TRACY MUNICIPAL AIRPORT
PAVEMENT EVALUATION STUDY
PAVEMENT MAINTENANCE/MANAGEMENT PLAN

Prepared for
City of Tracy, California

Prepared by:
Reinard W. Brandley
Consulting Airport Engineer

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TRACY MUNICIPAL AIRPORT
PAVEMENT EVALUATION STUDY AND
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CHAPTER 1. INTRODUCTION

Tracy Municipal Airport was originally constructed in 1943 for the U.S. Army Air Corps on land donated by the City. The facility was utilized as a training base during World War II and was returned to the City of Tracy in 1946. The military airfield consisted of three paved landing strips approximately 300 feet wide, which sloped in one direction at a slope of approximately one percent (1%). When the City took over the airport, they maintained two of the runways – Runway 12-30 and Runway 8-26 – and converted the pavement on the third landing strip into aircraft parking apron and hangar development areas.

The runway layout consisted of marking a 100-foot wide runway on one side of the old military 300-foot strip and a 40-foot wide taxiway on the other side. The distance between runway centerline and taxiway centerline was established at 220 feet. There is approximately five feet (5') of original military pavement remaining outside of the runway and taxiway edges and in the total 150-foot wide infield area.

The airport consists of two runways with parallel taxiways, hangar areas and aircraft parking aprons. Runway 12-30 is 4,000 feet long and 100 feet wide with a 40-foot wide parallel taxiway. Runway 8-26 is 3,438 feet long and 100 feet wide with a 40-foot wide parallel taxiway. There is development on the north and south sides of the airport. The development on the north side consists of a large tie down apron, self serve fuel island, tee hangars, and a fixed base operator. The development on the south side of the airport consists mainly of aircraft storage hangars.

Major sections of the pavement at this airport are 70 years old and have been subjected to significant traffic. In recent times larger propeller-driven aircraft, as well as jet aircraft, have frequently used the airport. The runways and taxiways were rehabilitated with a heater remix and bituminous surface course overlays applied in 1977 and 1980. Sections of the north apron development were overlaid or reconstructed in 1983 and 1985. The north apron was expanded with a new section constructed in 1999. A slurry seal was applied to the surface of all runways, taxiways, and portions of the aprons in the mid-2000s. All pavements at the airport are flexible pavements where the surface consists of a bituminous surface course. These pavements have been subjected to significant traffic and severe environmental conditions including large daily temperature changes, hot temperatures in the summer, cool temperatures in the winter, and significant rain in the winter. Significant surface distress is evident in the form of cracking, weathering, and extensive raveling. There has been little evidence of deep-seated distress except on a portion of the north apron and south hangar developments.

The pavements at this airport have reached a state where significant maintenance is required and it is anticipated that reconstruction of the pavements will be necessary within the next 5 years. Since funding for pavement maintenance is limited to the grants available from the Federal Aviation Administration and the

California Division of Aeronautics and to local funds, it is necessary to establish a Pavement Maintenance and Management Program (PMMP) that will schedule reconstruction of the facilities within the necessary timeframe and adequate maintenance on all pavements so as to allow safe operation of all aircraft. This PMMP must take into consideration available funding each year.

There are two major distress types that develop at an airport. One is deep-seated distress and the second is surface distress. Deep-seated distress is caused by repetitive loading and development of stresses in the subgrade materials and subsoils that lead to a fatigue-type failure of these materials. When these materials fail, then there is a corresponding complete failure of the materials in the pavement section and it becomes necessary to completely reconstruct these failed sections. These type failures show up as rutting and severe alligator cracking in the surface of the pavement.

Surface distress is not only caused by the deep-seated failures, but also by age, traffic, and environmental conditions. The older pavements shrink and become brittle, which leads to surface cracking, raveling, and spalling. Environmental factors such as large temperature changes each day throughout most of the year, seasonal temperature variations, and rain all cause thermal cracking, raveling, and spalling. Traffic also contributes to surface distress.

A detailed pavement evaluation study has been conducted at Tracy Municipal Airport, which identifies and quantifies the distress that has developed in the pavement sections and evaluates and determines the time and type of maintenance that is required and the time and type of reconstruction, strengthening, or overlays that are required to maintain the quality, rideability, and aesthetic characteristics necessary for the safe operation of the airport. All pavement elements on the airport were evaluated in this study. The office of Reinard W. Brandley, Consulting Airport Engineer, has conducted these studies and the results of these studies are included in this report.

CHAPTER 2. DATA COLLECTION

Significant data was collected for the development of this Pavement Evaluation and Pavement Maintenance/Management Program. All previous test information available was gathered, a testing and inspection program was developed, and new data from the new test program were accumulated. A summarization of the data collected is provided herewith, and the detailed reporting of the test programs and data collected are included in Appendices A, B, C, and D.

2-1 Geotechnical Studies

Before a Pavement Evaluation Study can be successfully completed, it is necessary that detailed data be available showing the character and strength of the existing soils at the site on which the pavement sections are constructed. With the operations of jet aircraft (30,000+ pounds) at this airport, detailed soils data are required to a depth of at least 10 feet. Soils data developed include uniformity of stratification, soil classification, soil density, soil moisture content, soil strength, and consolidation characteristics.

The office of Reinard W. Brandley has completed several geotechnical studies at the Tracy Municipal Airport dating back to 1975. Soil borings from 1975, 1983, 1985, 1989, and 2012 have been studied, and results from these studies are included in Appendix A. Test holes varied from 5 to 18 feet in depth. Most soil borings indicate that there is a layer of relatively soft, dark brown silty clays or sandy silts that varies from 3 to 7 feet in depth beneath the existing pavement sections. In most areas the thickness of this material is 3 to 4 feet, but in some areas the silty clays and sandy silts are missing completely and a loose silty sand exists near the surface. Below this layer is a very stable thick layer of compact sands and gravels that classify as silty fine sands to medium coarse sands and gravels. This stratum was the previous source of sand and gravel for a commercial operation, and the abandoned gravel pits to the northeast of the airport are the remains of these operations. The underlying layer is very compact and stable. No groundwater was encountered in any of the test borings conducted by this office.

The soft surface silty clays and sandy silts have a California Bearing Ratio (CBR) when compacted to 95 percent relative compaction of 5 to 6 and a Modulus of Elasticity in the existing condition ranging from 5,000 to 10,000 pounds per square inch (psi). The compact underlying sands and gravels when compacted to 95 percent relative compaction will have a CBR of 20 to 30 and an in-place Modulus of Elasticity of 15,000 to 25,000 psi.

All test pits and test holes were located on or adjacent to the runways, taxiways, aprons, and hangar areas. Samples of the subgrade and subsoils from all test holes and test pits were obtained and submitted to the laboratory for classification and strength characteristics tests. The results of this study are summarized in Appendix A.

2-2 Existing Pavement Sections

The existing pavement sections throughout the airport were evaluated based on the study of original construction drawings, reconstruction and maintenance drawings, test pits excavated, previous reports, and F.A.A. files.

In general, all existing pavements are F.A.A. Marshall mix design materials or California Highway Department specification materials. These pavements are a good quality product but are old, weathered, and somewhat brittle. The existing aggregate base course consists mainly of a well-graded crushed aggregate base course with a maximum size of ¾ inch to 1½ inch depending on location.

The thickness of each layer of asphalt pavement or aggregate base is shown, wherever it is known, in Appendix C, Tables C1 through C31. In general, the pavement sections are as follows:

Item	Section Thickness - inches			
	AC	AB	ASB	Total
Runway 12-30	6	12	-	18
Taxiway B and E	3.5	11	-	14.5
Runway 8-26	6	11	-	17
Taxiways A and F	6	7.5-10	-	13.5-16
Taxiway C	2	8	-	10
Apron A1	5.5	6	-	11.5
Apron A2 and A3	2-3	5	4.5-5	11.5-13
Apron A4 and A5	2	4	-	6
Hangar Area H1	2	4	-	6
Hangar Area H2	2	5	-	7
Hangar Area H3	3	7	-	10
Hangar Area H4	2	5	5	12

In general, the old pavement sections constructed by the military in 1943 consisted of 2 inches of asphaltic concrete pavement over 8 to 12 inches of crushed aggregate base for Runway 12-30, Runway 8-26 and associated taxiways. For the third strip paved by the military the pavement section generally consisted of 2 inches of bituminous surface course over 4 to 6 inches of aggregate base course. In the period 1975 to 1985 the newly designated runways, taxiways, and portions of the apron were heater remixed and overlaid with 1.5 to 3 inches of new asphaltic concrete pavement.

2-3 Falling Weight Deflectometer (FWD) Tests

The heavy-duty falling weight deflectometer (FWD) as manufactured by Dynatest Corporation is capable of applying dynamic loads to the pavement of up to 50,000 pounds on a 12 or 18-inch diameter plate. This FWD measures the deflections of the surface of the pavement not only under the center of the plate, but at various increments out to 7 feet from the centerline of the plate. The shape and magnitude of the deflection bowl caused at the surface of the pavement under the applied loads can thus be determined. These FWD tests can be conducted fairly quickly, generally 20 to 30 tests per hour. Therefore, enough tests can be conducted to determine the uniformity of the load-carrying characteristics of the pavement in one element of the airport, together with the size and shape of the deflection bowl of the surface of the pavement under load.

At Tracy Municipal Airport FWD tests were conducted on each side of the runway centerline in the wheel path at a spacing of 200 feet. The locations of the tests were staggered so that test results are available at 100-foot intervals. One row of tests at 200-foot spacing was conducted on all taxiways, approximately 10 feet off centerline. On all aprons tests were conducted on a grid of approximately 100-foot by 100-foot. On all hangar taxilanes FWD tests were conducted in the wheel path of the taxilane at a spacing of approximately 100 feet.

The FWD tests not only measure the deflection obtained under each test, but also measure the load that was applied to the pavement. Even though the height of fall of the weights remains the same, the actual load applied to the pavement varies somewhat depending on the resistance to load. In order to compare the test results, all deflections obtained were normalized to the deflections under loads of 10, 14, and/or 17 kips. The results of the falling weight deflectometer tests showing center plate deflections are included in Appendix B, Plates B1 through B3. A full-size copy of these drawings is located in the back pocket of this report. The center deflections for each element of the airport were also plotted as profiles and these data are included in Appendix B, Plates B4 through B38.

The measured surface deflections under the FWD tests varied considerably from one location to another even though the pavement sections are similar in most areas. This shows the large variation in subgrade and subsoil strength.

The basic soil parameters that are utilized in the Fatigue Analysis to determine pavement life are Modulus of Elasticity and Poisson's Ratio. The magnitude of deflection and shape of the deflection bowl of the surface of the pavement under load can be used with the computer program for calculations of stresses, strains, and deflections on multi-layer systems to back calculate the soil parameter of Modulus of Elasticity. The data developed from all of the falling weight deflectometer tests were utilized to back calculate Modulus of Elasticity of each layer of the pavement section, the upper 4 feet of subgrade soil, and the subsoils located below 4 feet from the surface. The results of these back calculated values of Modulus of Elasticity of each layer analyzed are included in Appendix C, Tables C1 through C31.

2-4 Pavement Condition Survey

Pavement condition surveys were conducted on all pavements at Tracy Municipal Airport to determine the type of distress and degree of distress that has occurred on each pavement element and the general character of the pavement.

A standard test method for pavement condition surveys is included in ASTM D 5340-11, *Standard Test Method for Airport Pavement Condition Index Surveys*. In the pavement condition survey a detailed assessment of the pavement is conducted, which evaluates the following surface distresses:

- Alligator Cracking
- Bleeding
- Block Cracking
- Corrugation
- Depression
- Jet Blast
- Joint Reflection (PCC)
- Longitudinal and Transverse Cracking
- Oil Spillage
- Patching
- Polished Aggregate
- Raveling/Weathering
- Rutting
- Shoving from PCC
- Slippage Cracking
- Swell

The normal procedure is to divide the element into sample units. The sample units generally represent approximately 10 percent of the total pavement section. The type and severity of each airport pavement distress is assessed by visual inspection of the pavement sample units. The quantity of distress is measured and the distress data are used to calculate the Pavement Condition Index (PCI) of each sample unit. The process involves detailed inspection of sample units throughout the section, which covers approximately 10 percent of the total area of the pavement.

The office of Reinard W. Brandley deviates from this process in that the types of distress that are apparent in three or four representative samples of the section are evaluated in detail, which includes the worst case unit as well as the average unit. Generally there are only three or four of the distress types that are evident on the unit. After these have been determined, 100 percent of the pavement surface is surveyed to determine the severity and magnitude of distress for each type of distress that is occurring on that section of pavement. By this procedure the coverage of the survey is increased from the 10 percent included in the standard ASTM method to 100 percent. It is considered important to expand the survey in this manner so as to identify the worst-case conditions as well as the average and best case conditions. Any unusual distress types are also recorded for the total unit.

The Pavement Condition Index (PCI) and pavement condition description were determined for each section of pavement. This information is included in Appendix C of this report. The data for each segment are included in Tables C1 through C31. Additional information is also included on these tables. Pavement condition determinations are based on visual observations and can vary significantly based on the experience and judgment of the Engineer.

The ASTM Standard provides a relationship between Pavement Condition Index (PCI) and pavement rating. On Plate No. 2-1 the rating system is indicated as a color legend and the rating of each segment of pavement is indicated by color. The PCI of each segment is also indicated adjacent to each segment of the pavement. It will be noted that most pavements at the airport range from the "poor" to "fair" condition. Most pavements are showing significant raveling of the slurry seals and asphalt surfaces. They also have cracked asphalt beneath the slurry seals that are reflecting through to the surface. As a result of the surface conditions on most of the pavements, most rehabilitation is recommended earlier than the forecast remaining life of the pavement.

2-5 Forecast Traffic

Traffic forecasts furnished by Tracy Municipal Airport were used to evaluate the pavements at this airport. This data included the type aircraft currently operating at the airport, along with the annual number of operations of each aircraft type. They also included the forecast growth of use of these aircraft. In Table No. 2-1 the traffic data used are presented.

Table No. 2-1a lists the 2012 annual operations for aircraft utilizing the airport and includes their maximum takeoff weight and gear configuration. These aircraft have been grouped into 4 aircraft groups and 2 groups for vehicular traffic on access roads. Each group represents the average aircraft characteristics of maximum takeoff weight and gear type for the different classifications of aircraft that utilize the airport.

In evaluating airfield pavements for deep-seated distress it is the number of coverages of each wheel on each aircraft over a given point of pavement that contributes to the deep-seated distress on or near that section of pavement. The distribution of aircraft traffic on the airport is a function of:

- Wind direction, which dictates which runway is used
- Landing length requirement of each aircraft and takeoff length requirement of each aircraft
- Destination on the airport of each aircraft type.

For this evaluation it was assumed that 80 percent of the traffic will use Runway 12-30 with 90 percent of this traffic utilizing Runway 30. The other 20 percent of the traffic will use Runway 8-26 with 90 percent of this traffic utilizing Runway 26. Jet traffic has a slightly different distribution with 90 percent the jet traffic utilizing Runway 12-30. For this evaluation, all jet traffic is assumed to operate on the runways, taxiways, and the north apron development but not in the south hangar development.

When an aircraft lands on a runway, only the large aircraft generally use the full length of runway. Intermediate and smaller size aircraft exit the runway at the appropriate cross taxiway. The taxiways that are used by aircraft are dependent upon the location at which the aircraft take off and land as well as the destination of the aircraft on the airport.

Based on the aircraft characteristics, the runway use dictated by wind, and the destination of aircraft on the airport, the annual operations of each aircraft have been evaluated to best represent the actual traffic that occurs on each segment of pavement. The traffic forecast to occur on each segment is defined as "Traffic Index." A total of 15 traffic indexes were evaluated. The number of annual operations and calculated average annual growth rates for each aircraft group and each traffic index are indicated in Table No. 2-1b. This traffic index was utilized in the evaluation of pavements for deep-seated distress.

The Fixed Base Operator (FBO) at the airport feels there is a potential for additional hangar development that he believes will attract an increased amount of general aviation aircraft as well as more jet aircraft to the Tracy Municipal Airport. The traffic indexes used in this analysis were based on existing traffic and likely potential increases in traffic. The FBO has a much more optimistic view of the amount of forecast traffic that his new hangar development could generate. Since the number of operations for the optimistic forecast is significantly different than the likely forecast traffic, some enhanced traffic indexes were created and used for additional analysis. The additional analysis has been provided for use if this future optimistic traffic forecast is realized. In order to evaluate the effects that additional traffic would have, a new set of traffic indexes were prepared and used in the Fatigue Analysis studies. These new enhanced traffic indexes utilize the optimistic forecasts that have higher operations of the single engine aircraft and all jet aircraft. The new enhanced traffic indexes have also been included in Table No. 2-1 as Table No. 2-1c. The traffic index designation is the same as with the existing likely forecasts except that a "1" has been added. For example, traffic index "A" is the likely forecast traffic and "A1" is the optimistic forecast of traffic. The Fatigue Analysis and FAARFIELD analysis was conducted using both the forecast traffic indexes and the enhanced traffic indexes.

Using the traffic index and the total annual operations, the number of operations on a given segment of the airport can be estimated. Each operation does not travel over the same spot on a pavement and, therefore, the number of coverages on the pavement section will be less than the total operations for each traffic index. The distribution of traffic on each section is a function of the aircraft type, the gear type, the wind conditions, and the skill of the pilot. There is generally a fairly wide distribution of traffic on a runway; whereas, on a taxiway the traffic is more concentrated. On the aprons the traffic generally follows specified taxilane markings, but only a fraction of the total aircraft operate onto each section of apron. Different factors are applied to the operations estimated for a given section to convert operations to coverages. Coverages are used in the Fatigue Analysis for remaining pavement life calculations.

The traffic distribution used for various segments of the pavement is shown on Plate No. 2-2.

