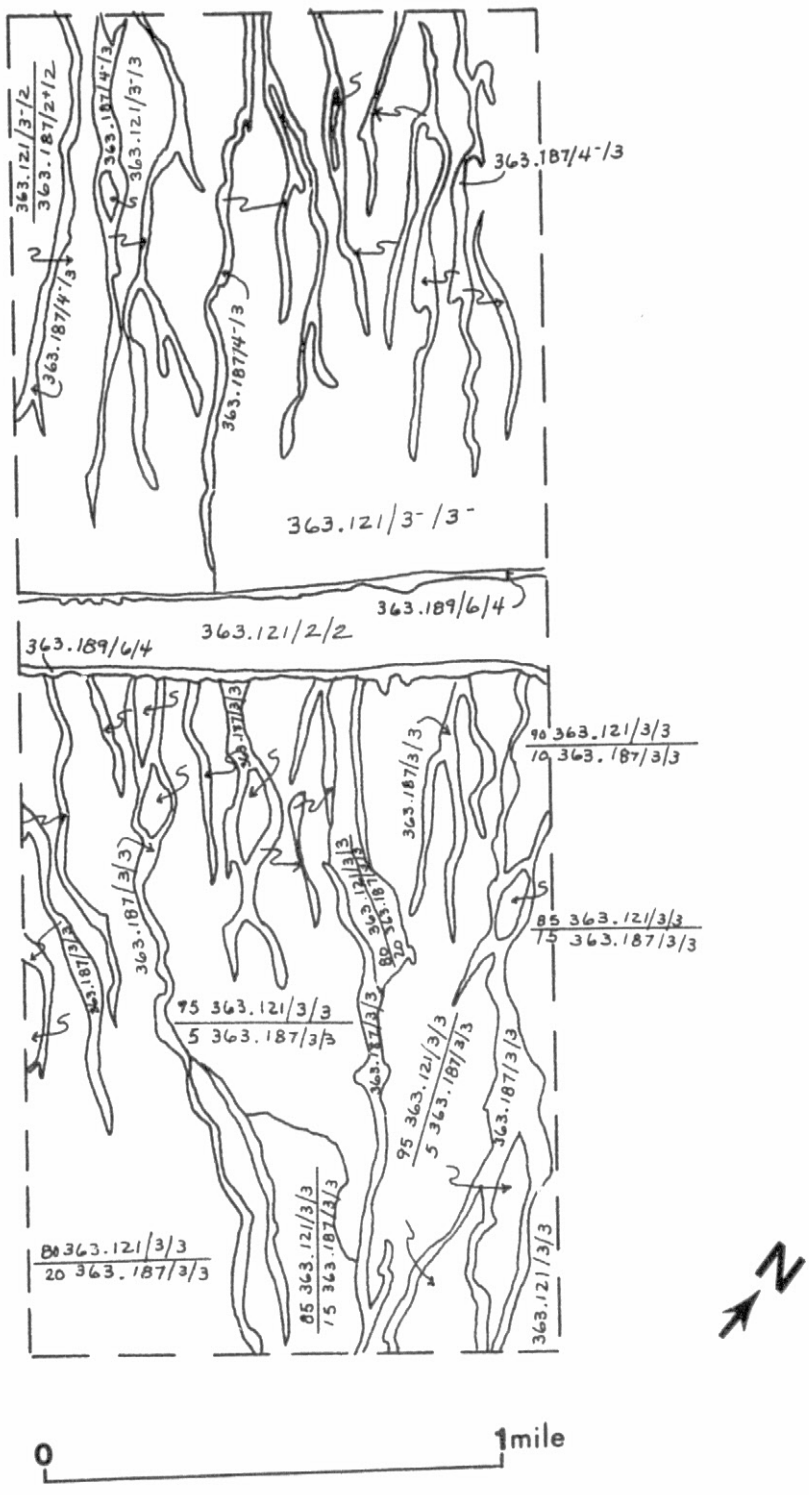


Figure 55. Vegetation map for West Sacaton Mountain Site (#18A).