TABLE No. 2-1 - TRAFFIC SUMMARY

TABLE No. 2-1a - Summary of Traffic Data for Tracy Municipal Airport

Aircraft Group	Aircraft Type	Aircraft MTOW (lbs)	Gear Configuration	2012 Annual Operations	2012 Daily Operations
1	Single Engine	3,000	Single	61,000	167
2	Twin Engine	4,000	Single	5,000	14
3	Jet Aircraft 15k	15,000	Dual	2,400	7
4	Jet Aircraft 30k	30,000	Dual	600	2
5	Automobile	4,000	Single	72,000	197
6	H-20 Truck	18,000/Axle	Dual	730	2
		Total 2012 Aircraft Operations		69,000	189
		Total 2012 Vehicle Operations		72,730	199

TABLE No. 2-1b - Summary of Traffic Indexes (Likely Forecast)

Aircraft Group	**Traffic Index (Aircraft Operations In 2012)**														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	48,800	13,664	7,534	28,304	8,479	12,200	6,100	6,009	22,021	29,402	7,412	3,081	48,800	3,000	-
2	4,000	1,480	1,808	2,045	785	1,000	500	218	1,715	620	3,283	528	1,000	-	-
3	2,160	1,771	1,177	1,042	821	240	120	176	379	-	2,219	181	-	-	-
4	540	443	294	262	197	60	30	46	103	-	557	44	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72,000
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	730
Total 2012 Operations	55,500	17,358	10,813	31,653	10,282	13,500	6,750	6,448	24,218	30,022	13,469	3,833			

Aircraft Group	**Traffic Index Growth Rates (Calculated Average Annual Growth Rate)**														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	1.06%	-
2	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	-	-
3	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	-	3.50%	3.50%	-	-	-
4	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	-	3.50%	3.50%	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.00%
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.00%

TABLE No. 2-1c - Summary of Enhanced Traffic Indexes (Optimistic Forecast)

Aircraft Group	**Traffic Index (Aircraft Operations In 2012)**														
	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1	L1	M1	N1	O1
1	55,200	15,456	8,522	32,016	9,591	13,800	6,900	6,797	24,909	33,258	8,384	3,485	55,200	3,500	-
2	4,000	1,480	1,808	2,045	785	1,000	500	218	1,715	620	3,283	528	1,000	-	-
3	3,096	2,539	1,687	1,493	1,176	344	172	253	544	-	3,180	260	-	-	-
4	774	635	422	376	283	86	43	66	147	-	798	62	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	86,400
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	876
Total 2012 Operations	63,070	20,109	12,438	35,930	11,835	15,230	7,615	7,333	27,315	33,878	15,644	4,334	56,200		

Aircraft Group	**Traffic Index Growth Rates (Calculated Average Annual Growth Rate)**														
	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1	L1	M1	N1	O1
1	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	-
2	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	1.94%	-	-
3	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	-	4.01%	4.01%	-	-	-
4	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	4.01%	-	4.01%	4.01%	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.00%
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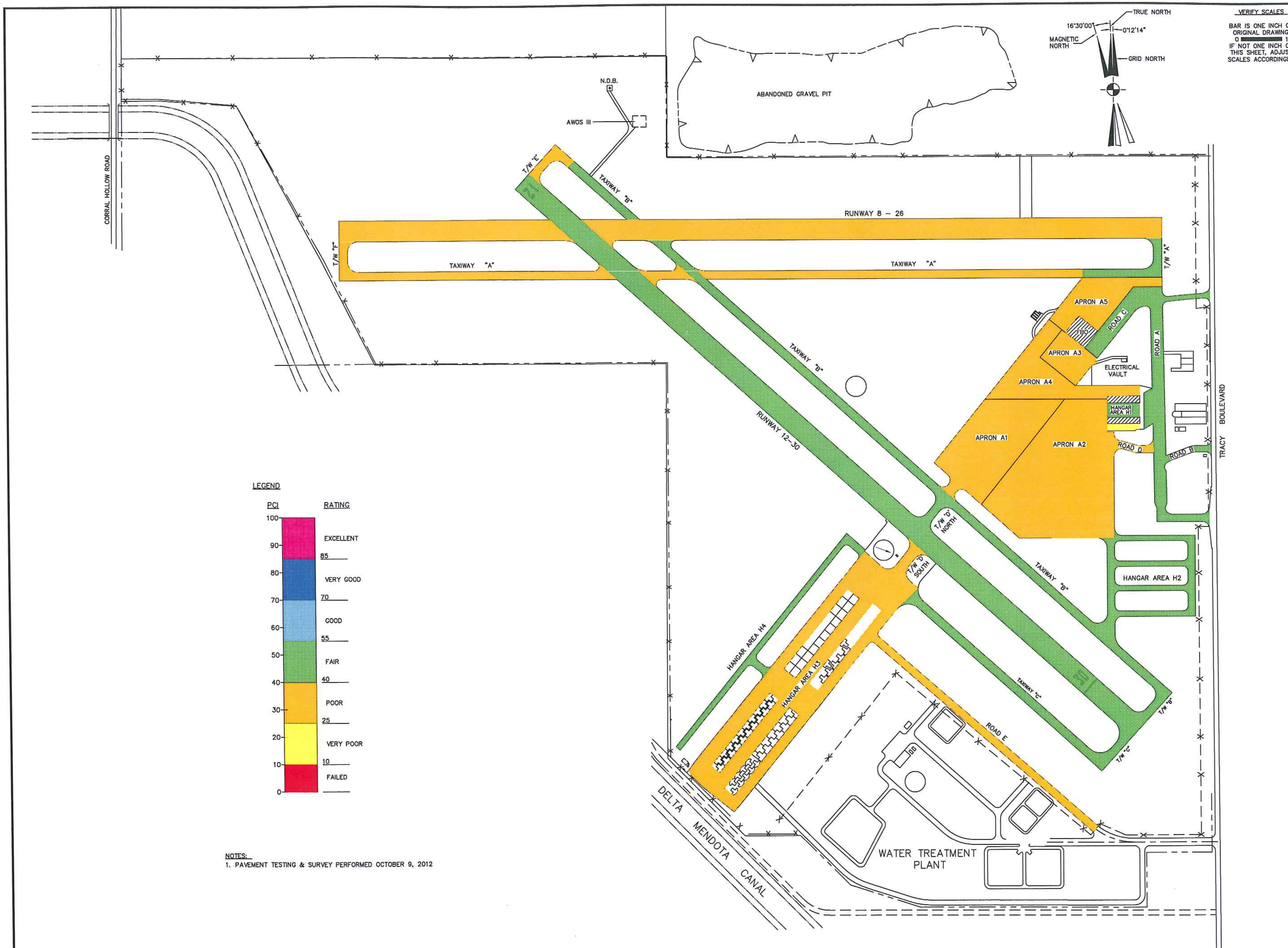


TRACY MUNICIPAL AIRPORT

TRACY, CALIFORNIA

PAVEMENT EVALUATION

SURFACE DISTRESS - PAVEMENT CONDITION INDEX (PCI)

NO.	REVISIONS	BY	APR	DATE

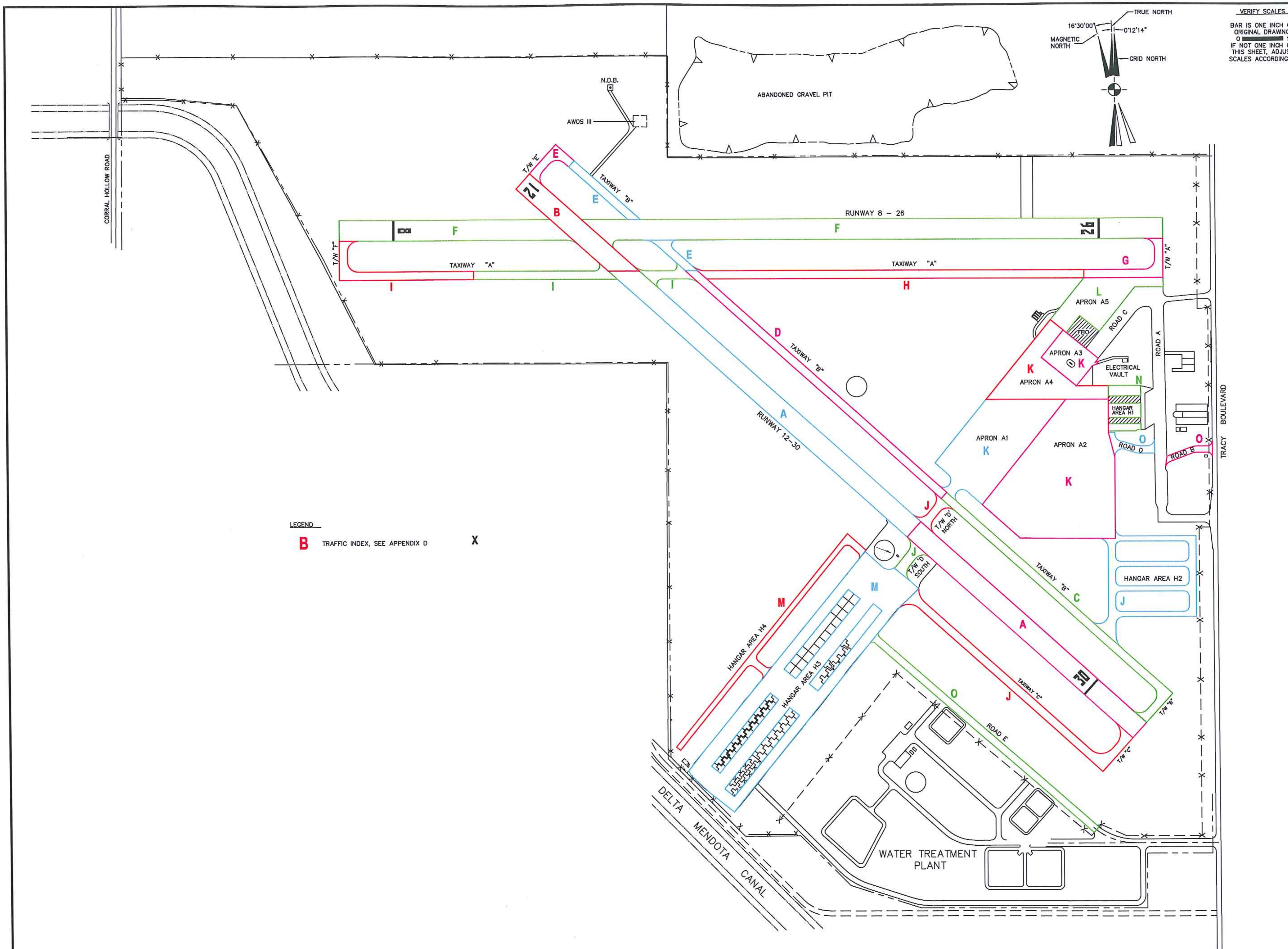
ENGINEER OF RECORD

REGISTERED PROFESSIONAL ENGINEER R. DAMON BRANDLEY No. C 66558 Exp. 6-30-2014 CIVIL STATE OF CALIFORNIA

Reinard W. Brandley
CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

DESIGN BY: DB
DRAWN BY: DB
CHK'D BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=200'

SHEET NUMBER
PLATE No. 2-1



Reinhard W. Brandley
CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8204 • (916) 652-4725

ENGINEER OF RECORD

NO.	REVISIONS	BY	APR	DATE

TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION

TRAFFIC DISTRIBUTION - TRAFFIC INDEX

DESIGN BY: DB
DRAWN BY: DB
CHK'D BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=200'

SHEET NUMBER
PLATE No. 2–2

CHAPTER 3. ANALYSIS AND EVALUATION

3-1 Distress Mode

There are two major distress types that lead to failure and/or deterioration of an airfield pavement. These are deep-seated distress and surface distress.

Deep-seated distress is distress in the lower sections of the pavement and the subgrade and subsoil beneath the pavement section and is caused by repeated stresses induced by aircraft movement on the surface of the pavement. Deep-seated distress can lead to complete failure of the pavement section, foundation soils, or both.

Surface distress is caused by traffic, age, and environmental factors including temperature, temperature changes, and moisture. Surface distress causes deterioration of the surface pavement layer including cracking, spalling, raveling, bleeding, and shoving.

3-2 Deep-Seated Distress

A pavement does not suddenly fail under load unless it is grossly overloaded. Load limits for infrequent use need to be applied to the pavements to avoid collapse of the aircraft through the pavement section. The failures that generally occur are fatigue-type failures where distresses develop to a point that rutting and accompanying failure of the pavement section occurs. It is important in developing a Pavement Maintenance/Management System (PMMP) to determine the time at which failure of the section caused by deep-seated distress will occur under forecast loadings. Several methods have been developed over the past 60 years for utilizing a Fatigue Analysis methodology to forecast remaining life of pavements under forecast loads. The degree of success has been varied depending on the method used. The BRANDLEY Fatigue Analysis methodology has a successful 60-year performance record, showing a 90 to 95 percent accuracy in predicting remaining pavement life. The BRANDLEY Fatigue Analysis methodology is utilized in this study. The FAARFIELD fatigue analysis has also been used for comparative purposes.

3-2.1 Back Calculated Modulus of Elasticity

Prior to the development of the computer, it was not possible to calculate stresses, strains, and deflections under loaded pavement sections at various depths in a section using a multi-layered system. As a result, the early methods of fatigue analysis utilized deflections of pavement surface, subgrade surface, or other locations as the failure criteria. With the development of the computer, it was possible to calculate stresses, strains and deflections at the surface and all depths below in a multi-layer system.

The basic soils and pavement parameters that were necessary for this computation were Modulus of Elasticity, Poisson's Ratio, and thickness of each layer in the system.

With the development of the heavy-duty falling weight deflectometer equipment and the heavy-duty vibratory load test equipment, it became possible to measure deflections of the pavement surface and to establish the size and shape of the deflection bowl caused by the applied loads. Using the deflection bowl data and the computer program for multi-layer systems, it is possible to back calculate values of Modulus of Elasticity for each layer of the system. Poisson's Ratio is not a critical parameter and values of Poisson's Ratio can be adequately estimated for each type material in each layer. As a result of this development, full-scale load tests are no longer required and the basic soil parameters can be developed from the results of heavy-duty falling weight deflectometer tests or vibratory load tests.

Modulus of Elasticity and Poisson's Ratio of each layer and the thickness of each layer of the pavement section, the subgrade materials, and various layers of subsoil can be developed and utilized with the Fatigue Analysis.

3-2.2 Forecast Traffic

Forecast traffic, including type aircraft, type gear, operating load, and distribution on the pavement, is a parameter that must be utilized in any fatigue analysis. This data must be converted to coverages, which is the number of wheels per year crossing a given point on the pavement. The forecast traffic at Tracy Municipal Airport for each pavement section is included as the Traffic Index in Table No. 2-1. These traffic indexes represent the total operations of each category of aircraft on each section of pavement. For input into the Fatigue Analysis methodology, these operations are converted to coverages to represent the distribution of aircraft tires on the pavement section in each segment.

3-2.3 Existing Pavement Sections

Thickness and type of material of each pavement section and each layer of subgrade and subsoil under the pavement section are important factors to input into any fatigue analysis. The section data for each pavement section are included in Appendix C.

3-2.4 Considered Rehabilitation Sections

Fatigue Analysis methodology not only provides a forecast remaining pavement life under forecast traffic for a given pavement section, but can also forecast extended pavement life after different rehabilitation or reconstruction processes have taken place. It is, therefore, important to not only evaluate the existing pavement sections and forecast remaining life, but to apply feasible rehabilitation methods to the existing pavement sections and calculate forecast extended life due to the rehabilitation process. It is important to make this evaluation for different rehabilitation processes that would be feasible at this airport in order to prepare a cost-benefit analysis to evaluate the most acceptable rehabilitation program for the pavement section. A series of rehabilitation processes that are considered feasible for this airport have been prepared and are included in Table No. 3-1. Where applicable, each of these rehabilitation procedures was evaluated using the Fatigue Analysis.

3-2.5 Fatigue Analysis – Deep Seated Distress

3-2.5.1 BRANDLEY Fatigue Analysis – Remaining Life Analysis

In 1948, as research for a doctoral thesis at Harvard University Graduate School of Engineering, Reinard W. Brandley developed the BRANDLEY Fatigue Analysis method of evaluating airfield pavements. This Fatigue Analysis was developed using full-scale load tests conducted by the Corps of Engineers near the end of World War II on various airports for the purpose of developing design criteria for pavements to serve the larger military aircraft that were being developed. The failure criterion that was used in this analysis was limiting subgrade deflection under design load. Measured deflections were used at that time since the computer had not been developed and the stresses, strains, and deflections in multi-layered systems could not be calculated. This Fatigue Analysis methodology and failure criteria has been utilized on many airports. However, the method of determining deflections of the surface of the subgrade has changed from direct measurement to calculating these deflections using layer thicknesses and the Modulus of Elasticity and Poisson's Ratio of each layer, which have been back calculated from the data obtained from the falling weight deflectometer tests. From the Fatigue Analysis, forecasts of remaining pavement life, so far as deep-seated distress is concerned, were calculated for each pavement section.

Since the original research was conducted on flexible pavements, it was anticipated that a separate failure criteria would be required for rigid pavement sections. Experience and comparison with actual performance show that the failure criteria used for flexible pavements is the same for rigid pavements and there was no change required in the failure criteria.

A comparison of forecast pavement life and time for failure under the forecast traffic over the past 60 years has shown very good correlation between forecast life and actual time to failure. The forecast life has always been within 90 to 110 percent of the actual life of the section.

3-2.5.2 FAARFIELD Airport Pavement Design – Remaining Life Analysis

Within the last 3 to 4 years the Federal Aviation Administration has developed a fatigue analysis methodology similar to that developed by Reinard W. Brandley called the "FAARFIELD Airport Pavement Design." The FAARFIELD design utilizes the same traffic distribution, forecasts, pavement section thickness, and Modulus of Elasticity and Poisson's Ratio of each layer within the section as are used in the BRANDLEY Fatigue Analysis. The only differences are the methodology of conversion of operations to coverages and the failure criteria. FAARFIELD uses limiting subgrade strain as the failure criteria.

In the Pavement Evaluation Study for Tracy Municipal Airport the same input information was used for evaluating each pavement section with the BRANDLEY Fatigue Analysis and with the FAARFIELD design. By this method, direct comparison for forecast remaining life of the section was obtained using the BRANDLEY Fatigue Analysis method and the F.A.A. FAARFIELD method. The actual remaining life of each section using both methods has been prepared and is included in Appendix C, Tables C1 through C31. The analyses were conducted for both methods using both the likely forecast traffic and the optimistic forecast traffic. On these tables a side-by-side comparison of remaining structural pavement life as determined using the BRANDLEY Fatigue Analysis and the FAARFIELD Fatigue Analysis methods has been presented.

Normally, any forecast pavement life that is in excess of 20 years is reported as 20+ years since it is not possible to anticipate all changes in existing pavement conditions resulting from load, weather, maintenance methods, etc. In this report to show a direct comparison the actual calculated extended life has been included. However, for practical purposes forecast life beyond 20 years will require updates every 10 years to take into consideration any changes that occur to forecast traffic, pavement condition, or other pavement section related items.

It will be noted that there are extreme differences in forecast pavement life between the BRANDLEY Fatigue Analysis and the FAARFIELD analysis methods. These differences are shown in Plates 3-1, 3-2, 3-3, and 3-4.

Plate No. 3-1 indicates in color those areas on the airport that are expected to fail due to deep seated distress within a 20-year period using the BRANDLEY Fatigue Analysis with the Likely Forecast Traffic Indexes. The circled numbers next to each section indicate the remaining life in years of each section.

Plate No. 3-2 indicates in color those areas on the airport that are expected to fail due to deep seated distress within a 20-year period using the FAARFIELD analysis with the Likely Forecast Traffic Indexes. The circled numbers next to each section indicate the remaining life in years of each section.

Plate No. 3-3 indicates in color those areas on the airport that are expected to fail due to deep seated distress within a 20-year period using the BRANDLEY Fatigue Analysis with the Optimistic Traffic Indexes. The circled numbers next to each section indicate the remaining life in years of each section.

Plate No. 3-4 indicates in color those areas on the airport that are expected to fail due to deep seated distress within a 20-year period using the FAARFIELD analysis with the Optimistic Traffic Indexes. The circled numbers next to each section indicate the remaining life in years of each section.

It should be noted that the FAARFIELD analysis shows an extremely wide range of remaining life for all pavements on the airport. It is also noted that the remaining life from the FAARFIELD analysis was either significantly lower or higher than the projected remaining life determined by the BRANDLEY Fatigue Analysis. It will be noted that when both the likely and optimistic forecast traffic is used that the BRANDLEY Fatigue Analysis and FAARFIELD analysis project the same segments of pavement with less than 20 years of remaining life, except for Road E. In all of these cases FAARFIELD shows a significantly shorter pavement remaining life than the BRANDLEY Fatigue Analysis.

Noting these differences, a comparative study of the two systems was made on some airport pavements that actually failed after they had been tested. In this analysis the same traffic, pavement section, Modulus of Elasticity values, and Poisson's Ratio values for each layer were used in both the BRANDLEY Fatigue Analysis and the FAARFIELD analysis. At each location Air Traffic Control Tower records indicated that the forecast traffic for aircraft type and operation matched the actual traffic experienced. The results of this study are tabulated below:

Airport	Facility	Forecast Remaining Life (Years)		Actual Life*
		BRANDLEY	FAARFIELD	
Sacramento International Airport	Runway 16L-34R	5	0.25	5.1
Stockton Metropolitan Airport	Runway 11-29	6 to 8	22	7
Nashville International Airport	Existing Apron Taxiway	3	0.2	3
Truckee-Tahoe Airport	Runway 11-29	16	1	10+**

*Number of years to actual failure.

**This section of the runway performed under forecast loading for 8 to 10 years with no sign of deep-seated distress. There was surface cracking of the asphalt pavement due to thermal stresses, which was the reason for reconstruction in 2012, not deep-seated distresses. According to FAARFIELD it should have had structural failure 7 to 9 years earlier.

Due to the long, accurate performance record of the BRANDLEY Fatigue Analysis methodology and the large discrepancies with the FAARFIELD method and short performance record of FAARFIELD, all maintenance and rehabilitation recommendations in this report are based on data obtained from the BRANDLEY analysis.

A detailed fatigue analysis was conducted using each type of rehabilitation and overlay considered appropriate and the extended pavement life was calculated. Taking this extended life for each section into account, the recommended pavement maintenance program was prepared. The recommended pavement rehabilitation method used was based on cost-benefit analysis, construction timing and difficulties, and availability of funding.

Two recommended rehabilitation procedures for deep-seated distress with estimated unit costs for each procedure are presented in Table 3-1. The rehabilitation plan for the next 20-year period to protect against deep-seated distress only is included in Table No. 3-2. Due to the severe surface distresses at the Tracy Municipal Airport, it should be noted that all areas that require rehabilitation due to deep-seated distress are scheduled to be rehabilitated at an earlier date than would normally be required by the deep seated distresses.

3-3 Surface Distress

3-3.1 Pavement Condition (PCI)

Surface distress in the pavements is not necessarily caused by deep-seated distress, nor does it forecast when the pavement section will fail. Surface distress generally is caused by inadequate quality of the pavement materials, and/or environmental factors such as temperature, moisture, and temperature changes between day and night and summer and winter. These defects show up as cracking, patching, raveling, weathering, swelling, and rutting. Rutting can be caused by deep-seated distress and failure of the section or associated with flushing of an asphalt mix.

The pavement condition is determined by visual inspection of the surface of the pavement as described previously. A Pavement Condition Index (PCI) can be determined for each segment to indicate the degree of distress. A typical plot of PCI vs. Time is included as Plate No. 3-5. On this plate a typical pavement index plot for asphalt concrete pavement and for Portland cement concrete pavement is shown. In both diagrams the PCI gradually decreases with time and when it reaches a certain point, it decreases at a much faster rate. The gradual decreasing portion of the curve indicates surface distress only. The sharp break off is generally caused by deep-seated distress. There is no way to predict when the deep-seated distress or failure of the section is going to occur using only the PCI and, therefore, it is not possible to predict when major rehabilitation or reconstruction will be required. If one waits until the PCI vs. Time curve shows deep-seated distress by the sharp break off, then failure has already occurred and it is not possible to extend the life of the section by overlays or adding to the surface of the existing pavement section. As a result, the Pavement Condition Index (PCI) cannot be successfully used to predict deep-seated distresses and failures but is effective in determining when surface rehabilitation and repairs are necessary.

Surface distress results in deterioration of the surface course. This distress shows up as cracks in the pavement, including transverse cracks, longitudinal cracks, block cracking, map cracking, secondary cracking, raveling, weathering, patching, or damage to the surface caused by jet blast or oil and chemical spillage. Each of these deficiencies can be treated so as to provide safe operation of the airport, but with time it will become more cost effective to completely rehabilitate or reconstruct the section. The timing of repair of cracks or other defects will be a function of cost benefit and availability of funds.

The typical rehabilitation procedures for surface distress for Tracy Municipal Airport are shown in Table No. 3-3.

3-3.2 Thermal Stresses

Surface cracking can be caused by thermal stresses in the pavement. These stresses are created by large changes in temperature of the pavement from day to night and summer to winter. Over time these temperature variations combined with the oil in the asphalt becoming old and brittle can cause cracking of the asphalt pavement.

Sealing of the cracks is an important maintenance procedure since it resists spalling or raveling of the pavement immediately adjacent to the cracks and inhibits the entry of storm water into the underlying aggregate base course. Normal crack sealing operations, including filling the crack with sealant and/or adding a "Band Aid" section of sealant on top of the crack will have limited life. It is recommended that all cracks to be sealed be prepared for sealing by routing a section to provide a depth to width ratio of the sealant of no more than 1 to 1. This will also require the installation of a backer rod below the sealant to keep the sealant from filling the bottom section of the crack. The sealant should include a "Band Aid" on the top of the pavement over the seal extending 1-inch minimum beyond the edge of the prepared repair on each side of the crack. The thickness of the "Band Aid" should be 1/8". A typical section of a crack seal repair is shown on Plate 3-6.

A sealant on the surface of the pavement should be considered when the weathering and development of fine cracks has developed to a point that it has a detrimental effect on the life of the pavement and the surface condition. This sealant can consist of reclamite, slurry seal, an SS1h fog seal or other suitable materials.

TABLE NO. 3-1

TRACY MUNICIPAL AIRPORT

PAVEMENT REHABILITATION PROCEDURES
DEEP-SEATED DISTRESS

Code	Rehabilitation Method	
A	Pulverize and Remove and Reconstruct Section	
	Pulverize, remove, stockpile AC & AB - 5"	
	Excavate to new Subgrade level - 7"	
	Scarify and Recompact Subgrade	
	New Section - ASB - Pulverized Existing AC & AB (+ 2" New)	7"
	AB - Crushed Aggregate Base (New)	4"
	AC - Asphalt Pavement (New)	3"
	Total Thickness	14"
	Cost per square foot	$5.40
B	Rehabilitate Existing Section	
	New Section - ASB - Pulverize & Recompact Existing AC & AB	10"-18"
	AB - Crushed Aggregate Base (New)	4"
	AC - Asphalt Pavement (New)	3"
	Total Thickness	17"-25"
	Cost per square foot	$4.90

Notes:
1. Costs indicated are based on 2013 prices and do not include any costs other than the pavement section itself.
2. Each rehabilitation method shown (A or B) will extend the remaining pavement life of the setion so far as deep seated distress to more than 30 years, provided good maintenance practices are adopted.

TABLE NO. 3-2

TRACY MUNICIPAL AIRPORT

REHABILITATION PLAN - DEEP-SEATED DISTRESS

Estimated Date of Rehabilitation	Element	Station	2012 Remaining Life (Years)	Estimated Year of Failure	Recommended Rehabilitation Code**	Recommended Rehabilitation Description
2027 *	Apron A2	All	18	2030	A	Remove Existing & Reconstruct
2025 *	Apron A3	All	16	2028	A	Remove Existing & Reconstruct
2014	Apron A4	All	2	2014	A	Remove Existing & Reconstruct
2019 *	Apron A5	All	10	2022	A	Remove Existing & Reconstruct
2021	Road E	All	12	2024	B	Rehabilitate Existing Section

*Date of rehabilitation that is required to protect against deep seated failure. Surface condition of pavement indicates that the total apron should be reconstructed as early as possible.

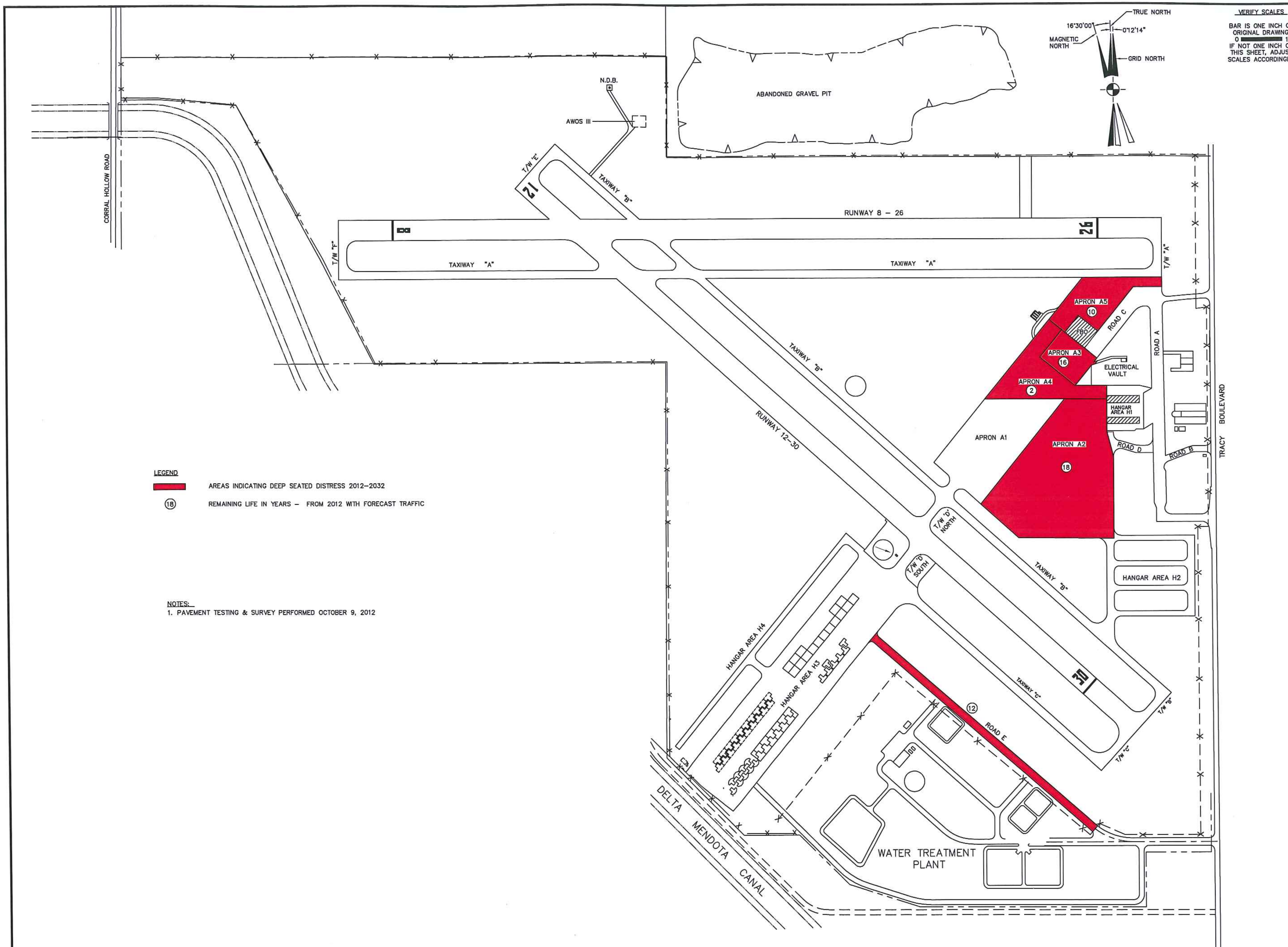
**See Table 3-1 for Rehabilitation Code.

TABLE NO. 3-3

TRACY MUNICIPAL AIRPORT

PAVEMENT REHABILITATION PROCEDURES
SURFACE DISTRESS

Code	Rehabilitation Method	Estimated Unit Costs
C	Remove and Replace AC Surface	$2.80/sq. ft.
D	Crack Repair, Seal Existing Cracks and Joints	$2.50/ln. ft.
E	New Seal Coat - Fog Seal, Reclamite, Slurry Seal, etc.	$1.25/sq. yd.
F	Remark Pavements	$1.00/sq. ft.