Quantitative Assessment

The statistics for this structure, shown in Appendix A, support the trends discussed above.

B. Interstate 10 Site

Qualitative Assessment

Vegetation upslope and downslope from the structure consists of the Foothill Paloverde/Ironwood type along the washes and the Creosote Bush type on the interfluves. Immediately upslope from the structure is a narrow strip, approximately 50 feet wide, of the Blue Paloverde/Mesquite vegetation type.

In general, vegetation upslope has more cover and vigor than vegetation downslope. Riparian vegetation adjacent and upslope from the structure is quite luxuriant and vigorous. Downslope vegetation, when compared to similar vegetation not in the immediate vicinity of the structure, is of lower cover and vigor. Figure 56, an aerial infrared photo of the site, shows the differences in upslope-downslope vigor and cover.

Due to the presence of agricultural fields a short distance downstream from the diversion, more upslope vegetation was mapped than downslope vegetation, as is shown by Figure 57, the vegetation map of the site. Because of the paucity of downslope vegetation data, conclusions regarding the differences in vegetation patterns upslope and downslope from the diversion are tenuous. The map does suggest however, that riparian vegetation patterns are interrupted by the structure.

Quantitative Assessment

The trends discussed above are supported by the statistics for the site shown in Appendix A. It should be noted however, that the relative lack of data on downslope vegetation may bias upslope-downslope comparison.

Figure 56. Aerial infrared photo of the structure and upslope-downslope vegetation (#18B).

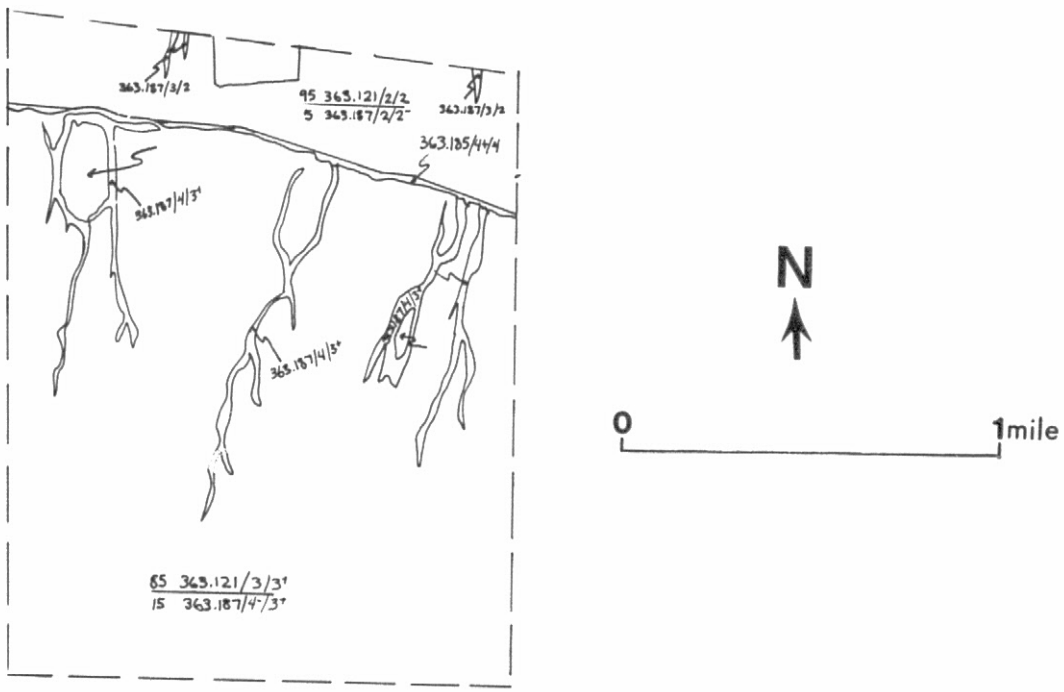


Figure 57. Vegetation map for I-10 Site (#18B)

C. Agency Peak Site

Qualitative Assessment

The vegetation upslope and downslope from the structure consists of the Foothill Paloverde/Ironwood type along the washes and the Creosote Bush type on the interfluves. Immediately upslope from the structure is a narrow strip of the Ironwood/Mesquite/Blue Paloverde vegetation type.