Reinard W. Brandley
CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

ENGINEER OF RECORD

REGISTERED PROFESSIONAL ENGINEER R. DAMON BRANDLEY No. C 66558 Exp. 6-30-2014 CIVIL STATE OF CALIFORNIA

NO.	REVISIONS	BY	APR	DATE

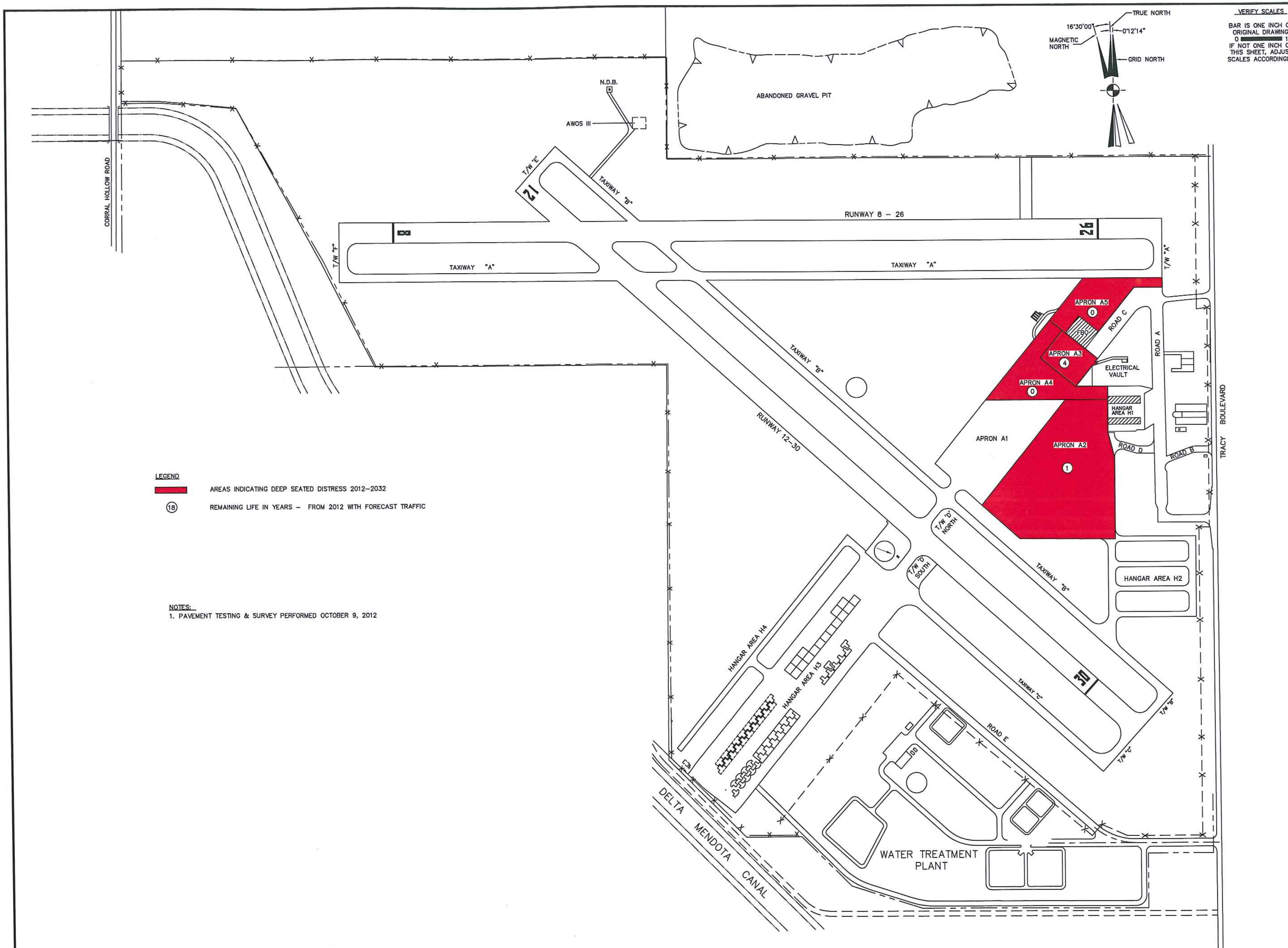
TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION

DEEP SEATED DISTRESS - BRANDLEY FATIGUE ANALYSIS - FORECAST TRAFFIC

DESIGN BY: DB
DRAWN BY: DB
CHK'D BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=200'

SHEET NUMBER
PLATE No. 3-1



VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Reinard W. Brandley
CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

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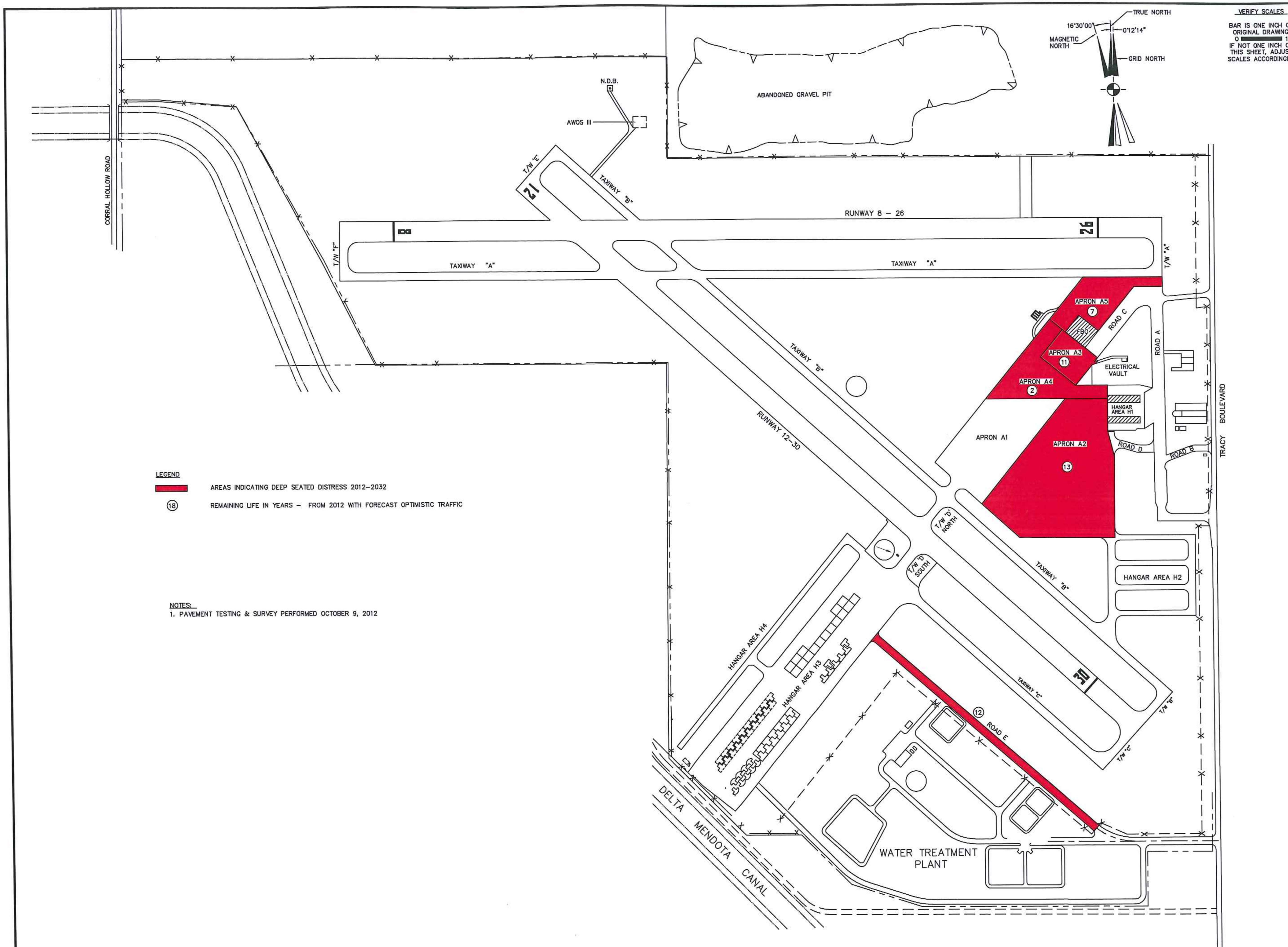
NO.	REVISIONS	BY	APR	DATE

TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION
DEEP SEATED DISTRESS - FAARFIELD ANALYSIS - FORECAST TRAFFIC

DESIGN BY: DB
DRAWN BY: DB
CHK'D BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=200'

SHEET NUMBER
PLATE No. 3-2



LEGEND

(red area) AREAS INDICATING DEEP SEATED DISTRESS 2012–2032

(18) REMAINING LIFE IN YEARS – FROM 2012 WITH FORECAST OPTIMISTIC TRAFFIC

NOTES:

1. PAVEMENT TESTING & SURVEY PERFORMED OCTOBER 9, 2012

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Reinard W. Brandley
CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

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NO.	REVISIONS	BY	APR	DATE

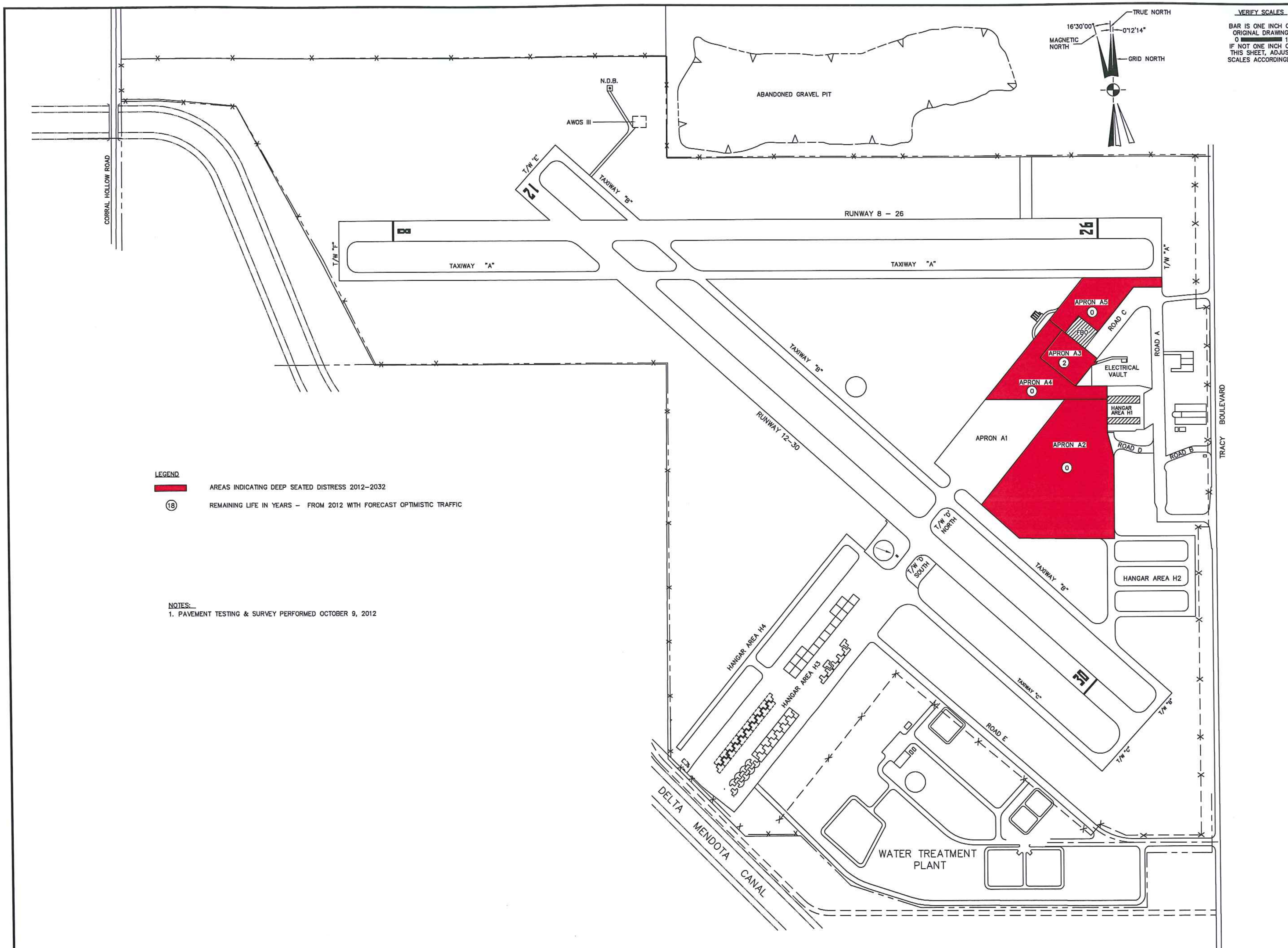
TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION

DEEP SEATED DISTRESS - BRANDLEY FATIGUE ANALYSIS - OPTIMISTIC TRAFFIC

DESIGN BY: DB
DRAWN BY: DB
CHK'D BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=200'

SHEET NUMBER
PLATE No. 3-3



LEGEND

AREAS INDICATING DEEP SEATED DISTRESS 2012–2032

(18) REMAINING LIFE IN YEARS – FROM 2012 WITH FORECAST OPTIMISTIC TRAFFIC

NOTES:

1. PAVEMENT TESTING & SURVEY PERFORMED OCTOBER 9, 2012

VERIFY SCALES

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Reinard W. Brandley
CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

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REGISTERED PROFESSIONAL ENGINEER R. DAMON BRANDLEY No. C 65558 Exp. 6-30-2014 CIVIL STATE OF CALIFORNIA

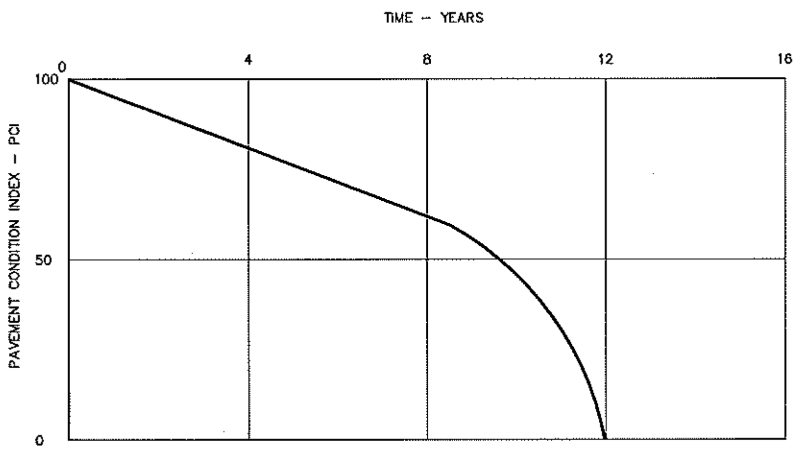
TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION

DEEP SEATED DISTRESS - FAARFIELD ANALYSIS - OPTIMISTIC TRAFFIC

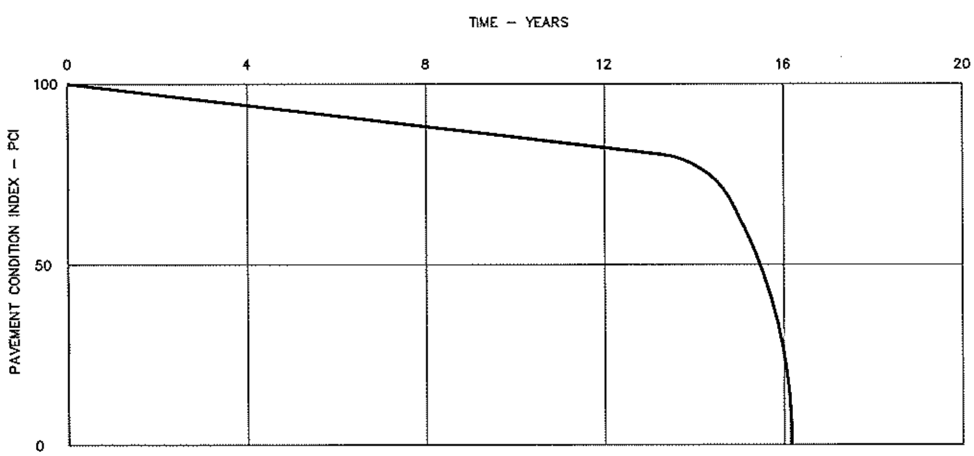
DESIGN BY: DB
DRAWN BY: DB
CHK'D BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=200'

SHEET NUMBER
PLATE No. 3-4



ASPHALT CONCRETE PAVEMENT SECTION

PCI VS. TIME - RELATIONSHIP



PORTLAND CEMENT CONCRETE PAVEMENT SECTION

PCI VS. TIME - RELATIONSHIP

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DRAWN BY: DB
CHKD BY: RWB
DATE: MARCH 11, 2013
CONTRACT NO.: -
PROJECT NO. 61.04-13
DWG FILE: Plate 3-5
DRAWING SCALE: AS SHOWN
PLATE NO. 3–5

TRACY MUNICIPAL AIRPORT

TRACY, CALIFORNIA

PAVEMENT EVALUATION

PCI vs. TIME

NO.	REVISIONS	BY	APP	DATE

ENGINEER OF RECORD

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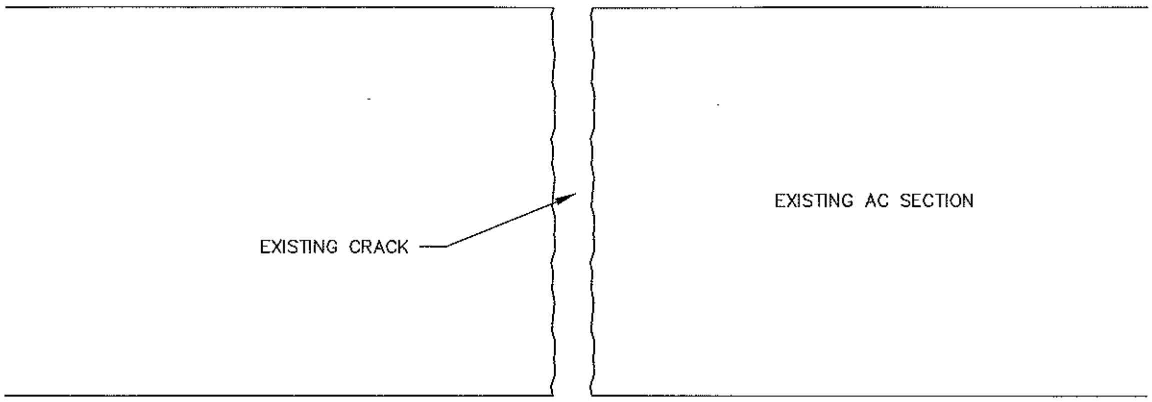
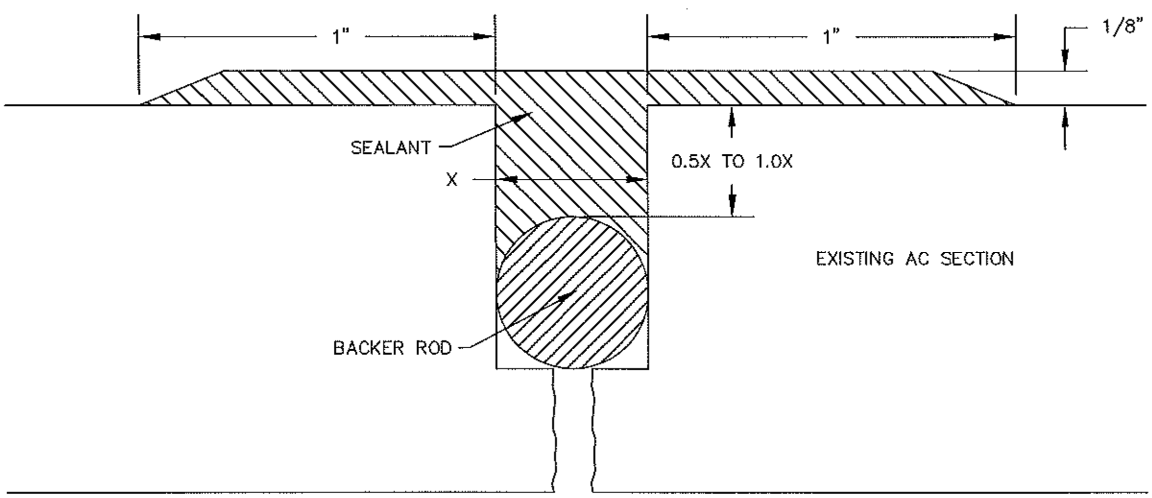
CONSULTING AIRPORT ENGINEER



EXISTING CRACK IN PAVEMENT



TYPICAL SEALED CRACK

DESIGN BY: DB
DRAWN BY: DB
CHKD BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: Plate 3-6
DRAWING SCALE: AS SHOWN
SHEET NUMBER
PLATE NO. 3-6

TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION

TYPICAL CRACK SEAL REHABILITATION

ENGINEER OF RECORD

Reinard W. Brandley
CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

CHAPTER 4. REHABILITATION PLAN AND SCHEDULE

4-1 General

Even with the success of the BRANDLEY Fatigue Analysis methodology in predicting remaining pavement life, pavement performance beyond 20 years cannot be accurately forecast due to unknown factors including weather, traffic, maintenance, and surface defects. Even beyond 10 years the forecast performance is somewhat questionable due to the same variables. It is, therefore, recommended that the rehabilitation plan be developed for a 20-year period but it should be updated periodically based on ongoing surveys and analyses. It is recommended that pavement condition surveys, which visually identify surface defects, be conducted annually by a general visual observation of all pavements and every 5 years using a detailed survey and determination of Pavement Condition Index (PCI). It is also recommended that detailed falling weight deflectometer testing and new fatigue analyses be conducted on a 10-year interval and the remaining life of the pavement based on deep-seated distress be evaluated and the rehabilitation program adjusted as necessary.

Rehabilitation of pavements to correct deep-seated distress problems should be performed 1 to 3 years before the forecast life of the pavement has occurred. If one waits until the pavement section has failed due to deep-seated distress, then the strength of the subgrade and subsoils and the strength and quality of the base and pavement materials will have decreased. It will not be feasible to strengthen the section and extend the life of the section by the placement of overlays or additional thicknesses of the pavement section. Once a failure has occurred, it will be necessary to reconstruct the entire section.

If the surface distress becomes severe, before the forecast remaining life due to deep-seated distress occurs, in many cases it will be more feasible from a cost-benefit analysis, performance, and aesthetic standpoint to rehabilitate or reconstruct the section earlier than forecast due to deep-seated distresses. This is the case for all pavements at the Tracy Municipal Airport.

Rehabilitation of the pavement section to correct surface distress problems can consist of patching, sealing of the cracks, application of a seal coat, or milling and replacing the asphalt surface. The timing for each of these will be based on cost-benefit analysis, rideability, and aesthetic conditions. The rehabilitation type and schedule to correct problems caused by surface distress is determined by engineering judgment, taking into consideration the cost-benefit, operational problems, and visual perception. The schedule for rehabilitation to correct surface distress issues is flexible, but timing of rehabilitation to correct deep-seated distress must be scheduled to occur no later than 1 to 3 years before the forecast time of failure.

If a pavement section is grossly overloaded, there is a risk that the pavement will be overstressed to a point that the landing gear will punch through the pavement. To protect against this happening, a load limit should be established, even for infrequent use. A different load limit is required for single wheel gear and for dual wheel gear aircraft.

4-2 Recommended Rehabilitation Schedule

The Fatigue Analysis to determine the remaining life of the existing pavements and the recommended maintenance and rehabilitation schedules have been based on the likely forecast aircraft operations at the airport. There is a potential that jet operations will increase to a point above the likely forecasts at Tracy Municipal Airport. Fatigue Analysis studies have been included in this report to show the effect on remaining pavement life by increasing all traffic forecasts to an optimistic forecast traffic level. All recommendations for pavement maintenance presented in this report are based on the likely forecast operations without the optimistic growth that the FBO projects.

When each rehabilitation project is being designed it is recommended that the forecast traffic be examined to determine if and when optimistic traffic forecast should be utilized. A cost-benefit analysis should then be conducted to determine the benefits of rehabilitating these sections to allow for the optimistic forecast traffic

Taking into consideration the timing required for rehabilitation of sections that have a forecast remaining life less than 20 years and requirements to correct surface defects caused by surface distress, a rehabilitation schedule has been prepared for each pavement item. The timing of complete rehabilitation of the section on those areas that are not forecast to fail within the 20-year period due to deep-seated distress was based on engineering judgment. Consideration was given to the requirements to maintain a good operational surface, to be cost effective, and to spread out the work in such a manner as to maintain a reasonably uniform annual cost of rehabilitation. The anticipation of receiving Federal grant funding to do major projects was also taken into consideration.

Based on this method of timing of rehabilitation or repair, the recommended rehabilitation schedule has been included in detail in Appendix C, Tables C1 through C31 and has been summarized in Table No. 4-1. Using this information a maintenance and rehabilitation schedule has been prepared showing the recommended projects for each year that maintenance or rehabilitation work is scheduled within the next 20 years and is summarized in Table No. 4-2. These maintenance schedules have also been shown on the Rehabilitation Schedule maps, Plates No. 4-2 through 4-6. With each of these schedules, assumptions have been made as to when Federal funding would be available, and the maintenance schedule has been adjusted to include these major projects during those periods.

The maintenance work recommended to correct surface distress is based on engineering judgment. The timing should be adjusted each year based on availability of funds and the results of the annual surface inspection. The schedule for rehabilitation and reconstruction required to correct deep-seated distresses must be adhered to since the timing established is 1 to 3 years before failure of the section is anticipated. Rehabilitation at earlier dates is acceptable.

All costs shown in this analysis are construction costs only and are based on 2013 prices. Engineering and administrative costs need to be added and adjustments made for inflation for each year.

In order to minimize the risk of overstressing the existing pavements at Tracy Municipal Airport to a point where an aircraft gear could punch through the pavement, it is recommended that the following load limits be established for the pavements, even for infrequent use:

Element	Gear Type	Existing Total Section Thickness (inch)	Existing Aircraft Load Limit x 1,000 lb.	Proposed Total Section Thickness (inch)	Proposed Aircraft Load Limit x 1,000 lb.
Runway 12-30 and Associated Taxiways	Single	16	35	23	50
	Dual	16	50	23	80
Runway 8-26 and Associated Taxiways	Single	16	35	23	50
	Dual	16	50	23	80
Aprons A1, A2, and A3	Single	12	12	14	20
	Dual	12	20	14	32
Aprons A4 and A5	Single	6	3	14	20
	Dual	6	--	14	32
North Hangar Development	Single	6	3	14	20
	Dual	6	--	14	32
South Hangar Development	Single	10	5	14	20
	Dual	10	--	14	32

It is recommended that all future rehabilitation projects be designed such that the maximum design load-carrying capacity of all elements matches the anticipated use. Runways 12-30 and 8-26 and associated taxiways, the aprons and any taxilanes anticipated to serve the jet aircraft should be designed to support operation of the higher load limits. The hangar taxilanes that only serve the light general aviation aircraft can be designed to support only these lighter weight aircraft.

A cost-benefit analysis has shown that it is more cost effective to pulverize the existing section and place 4 inches of new aggregate base (AB) and 3 inches of new bituminous surface course (AC) than to reconstruct the total section. The additional base course is required since the pulverization of the existing AC and AB causes a decrease in CBR of the pulverized material to 40 to 50, which is inadequate. It is, therefore, recommended that all rehabilitation sections, except where grade control such as building proximity is concerned, be performed by pulverizing the existing AC and AB to a depth of 6 inches, recompacting it to aggregate subbase course, and placing 4 inches of aggregate base and 3 inches of bituminous surface course. This type of design is not only cost effective, but it increases the life of the pavement section by more than 40 years, even with the enhanced traffic indexes.

As an aid in preparing this report Table No. 4-3 entitled, "Summary of Existing Conditions and Rehabilitation Requirements" was prepared. This table should be useful to Operations and Maintenance staff.

Disclaimer

The recommendations presented in this report are based on the results of tests conducted. Soil borings were spaced to represent typical subsurface conditions and falling weight deflectometer (FWD) tests were spaced at approximately 200 feet. While it is unlikely, it is possible that significantly different conditions exist between the location of the test holes and FWD test locations that could lead to pavement distress occurring later or earlier than forecast.

Delays in maintenance, changes in traffic, and changes in environmental conditions from those assumed in this study can also have a significant effect on the recommended schedule for maintenance and rehabilitation. It is recommended that visual inspections be conducted annually, detailed pavement condition surveys be conducted every five years, and FWD tests and Fatigue Analysis studies be conducted every 10 years. As a result of these inspections, tests and evaluations, the maintenance and rehabilitation schedule should be adjusted as necessary.

Reinard W. Brandley

TABLE NO. 4-1
TRACY MUNICIPAL AIRPORT
REHABILITATION PLAN

Required for Deep Seated Distress
Estimated - Surface Distress

Year	Element	Station	2012 PCI	Recommended Rehabilitation Code	Recommended Rehabilitation Description	Estimated Construction Cost
				RUNWAY 12-30 COMPLEX		
2013	Runway 12-30	All		B	Rehabilitate Existing Section	$ 2,670,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 400,000
2028		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 439,000
2013	Taxiways B, E, D (North)	All		B	Rehabilitate Existing Section	$ 1,060,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 130,000
2028		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 143,000
				RUNWAY 8-26 COMPLEX		
2015	Runway 8-26	All		B	Rehabilitate Existing Section	$ 2,065,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 330,000
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 370,000
2015	Taxiways A and F	All		B	Rehabilitate Existing Section	$ 920,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 90,000
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 93,000

Notes:
1. For Rehabilitation Code See Tables 3-1 and 3-3
2. See Plate 4-1 for Stationing Controls
3. See Plates 4-2 through 4-6 for Rehabilitation Schedule Maps

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TABLE NO. 4-1 (continued)
TRACY MUNICIPAL AIRPORT
REHABILITATION PLAN

Required for Deep Seated Distress
Estimated - Surface Distress

				NORTH APRON COMPLEX		
2014	Aprons A1, A2, A3 & A5	All		A	Remove and Reconstruct Existing Section	$ 3,440,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 261,000
2030		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 313,000
2014	Apron A4	All		A	Remove and Reconstruct Existing Section	$ 515,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 39,000
2030		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 47,000
2014	Hangar Area H1	All		A	Remove and Reconstruct Existing Section	$ 90,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 18,000
2031		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 19,000
2015	Hangar Area H2	All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 48,000
2022		All		D	Crack Repair, Seal Cracks	$ 25,000
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 44,000
				SOUTH APRON COMPLEX		
2016	Hangar Area H3 & T/W D (South)	All		A	Remove and Reconstruct Existing Section	$ 1,135,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 140,000
2031		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 164,000
2016	Taxiway C	All		B	Rehabilitate Existing Section	$ 225,000
2023		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 40,000
2031		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 45,000
2015	Hangar Area H4	All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 28,000
2022		All		D	Crack Repair, Seal Cracks	$ 15,000
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$ 26,000

Notes:
1. For Rehabilitation Code See Tables 3-1 and 3-3
2. See Plate 4-1 for Stationing Controls
3. See Plates 4-2 through 4-6 for Rehabilitation Schedule Maps

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TABLE NO. 4-1 (continued)
TRACY MUNICIPAL AIRPORT
REHABILITATION PLAN

Required for Deep Seated Distress

Estimated - Surface Distress

Airport Access Roads							
2015	Road A	All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	44,000
2022		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	52,800
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	61,600
2015	Road B	All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	4,000
2022		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	4,800
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	5,600
2015	Road C	All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	20,000
2022		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	24,000
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	28,000
2015	Road D	All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	5,000
2022		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	6,000
2029		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	7,000
2015	Road E	All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	27,000
2021		All		B	Rehabilitate Existing Section	$	253,000
2031		All		D, E	Crack Repair, Seal Cracks, Seal Coat	$	32,400

Notes:
1. For Rehabilitation Code See Tables 3-1 and 3-3
2. See Plate 4-1 for Stationing Controls
3. See Plates 4-2 through 4-6 for Rehabilitation Schedule Maps

TABLE NO. 4-2
TRACY MUNICIPAL AIRPORT
MAINTENANCE AND REHABILITATION SCHEDULE

Required for Deep Seated Distress
Estimated - Surface Distress

Year	Element	Station	2012 PCI	Recommended Rehabilitation Code	Recommended Rehabilitation Description	Estimated Construction Cost
2013	Runway 12-30	All	40	B	Rehabilitate Existing Section	$ 2,670,000
	Taxiways B, E, D (North)	All	35-40	B	Rehabilitate Existing Section	$ 1,060,000
					2013 Total Cost	$ 3,730,000
2014	Aprons A1, A2, A3 & A5	All	35-39	A	Remove and Reconstruct Existing Section	$ 3,440,000
	Apron A4	All	39	A	Remove and Reconstruct Existing Section	$ 515,000
	Hangar Area H1	All	24-44	A	Remove and Reconstruct Existing Section	$ 90,000
					2014 Total Cost	$ 4,045,000
2015	Runway 8-26	All	30	B	Rehabilitate Existing Section	$ 2,065,000
	Taxiways A and F	All	35-40	B	Rehabilitate Existing Section	$ 920,000
	Hangar Area H2	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 48,000
	Hangar Area H4	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 28,000
	Road A	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 44,000
	Road B	All	45	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 4,000
	Road C	All	45	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 20,000
	Road D	All	35	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 5,000
	Road E	All	37	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 27,000
					2015 Total Cost	$ 3,161,000
2016	Hangar Area H3 & Taxiway D (South)	All	32-39	A	Remove and Reconstruct Existing Section	$ 1,135,000
	Taxiway C	All	40	B	Rehabilitate Existing Section	$ 225,000
					2016 Total Cost	$ 1,360,000
2017	No Scheduled Projects					$ -
					2017 Total Cost	$ -
2018	No Scheduled Projects					$ -
					2018 Total Cost	$ -
2019	No Scheduled Projects					$ -
					2019 Total Cost	$ -
2020	No Scheduled Projects					$ -
					2020 Total Cost	$ -
2021	Road E	All	37	B	Rehabilitate Existing Section	$ 253,000
					2021 Total Cost	$ 253,000
2022	Hangar Area H2	All	40	D	Crack Repair, Seal Cracks	$ 25,000
	Hangar Area H4	All	40	D	Crack Repair, Seal Cracks	$ 15,000
	Road A	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 52,800
	Road B	All	45	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 4,800
	Road C	All	45	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 24,000
	Road D	All	35	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 6,000
					2022 Total Cost	$ 127,600

Notes:
1. See Plate 4-1 for Stationing Controls
2. See Plates 4-2 through 4-6 for Rehabilitation Schedule Maps

TABLE NO. 4-2 (continued)
TRACY MUNICIPAL AIRPORT
MAINTENANCE AND REHABILITATION SCHEDULE

Required for Deep Seated Distress

Estimated - Surface Distress

2023	Runway 12-30	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 400,000
	Taxiways B, E, D (North)	All	35-40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 130,000
	Runway 8-26	All	30	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 330,000
	Taxiways A and F	All	35-40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 90,000
	Aprons A1, A2, A3, A4, & A5	All	35-39	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 300,000
	Hangar Area H1	All	24-44	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 18,000
	Hangar Area H3 & Taxiway D (South)	All	32-39	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 140,000
	Taxiway C	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 40,000
					2023 Total Cost	**$ 1,448,000**
2024	No Scheduled Projects					$ -
					2024 Total Cost	**$ -**
2025	No Scheduled Projects					$ -
					2025 Total Cost	**$ -**
2026	No Scheduled Projects					$ -
					2026 Total Cost	**$ -**
2027	No Scheduled Projects					$ -
					2027 Total Cost	**$ -**
2028	Runway 12-30	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 439,000
	Taxiways B, E, D (North)	All	35-40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 143,000
					2028 Total Cost	**$ 582,000**
2029	Runway 8-26	All	30	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 370,000
	Taxiways A and F	All	35-40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 93,000
	Hangar Area H2	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 44,000
	Hangar Area H4	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 26,000
	Road A	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 61,600
	Road B	All	45	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 5,600
	Road C	All	45	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 28,000
	Road D	All	35	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 7,000
					2029 Total Cost	**$ 635,200**
2030	Aprons A1, A2, A3, A4, & A5	All	35-39	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 360,000
					2030 Total Cost	**$ 360,000**
2031	Hangar Area H1	All	24-44	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 19,000
	Hangar Area H3 & Taxiway D (South)	All	32-39	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 164,000
	Taxiway C	All	40	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 45,000
	Road E	All	37	D, E	Crack Repair, Seal Cracks, Seal Coat	$ 32,400
					2031 Total Cost	**$ 260,400**
2032	No Scheduled Projects					$ -
					2032 Total Cost	**$ -**

Notes:
1. See Plate 4-1 for Stationing Controls
2. See Plates 4-2 through 4-6 for Rehabilitation Schedule Maps