With the exception of some dense vigorous riparian vegetation along washes upslope from the diversion, upslope and downslope vegetation is quite similar with respect to cover and vigor. Figure 58, an aerial infrared photo of the site, shows the upslope-downslope vegetation.

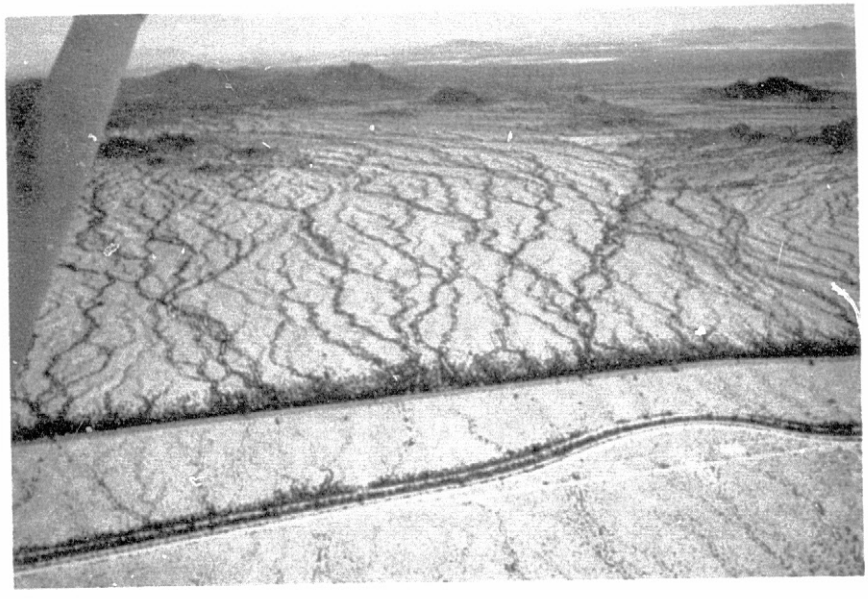


Figure 58. Infrared low altitude photo of the structure and associated vegetation (#18C).

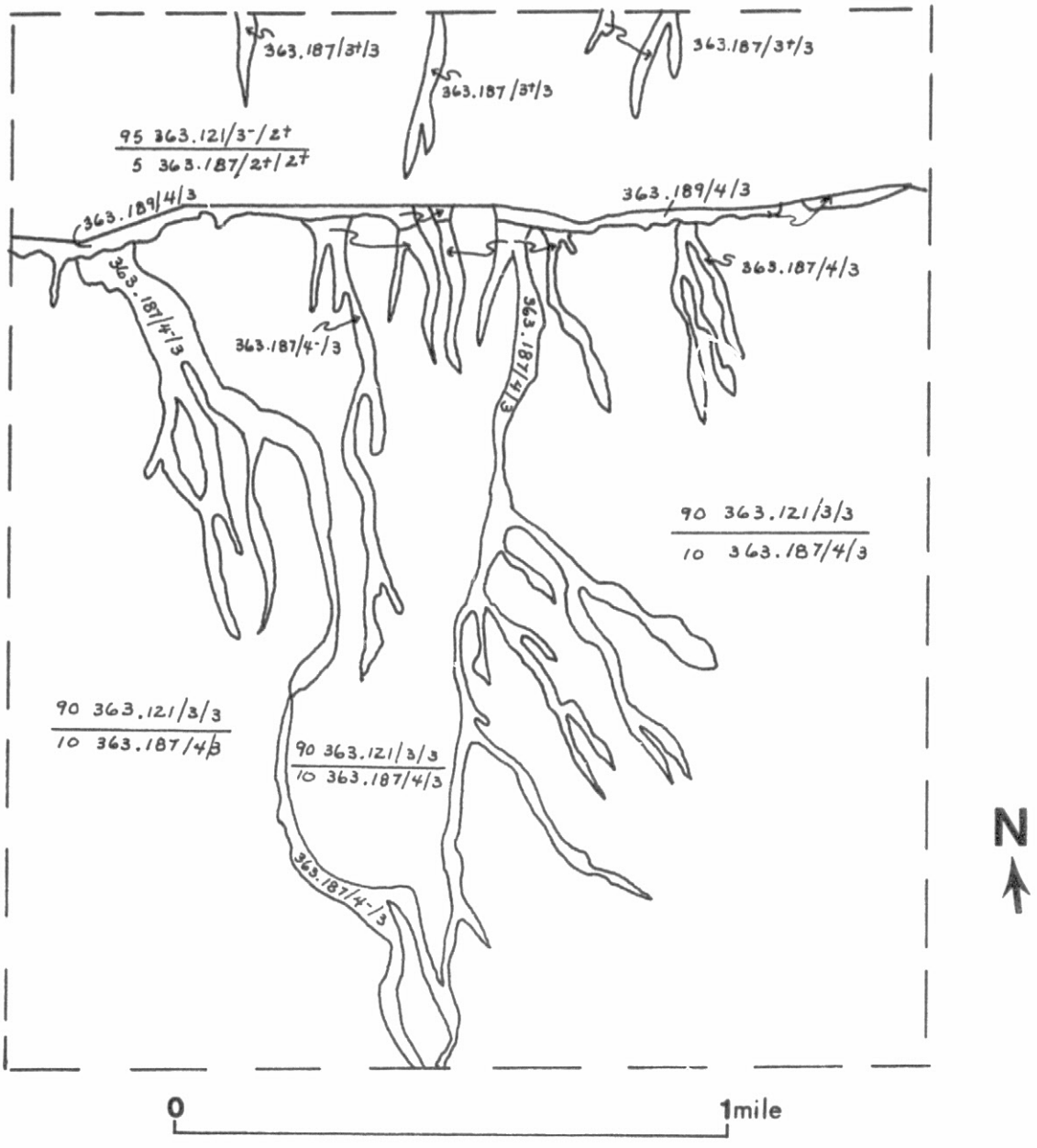


Figure 59. Vegetation map for Agency Peak Site (#18C).

As is shown by the vegetation map of the site, Figure 59, comparison of upstream-downstream vegetation patterns is made more difficult by the presence of agricultural fields downslope. The map suggests, however, that the riparian patterns are interrupted by the diversion structure.

Quantitative Assessment

The trends discussed above are supported by the site statistics presented in Appendix A. As noted before, the large difference in the amount of data collected for the areas upstream and downstream from the structure make quantitative comparisons inconclusive.

CONCLUSIONS

As was shown in the preceding section, differences between vegetation upslope and downslope from diversion structures were pronounced for some structures and less pronounced for others. Structures such as the Trilby Wash Detention Basin had very marked upslope-downslope vegetation differences, while structures such as the U. S. Highway 80 Diversion Structure had very little upslope-downslope vegetation differences. Differences between structures with respect to upslope and downslope vegetation may or may not be due to the differing effects of the diversion structures however.

It was noticed that most of the structures occur at or near natural geomorphic boundaries. The diversions, which occur at the bajada-alluvial plain interface, protect agricultural fields and urban areas from flood. The bajada-alluvial plain boundary marks the following changes from bajada to plain: 1) change in slope angle; 2) change in soils; 3) change in vegetation; and 4) change in land use. Bajada slopes are steeper and more deeply dissected than are the alluvial plain slopes, thus agricultural and urban land is restricted to the plains. Soils of the bajadas are generally more coarse-textured than are the soils of the alluvial plains (Yang and Lowe, 1956).