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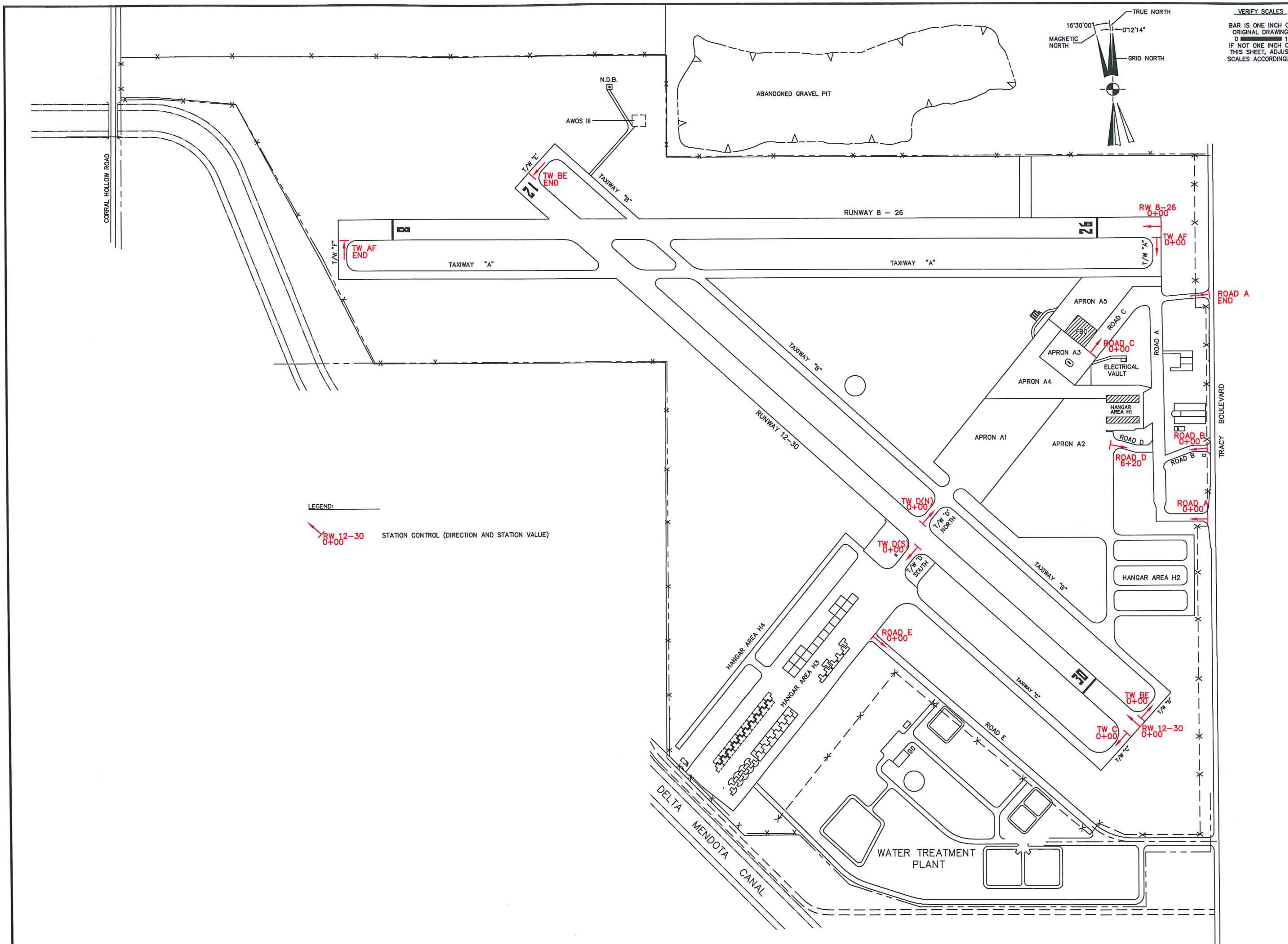
Table No. 4-3
Summary of Existing Conditions and Rehabilitation Requirements
Tracy Municipal Airport

Element	Station	Construction Dates			FWD Data			Surface Data		Existing Pavement Section - inches						Existing Modulus of Elasticity (E) - ksi					Traffic Index	Remaining Pavement Life - Years from 2012: Fatigue Analysis		Remaining Pavement Life - Years from 2012: FAARFIELD Analysis	
		Original	Reconstruct	Overlay	Load (kips)	Deflection Range (mils)	Deflection Used (mils)	Pavement Rating	PCI	PCC	AC	AB	ASB	Subgrade	Subsoil	AC	AB	ASB	Subgrade	Subsoil		Subgrade Distress Std. Traffic	Subgrade Distress Optimistic	Subgrade Distress Std. Traffic	Subgrade Distress Optimistic
Runway 12-30	0+00 to 14+50			1980	17	13-37	35	Fair	40		6	12		48	S.I.	150	40		10	25	A	182	145	1,998	1,556
Runway 12-30	14+50 to 33+00			1980	17	17-34	35	Fair	40		6	12		48	S.I.	150	40		10	25	A	182 - 270	145 - 226	1,998	1,556
Runway 12-30	33+00 to 40+00			1980	17	14-36	35	Fair	40		6	12		48	S.I.	150	40		10	25	B	228 - 225	178 - 176	2,211	1,722
Taxiway BE	0+00 to 16+00			1980	17	15-35	36	Fair	40		3.5	11		48	S.I.	350	50		11	25	C	105	80	971	754
Taxiway BE	16+00 to 32+00			1980	17	17-40	36	Fair	40		3.5	11		48	S.I.	350	50		11	25	D	106	82	1,030	800
Taxiway BE	32+00 to 40+00			1980	17	28-37	36	Fair	40		3.5	11		48	S.I.	350	50		11	25	E	132	101	1,189	928
Taxiway BE	40+00 to 43+00			1980	17	40-45	45	Poor	35		3.5	11		48	S.I.	150	40		12	25	E	116	89	438	340
Runway 8-26	0+00 to 40+00			1977	17	21-51	48	Poor	30		6	11		18	S.I.	150	30		5	15	F	338 - 615	269 - 518	141 - 9670	115 - 8072
Taxiway AF	0+00 to 5+00			1977	17	34-44	38	Fair	40		6	10		18	S.I.	150	40		12	15	G	408	327	5,700	4,395
Taxiway AF	5+00 to 24+00			1977	17	22-48	38	Poor	35		6	10		18	S.I.	150	40		12	15	H	342	270	4,598	3,583
Taxiway AF	24+00 to 35+00			1977	17	30-35	38	Poor	35		6	10		18	S.I.	150	40		12	15	I	204	163	3,079	2,385
Taxiway AF	35+00 to 43+00			1977	17	38-49	47	Poor	35		6	7.5		18	S.I.	150	20		9	20	I	114	88	99	75
Taxiway D (North)	0+00 to 1+50			1977	17	30-37	32	Fair	40		5.5	12.5		48	S.I.	250	40		11	25	J	413	381	Infinite	Infinite
Taxiway D (South)	0+00 to 1+50				17	52+56	54	Poor	39		3	7		48	S.I.	250	35		10	25	J	208	191	Infinite	Infinite
Taxiway C	0+00 to 14+00	1989			17	28-53	53	Fair	40		2	8		48	S.I.	250	45		11	25	J	232 - 406	214 - 375	Infinite	Infinite
Apron A1	83/85 Overlay			1983/1985	17	25-30	30	Poor	35		5.5	6		48	S.I.	250	50		13	25	K	77 - 163	58 - 126	361 - 15600	279 - 12185
Apron A2	83/85 Reconstruct		1983/1985		17	40-78	78	Poor	35		2	5	4.5	48	S.I.	250	35	20	6	25	K	18 - 130	13 - 99	1 - 2600	0 - 2025
Apron A3	1999 Reconstruct		1999		17	30-69	69	Poor	38		3	5	5	48	S.I.	150	40	15	7	25	K	16	11	4	2
Apron A4	Old North Apron (South Portion)				17	45-85	80	Poor	39		2	4		48	S.I.	250	60		7	25	K	2	2	0	0
Apron A5	Old North Apron (North Portion)				17	45-80	80	Poor	39		2	4		48	S.I.	250	60		7	25	L	10	7	0	0
Hangar Area H1	North Hangars Row H1	1975			10	22-27	27	Poor	39		2	4		48	S.I.	250	50		20	25	N	321	289	Infinite	Infinite
Hangar Area H1	North Hangars Row H2	1975			10	73-90	80	Fair	44		2	4		48	S.I.	150	20		5	25	N	27	24	93	82
Hangar Area H1	North Hangars Row H3	1975			10	32-45	40	Very Poor	24		2	4		48	S.I.	250	50		10	25	N	132	117	Infinite	Infinite
Hangar Area H2	North Hangars Future Rows H4 to H8	1985			17	26-80	78	Fair	40		2	5	4.5	48	S.I.	250	35	20	6	25	J	138 - 413	127 - 381	Infinite	Infinite
Hangar Area H3	Taxilanes for Existing South Hangars				17	35-65	61	Poor	32		3	7		48	S.I.	250	25		10	25	M	76 - 177	69 - 163	Infinite	Infinite
Hangar Area H4	Taxilane for Future South Development				17	34-46	42	Fair	40		2	5	5	48	S.I.	250	60	35	15	25	M	194 - 196	178 - 179	Infinite	Infinite
Road A - Airport Access Road	0+00 to 14+00				17	33-95	95	Fair	40		-	-		-	S.I.	-	-		-	-	-	-	-	-	-
Road B - Airport Secondary Access Road	0+00 to 1+20	1985			17	30-38	38	Fair	45		2	5	5	48	S.I.	250	80	55	13	25	O	39	34	6,256	5,708
Road C - FBO Parking Lot	0+00 to 3+70				17	26-61	38	Fair	45		-	-		-	S.I.	-	-		-	-	-	-	-	-	-
Road D - North Apron Access Road	6+20 to 7+20	1985			17	18-28	28	Poor	35		2	5	5	48	S.I.	250	90	60	23	25	O	65	57	83,000	75,000
Road E - South Hangar Access Road	0+00 to 14+00	1989			17	26-85	58	Poor	37		2.5	6		48	S.I.	250	30		13	25	O	3 - 12	2 - 12	4 - 59	3 - 52

Recommended Rehabilitation and Maintenance: 2013-2017	2018-2022	2023-2027	2028-2032	Element
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Runway 12-30
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Runway 12-30
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Runway 12-30
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway BE
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway BE
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway BE
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway BE
2015 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2029 - Crack Repair, Seal Cracks, & Seal Coat	Runway 8-26
2015 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2029 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway AF
2015 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2029 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway AF
2015 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2029 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway AF
2015 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2029 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway AF
2013 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2028 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway D (North)
2016 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2031 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway D (South)
2016 - Rehabilitate Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2031 - Crack Repair, Seal Cracks, & Seal Coat	Taxiway C
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2030 - Crack Repair, Seal Cracks, & Seal Coat	Apron A1
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2030 - Crack Repair, Seal Cracks, & Seal Coat	Apron A2
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2030 - Crack Repair, Seal Cracks, & Seal Coat	Apron A3
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2030 - Crack Repair, Seal Cracks, & Seal Coat	Apron A4
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2030 - Crack Repair, Seal Cracks, & Seal Coat	Apron A5
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2031 - Crack Repair, Seal Cracks, & Seal Coat	Hangar Area H1
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2031 - Crack Repair, Seal Cracks, & Seal Coat	Hangar Area H1
2014 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2031 - Crack Repair, Seal Cracks, & Seal Coat	Hangar Area H1
2015 - Crack Repair, Seal Cracks, & Seal Coat	2022 - Crack Repair, Seal Cracks, & Seal Coat		2029 - Crack Repair, Seal Cracks, & Seal Coat	Hangar Area H2
2016 - Remove and Reconstruct Existing Section		2023 - Crack Repair, Seal Cracks, & Seal Coat	2031 - Crack Repair, Seal Cracks, & Seal Coat	Hangar Area H3
2015 - Crack Repair, Seal Cracks, & Seal Coat	2022 - Crack Repair, Seal Cracks, & Seal Coat		2029 - Crack Repair, Seal Cracks, & Seal Coat	Hangar Area H4
2015 - Crack Repair, Seal Cracks, & Seal Coat	2022 - Crack Repair, Seal Cracks, & Seal Coat		2029 - Crack Repair, Seal Cracks, & Seal Coat	Road A - Airport Access Road
2015 - Crack Repair, Seal Cracks, & Seal Coat	2022 - Crack Repair, Seal Cracks, & Seal Coat		2029 - Crack Repair, Seal Cracks, & Seal Coat	Road B - Airport Secondary Access Road
2015 - Crack Repair, Seal Cracks, & Seal Coat	2022 - Crack Repair, Seal Cracks, & Seal Coat		2029 - Crack Repair, Seal Cracks, & Seal Coat	Road C - FBO Parking Lot
2015 - Crack Repair, Seal Cracks, & Seal Coat	2022 - Crack Repair, Seal Cracks, & Seal Coat		2029 - Crack Repair, Seal Cracks, & Seal Coat	Road D - North Apron Access Road
2015 - Crack Repair, Seal Cracks, & Seal Coat	2021 - Rehabilitate Existing Section		2031 - Crack Repair, Seal Cracks, & Seal Coat	Road E - South Hangar Access Road



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CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

ENGINEER OF RECORD

NO.	REVISIONS	BY	APR	DATE

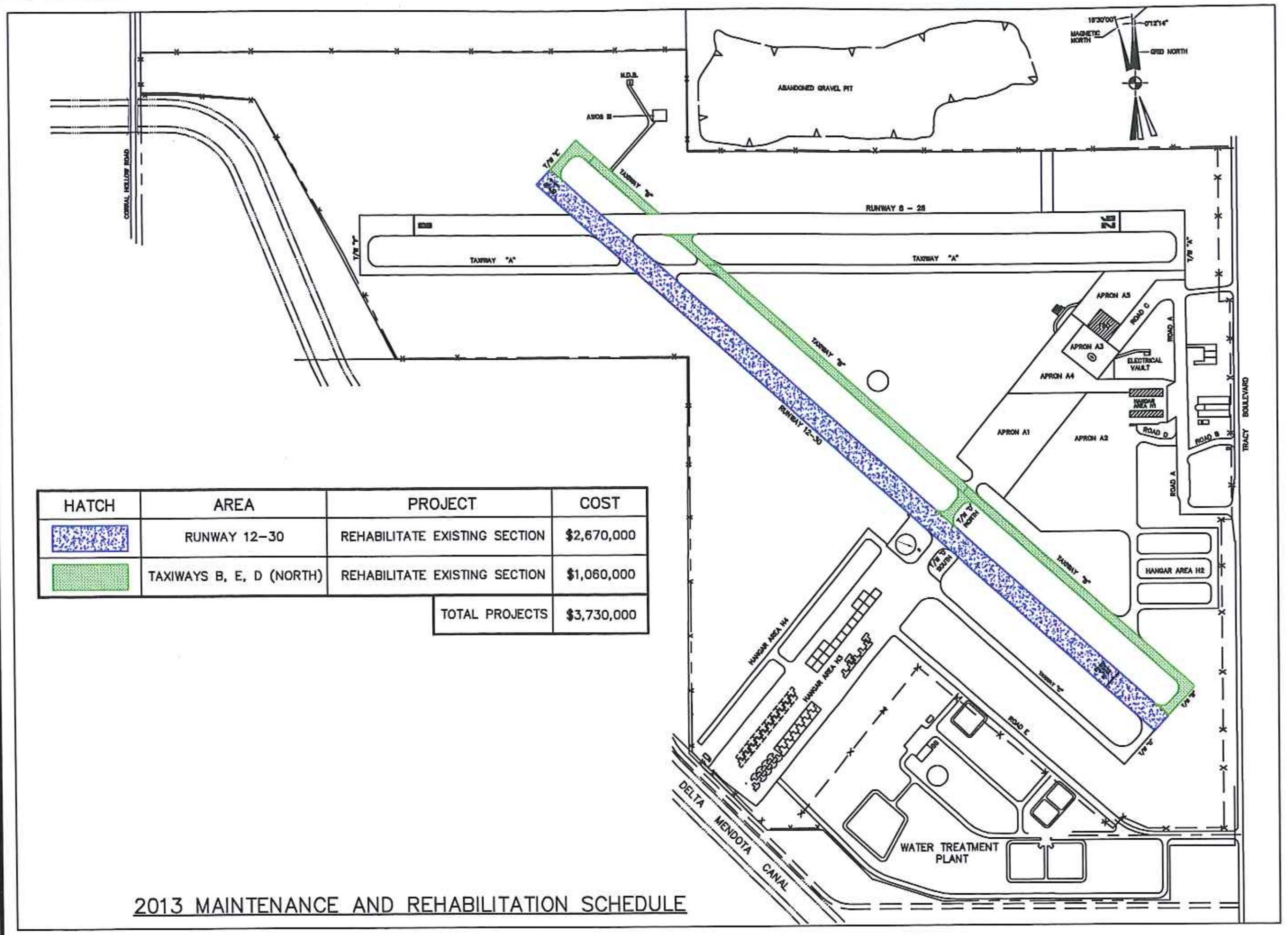
TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION

STATIONING CONTROL LAYOUT PLAN

DESIGN BY: DB
DRAWN BY: DB
CHK'D BY: RWB
DATE: MARCH 11, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=200'

SHEET NUMBER
PLATE No. 4–1



HATCH	AREA	PROJECT	COST
	RUNWAY 12–30	REHABILITATE EXISTING SECTION	$2,670,000
	TAXIWAYS B, E, D (NORTH)	REHABILITATE EXISTING SECTION	$1,060,000
		TOTAL PROJECTS	$3,730,000