Vegetation types are also different on bajadas and alluvial plains. This is partially a response to the different soil types and moisture availability of the two landforms. Associated with bajadas are vegetation types such as the Foothill Paloverde/Triangle-leaf Bursage type and the Foothill Paloverde/Creosote Bush/ Triangle-leaf Bursage type. Alluvial plain vegetation consists primarily of the Creosote Bush type. Bajada vegetation generally has a greater cover and density than does alluvial plain vegetation.

Since there is a natural difference in the vegetation which occurs upslope and downslope from the bajada-alluvial plain boundary, it is difficult to separate natural vegetation upslope-downslope differences and diversion-caused upslope-downslope vegetation differences for diversion structures occurring on the boundary. In cases where there is not an obvious build up of riparian vegetation behind the diversion, it is risky to say that the greater vegetation cover and vigor upslope is attributable to the structure. In the same vein it is not possible to state that reduced cover and vigor downstream is a result of the structure, except in cases where there is an obvious difference in the cover and vigor of adjacent vegetation not downslope from the structure.

Due to the naturally occurring vegetation change at the bajada-alluvial plain interface, comparison of upslope vegetation to downslope vegetation is not enough, in some cases, to understand the effect of diversion structures on vegetation. A comparison of vegetation parameters of the sites before diversion structure construction to present vegetation parameters would be a useful method for determining the impact of the structures on vegetation. Aerial photos predating diversion construction combined with recent aerial photos could serve as the data base for the "before-after" comparisons.

One of the most important conclusions reached concerns the flow-through points on the structures. The differences between vegetation upslope and downslope from the structure are minimized when water is allowed to pass through the structure. When water is restricted, however, there appears to be a marked change in vegetation parameters.

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APPENDIX A

Vegetation Statistics for Diversion Structure Sites

I. Vegetation Measurement Equations

Total Vegetation Acreage (TVA) = total acreage occupied by vegetation

Riparian Vegetation Acreage (RVA) = total acreage occuppied by riparian vegetation

Interfluvial Vegetation Acreage (IVA) = total acreage occupied by interfluve vegetation

% Total Cover (C) = [TVA ÷ total acreage (soil + vegetation)] x100

% Riparian Cover (C_r) = [RVA ÷ total acreage] x100

% Interfluvial Cover (C_i) = [IVA ÷ total acreage] 100

% Average Interfluvial Cover ($\overline{C}_i$) = [IVA ÷ total interfluvial acreage] 100

Average Vigor ($\overline{V}$) = Σ(Vigor Class Constant x basal area for each vegetation type) ÷ TVA

Average Riparian Vigor ($\overline{V}_r$) = Σ(Vigor Class Constant x RVA for each type) ÷ RVA

Average Interfluvial Vigor ($\overline{V}_i$) = Σ (Vigor Class Constant x IVA for each type) ÷ IVA

II. White Tanks Proving Ground Diversion (#3)

Measurement	Downstream	Upstream
ΣAcres	988.3	1849.8
ΣRiparian Acres	313.6	452.0
ΣInterfluvial Acres	674.7	1397.0
TVA	189.7	440.6
RVA	88.5	161.2
IVA	101.2	279.4
C	19.2%	23.8%
C_r	9.0%	3.3%
C_i	68.3%	75.5%
$\overline{C}_i$	28.2%	35.7%
$\overline{C}_r$	15.0%	20.0%
$\overline{V}$	2+	3+
$\overline{V}_r$	2+	3+
$\overline{V}_i$	2+	3

III. White Tanks No. 2 Structure (#4)

Measurement	Downstream	Upstream
ΣAcres	807.0	904.2
ΣRiparian Acres	89.2	279.3
ΣInterfluvial Acres	717.8	606.9
TVA	122.8	259.0
RVA	28.7	108.7
IVA	94.1	150.3
C	15.2%	28.7%
C_r	3.6%	12.0%
C_i	11.6%	16.7%
$\overline{C}^r$	32.2%	36.6%
$\overline{C}^i$	13.1%	24.8%
$\overline{V}$	3-	3+
$\overline{V}_r$	3-	4-
$\overline{V}^r_i$	3-	3

IV. Trilby Wash Detention Basin (#5)

ΣAcres	4361.0	9791.0
ΣRiparian Acres	803.0	2964.0
ΣInterfluve Acres	3558.0	6827.0
TVA	683.0	2269.0
RVA	221.0	1061.0
IVA	461.0	1208.0
C	15.7%	23.2%
C_r	5.1%	10.8%
C_i	10.6%	12.3%
$\overline{C}^r$	27.6%	35.8%
$\overline{C}^i$	13.0%	17.7%
$\overline{V}$	2	3+
$\overline{V}_r$	2	4
$\overline{V}^r_i$	2	3

VII. BLM Narrows Dam (#8)

ΣAcres	380.1	374.2
ΣRiparian Acres	178.2	193.2
ΣInterfluve Acres	201.9	181.0
TVA	61.3	111.6
RVA	31.0	76.9
IVA	30.3	34.7
C	16.1%	29.8%
C_r	8.1%	20.6%
C_i	8.0%	9.2%
$\overline{C}^r$	17.4%	39.8%
$\overline{C}^i$	15.4%	19.2%
$\overline{V}$	3	4-
$\overline{V}_r$	3+	4
$\overline{V}^r_i$	3	3+

X. Old Verde Canal (#11)

Measurement	Downstream	Upstream
ΣAcres	737.5	828.5
ΣRiparian Acres	182.8	209.8
ΣInterfluve Acres	554.7	618.7
TVA	187.1	208.7
RVA	64.7	67.3
IVA	122.4	141.4
C	25.4%	30.6%
C_r	8.8%	13.5%
C_i	16.6%	17.1%
$\overline{C}^r$	35.4%	53.3%
$\overline{C}_i$	22.1%	22.9%
$\overline{V}$	3+	3
$\overline{V}_r$	3	3
$\overline{V}_i$	4-	3+

XI. Powerline Dam (#12)

ΣAcres	975.7	770.3
ΣRiparian Acres	187.5	180.0
ΣInterfluve Acres	788.2	590.3
TVA	141.4	161.6
RVA	39.5	60.7
IVA	101.9	100.9
C	14.5%	21.0%
C_r	4.0%	7.9%
C_i	10.5%	13.1%
$\overline{C}^r$	21.1%	33.7%
$\overline{C}_i$	12.9%	17.1%
$\overline{V}$	3-	3+
$\overline{V}_r$	2+	4
$\overline{V}_i$	3-	3

XII. Vineyard Road Dam (#13)

ΣAcres	2860.0	1627.7
ΣRiparian Acres	345.5	304.6
ΣInterfluve Acres	2514.5	1323.1
TVA	450.0	329.2
RVA	113.1	113.5
IVA	336.9	216.7
C	15.7%	20.2%
C_r	4.0%	7.0%
C_i	13.4%	13.2%
$\overline{C}^r$	32.7%	37.3%
$\overline{C}_i$	13.4%	16.4%
$\overline{V}$	3-	3+
$\overline{V}_r$	3-	4-
$\overline{V}_i$	3-	3

XIII. Rittenhouse Dam Structure (#14)

Measurement	Downstream	Upstream
ΣAcres	1313.4	1232.8
ΣRiparian Acres	211.4	156.7
ΣInterfluve Acres	1102.0	1076.1
TVA	169.9	266.9
RVA	62.7	59.1
IVA	107.2	207.8
C	12.9%	21.6%
C_r	4.8%	4.8%
C_i	9.1%	16.8%
$\overline{C}^r$	29.7%	37.7%
$\overline{C}_i$	9.7%	19.3%
$\overline{V}^i$	2-	3+
$\overline{V}_r$	1+	4
$\overline{V}_i^r$	2-	3+