2013 MAINTENANCE AND REHABILITATION SCHEDULE

VERIFY SCALES
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0 1"
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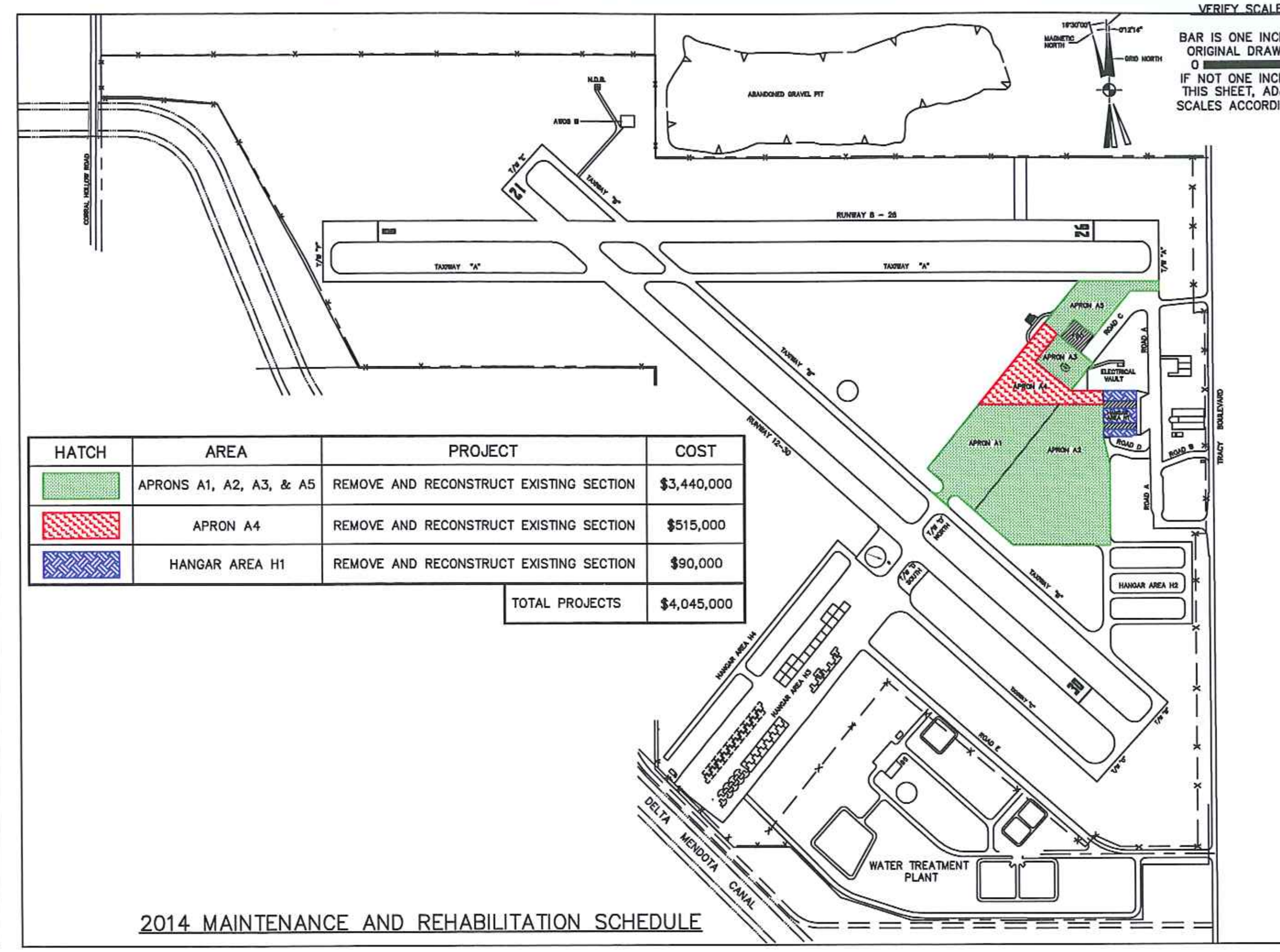
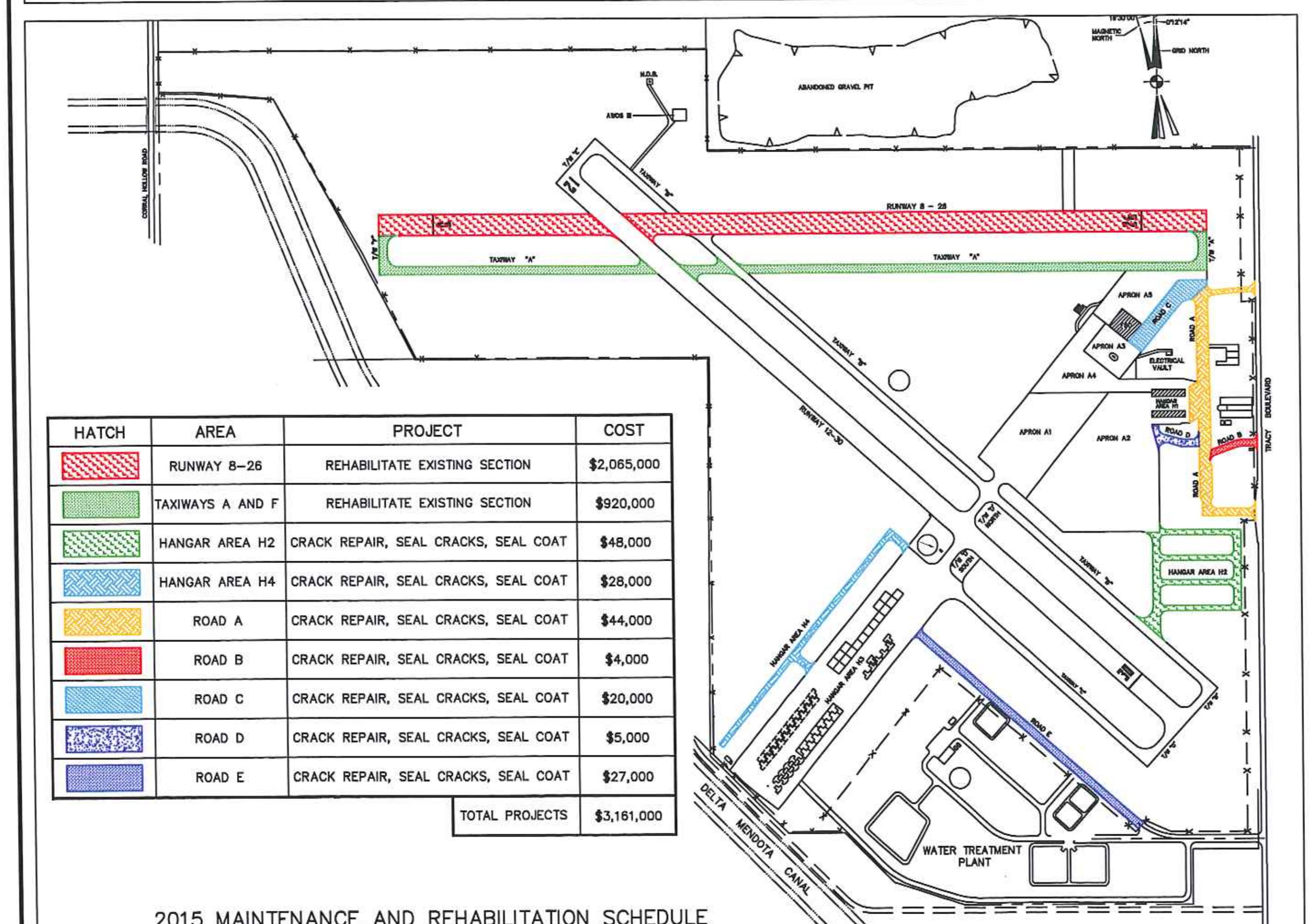


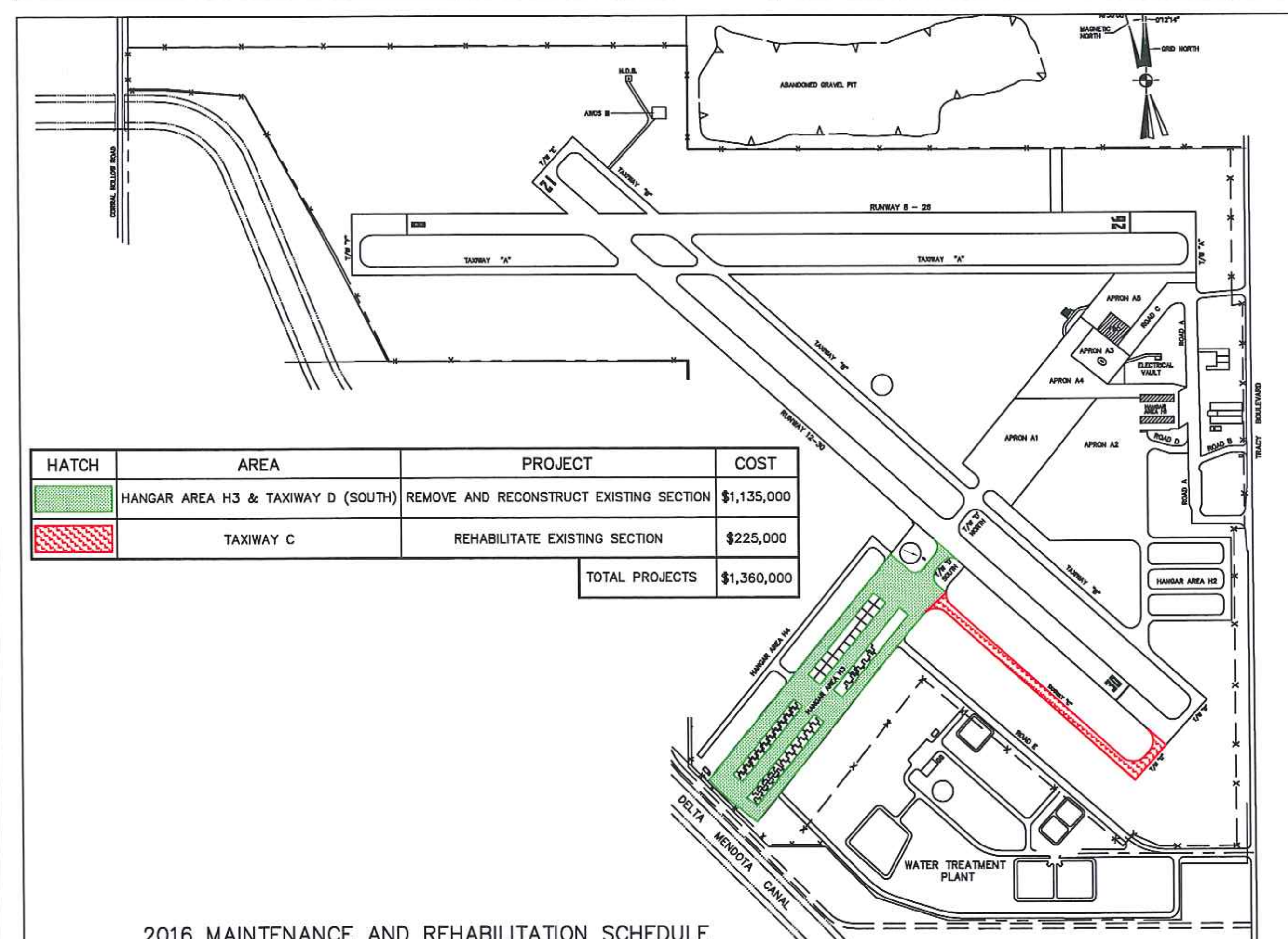
HATCH	AREA	PROJECT	COST
	APRONS A1, A2, A3, & A5	REMOVE AND RECONSTRUCT EXISTING SECTION	$3,440,000
	APRON A4	REMOVE AND RECONSTRUCT EXISTING SECTION	$515,000
	HANGAR AREA H1	REMOVE AND RECONSTRUCT EXISTING SECTION	$90,000
		TOTAL PROJECTS	$4,045,000

2014 MAINTENANCE AND REHABILITATION SCHEDULE



HATCH	AREA	PROJECT	COST
	RUNWAY 8–26	REHABILITATE EXISTING SECTION	$2,065,000
	TAXIWAYS A AND F	REHABILITATE EXISTING SECTION	$920,000
	HANGAR AREA H2	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$48,000
	HANGAR AREA H4	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$28,000
	ROAD A	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$44,000
	ROAD B	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$4,000
	ROAD C	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$20,000
	ROAD D	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$5,000
	ROAD E	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$27,000
		TOTAL PROJECTS	$3,161,000

2015 MAINTENANCE AND REHABILITATION SCHEDULE



HATCH	AREA	PROJECT	COST
	HANGAR AREA H3 & TAXIWAY D (SOUTH)	REMOVE AND RECONSTRUCT EXISTING SECTION	$1,135,000
	TAXIWAY C	REHABILITATE EXISTING SECTION	$225,000
		TOTAL PROJECTS	$1,360,000

2016 MAINTENANCE AND REHABILITATION SCHEDULE

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CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8804 • (916) 652-4725

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TRACY MUNICIPAL AIRPORT

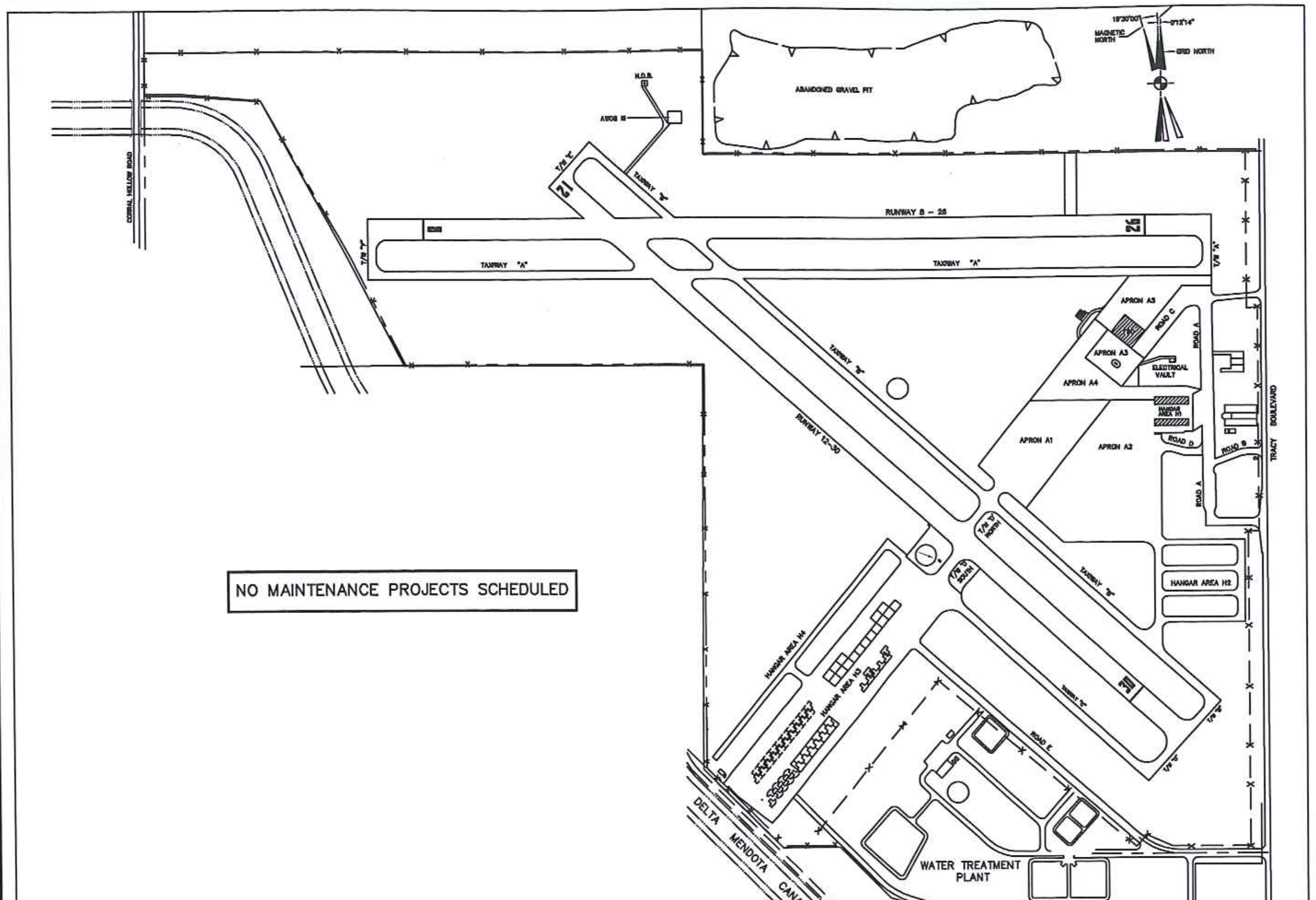
TRACY, CALIFORNIA

PAVEMENT EVALUATION

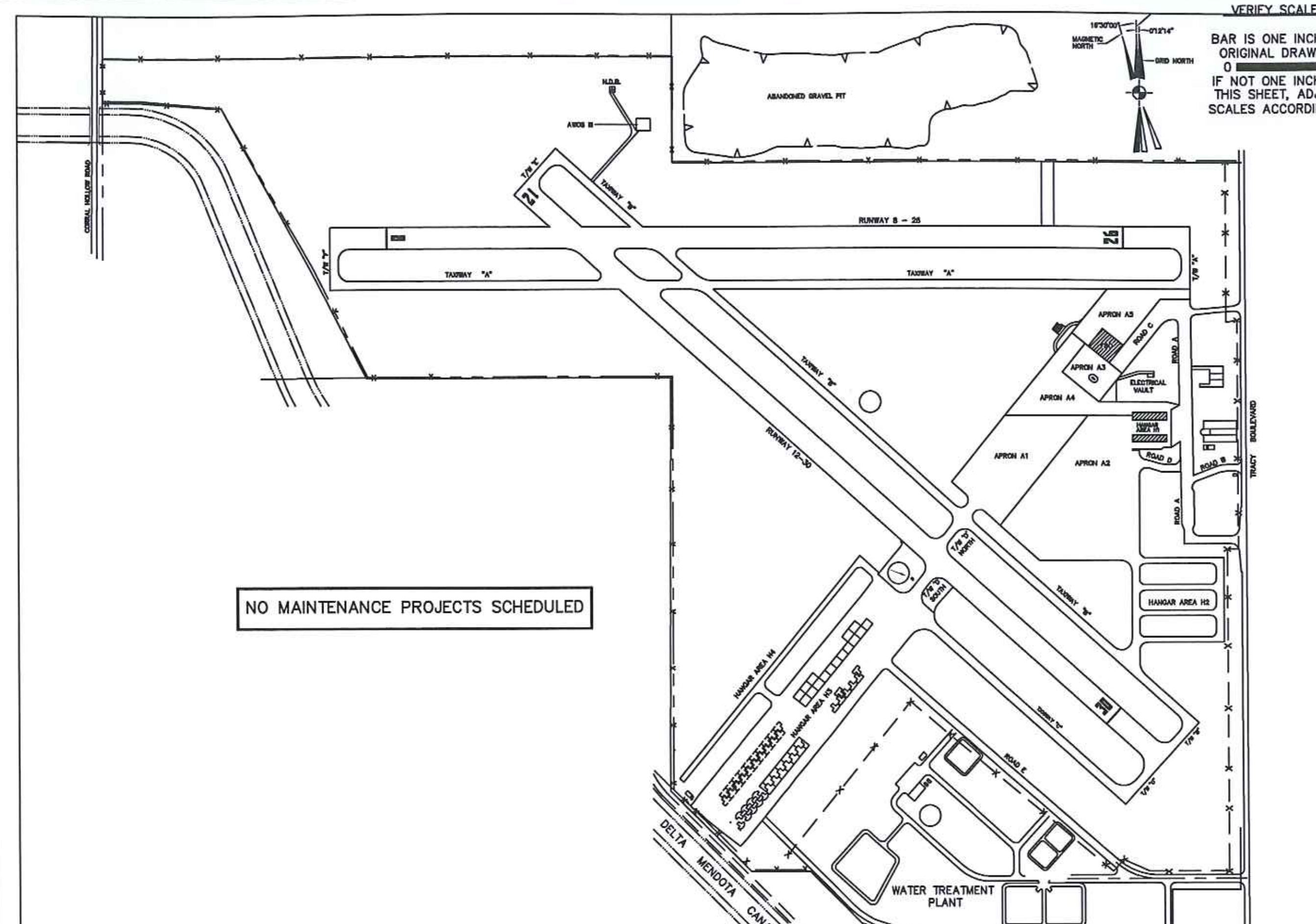
REHABILITATION SCHEDULR 2013-2016

DESIGN BY: DB
DRAWN BY: DMB
CHK'D BY: RWB
DATE: MARCH 18, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=400'