XIV. Magma Dam Structure (#15)

ΣAcres	2352.0	8899.4
ΣRiparian Acres	479.1	2710.2
ΣInterfluve Acres	1872.9	6189.2
TVA	378.6	1705.2
RVA	125.5	835.5
IVA	353.1	869.4
C	16.1%	19.2%
C_r	5.3%	9.4%
C_i	10.8%	9.8%
$\overline{C}^r$	26.2%	30.8%
$\overline{C}_i$	13.5%	14.0%
$\overline{V}^i$	2-	3+
$\overline{V}_r$	2-	4
$\overline{V}_i^r$	2-	3

XV. Brady Wash Structure (#16)

ΣAcres	452.4	342.7
ΣRiparian Acres	98.7	121.3
ΣInterfluve Acres	353.7	221.4
TVA	127.0	123.2
RVA	41.4	70.0
IVA	85.6	53.2
C	28.1%	35.9%
C_r	9.2%	20.4%
C_i	18.9%	15.5%
$\overline{C}^r$	40.9%	57.7%
$\overline{C}_i$	24.2%	24.0%
$\overline{V}^i$	3	4-
$\overline{V}_r$	3+	4
$\overline{V}_i^r$	3	3

XVI. South Side Canal (#18)

A. West Sacaton Mountain Site

Measurement	Downstream	Upstream
ΣAcres	847.1	1074.9
ΣRiparian Acres	173.5	222.0
ΣInterfluve Acres	673.6	852.9
TVA	106.3	165.1
RVA	32.2	42.5
IVA	74.1	122.6
C	12.5%	15.4%
C_r	3.8%	4.0%
C_i	8.7%	11.4%
$\overline{C}^r$	18.6%	19.1%
$\overline{C}^i$	11.0%	14.4%
$\overline{V}^i$	2+	3
$\overline{V}_r$	3-	3+
$\overline{V}_i^r$	2	3-

B. Interstate 10 Site

ΣAcres	197.6	230.7
ΣRiparian Acres	12.5	55.5
ΣInterfluve Acres	185.1	175.2
TVA	15.0	39.0
RVA	1.1	12.7
IVA	13.9	26.3
C	7.6%	16.9%
C_r	0.1%	5.5%
C_i	7.0%	11.4%
$\overline{C}^r$	8.8%	22.9%
$\overline{C}^i$	7.5%	15.0%
$\overline{V}^i$	2	3+
$\overline{V}_r$	2-	3+
$\overline{V}_i^r$	2	3+

C. Agency Peak Site

ΣAcres	330.0	319.5
ΣRiparian Acres	26.8	86.8
ΣInterfluve Acres	303.2	232.7
TVA	36.9	55.0
RVA	3.5	20.1
IVA	33.4	34.9
C	11.2%	17.2%
C_r	1.1%	6.3%
C_i	10.1%	10.9%
$\overline{C}^r$	13.1%	23.2%
$\overline{C}^i$	11.0%	15.0%
$\overline{V}^i$	2+	3-
$\overline{V}_r$	3-	3-
$\overline{V}_i^r$	2+	3-

APPENDIX B

Common and Scientific Names of Plants Mentioned

Scientific and Common names are from Kearney and Peebles (1964).

Common names	Scientific names
blue paloverde	Cercidium floridum
cholla	Opuntia spp.
cottonwood	Populus fremontii
creosote bush	Larrea tridentata
desert broom	Baccharis sarothroides
foothill paloverde	Cercidium microphyllum
catclaw acacia	Acacia greggii
ironwood	Olneya tesota
mesquite	Prosopis juliflora
saguaro	Cereus giganteus
seep willow	Baccharis glutinosa
snakeweed	Gutierrezia sarothrae
tamarisk	Tamarix pentandra
triangle-leaf bursage	Ambrosia deltoidea
white bursage	Ambrosia dumosa
whitethorn acacia	Acacia constricta