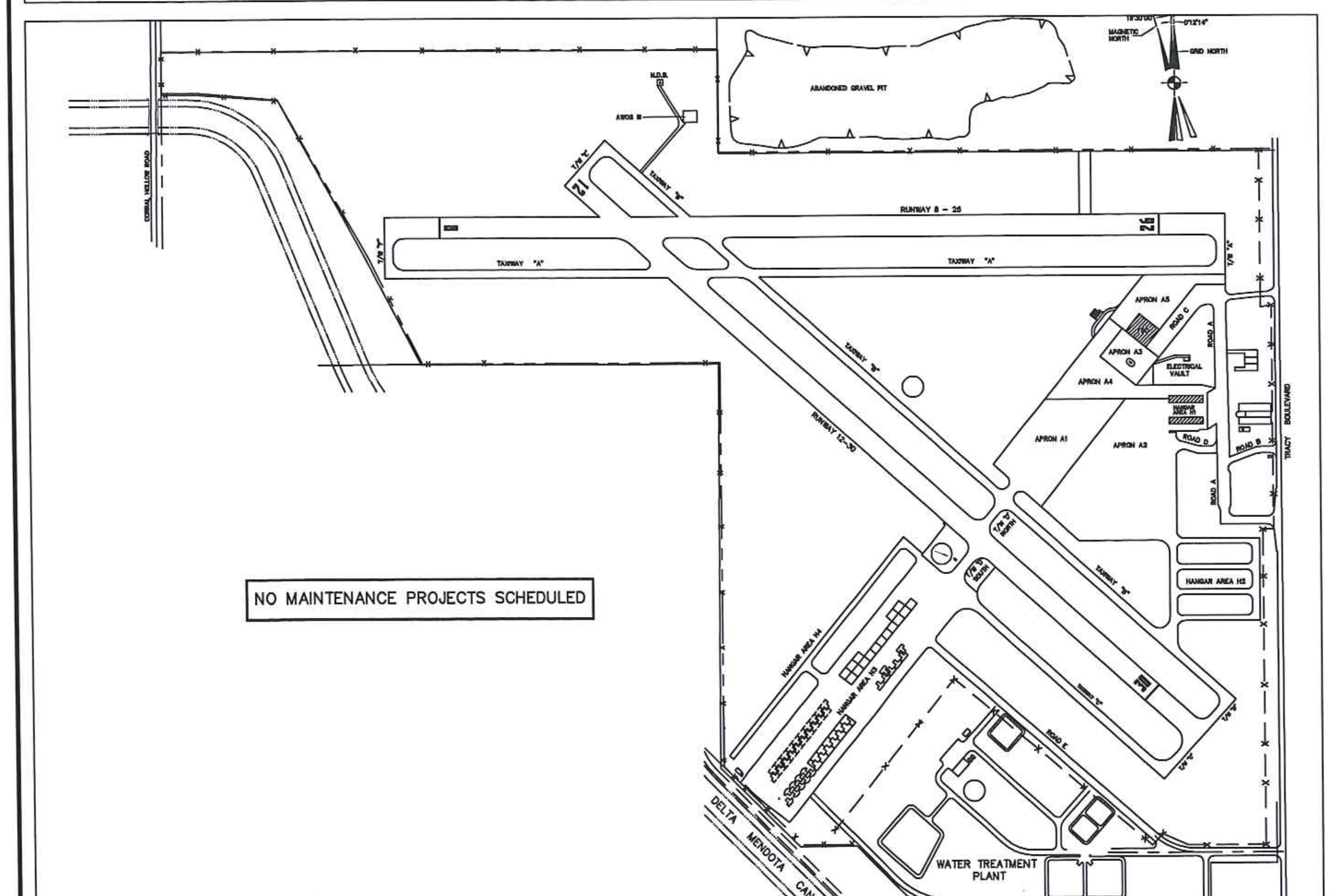
SHEET NUMBER
PLATE No. 4–2



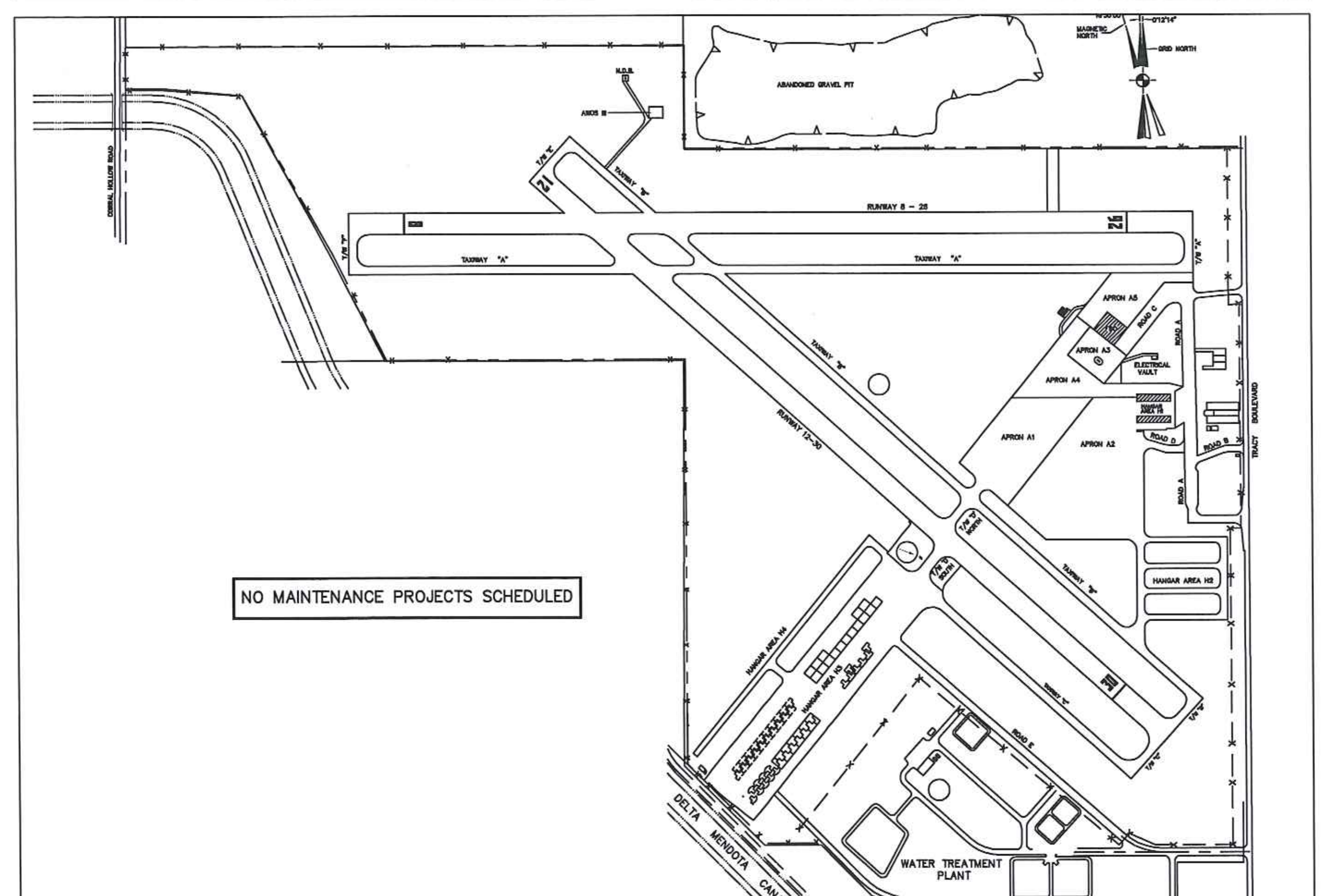
2017 MAINTENANCE AND REHABILITATION SCHEDULE



2018 MAINTENANCE AND REHABILITATION SCHEDULE



2019 MAINTENANCE AND REHABILITATION SCHEDULE



2020 MAINTENANCE AND REHABILITATION SCHEDULE

VERIFY SCALES
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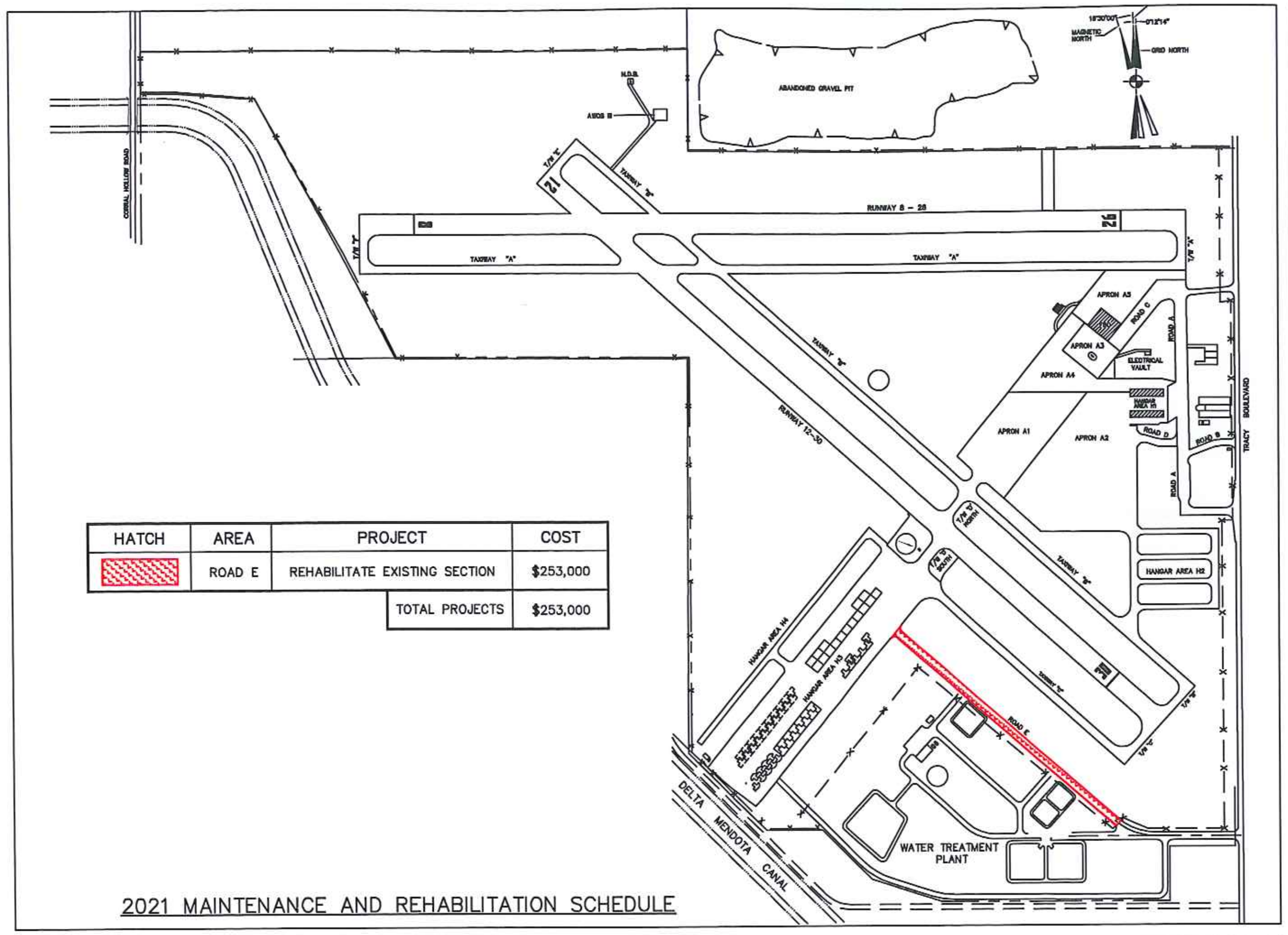
TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION
REHABILITATION SCHEDULR 2017-2020

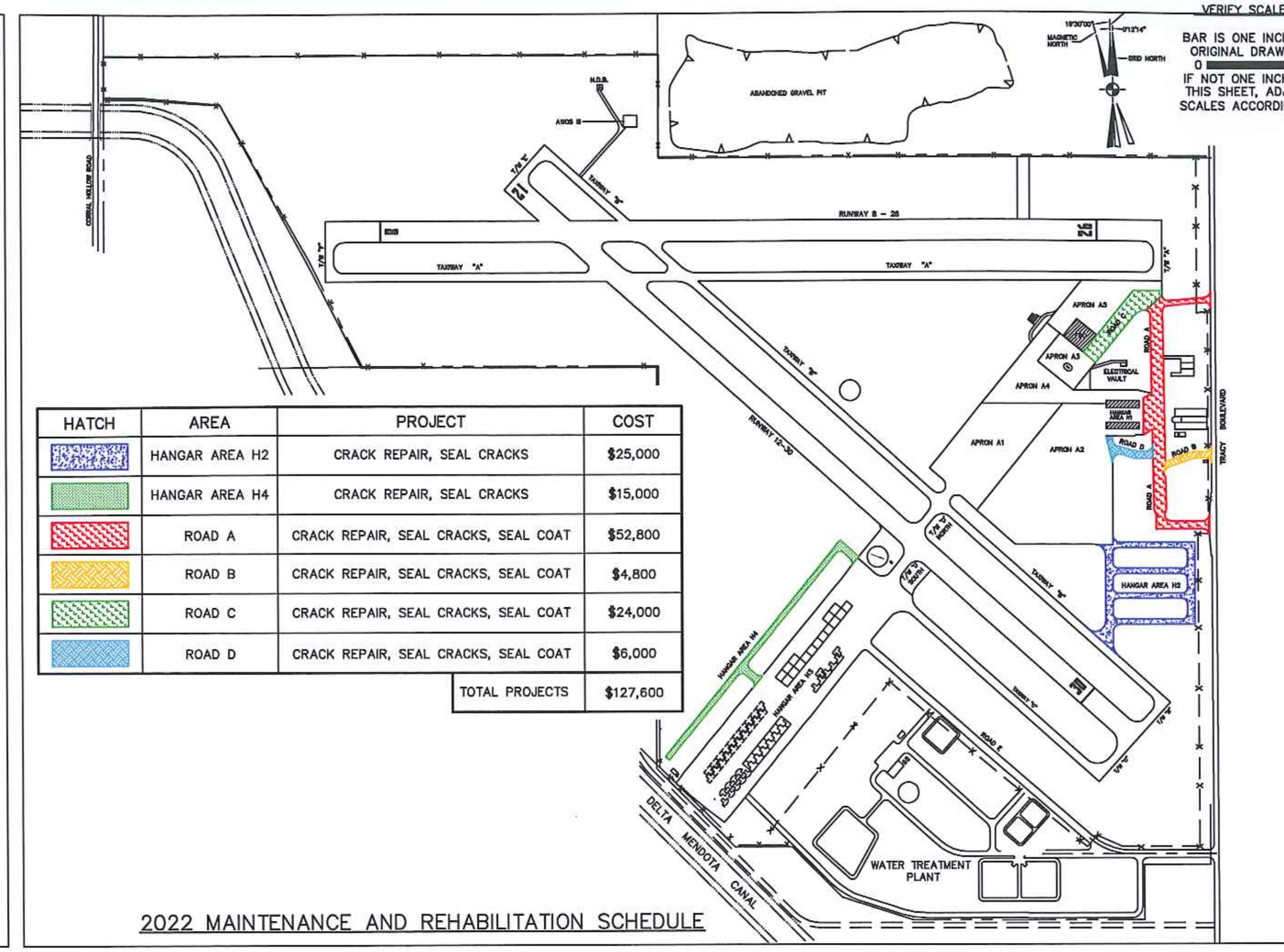
DESIGN BY: DB
DRAWN BY: DMB
CHK'D BY: RWB
DATE: MARCH 18, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=400'

SHEET NUMBER
PLATE No. 4-3



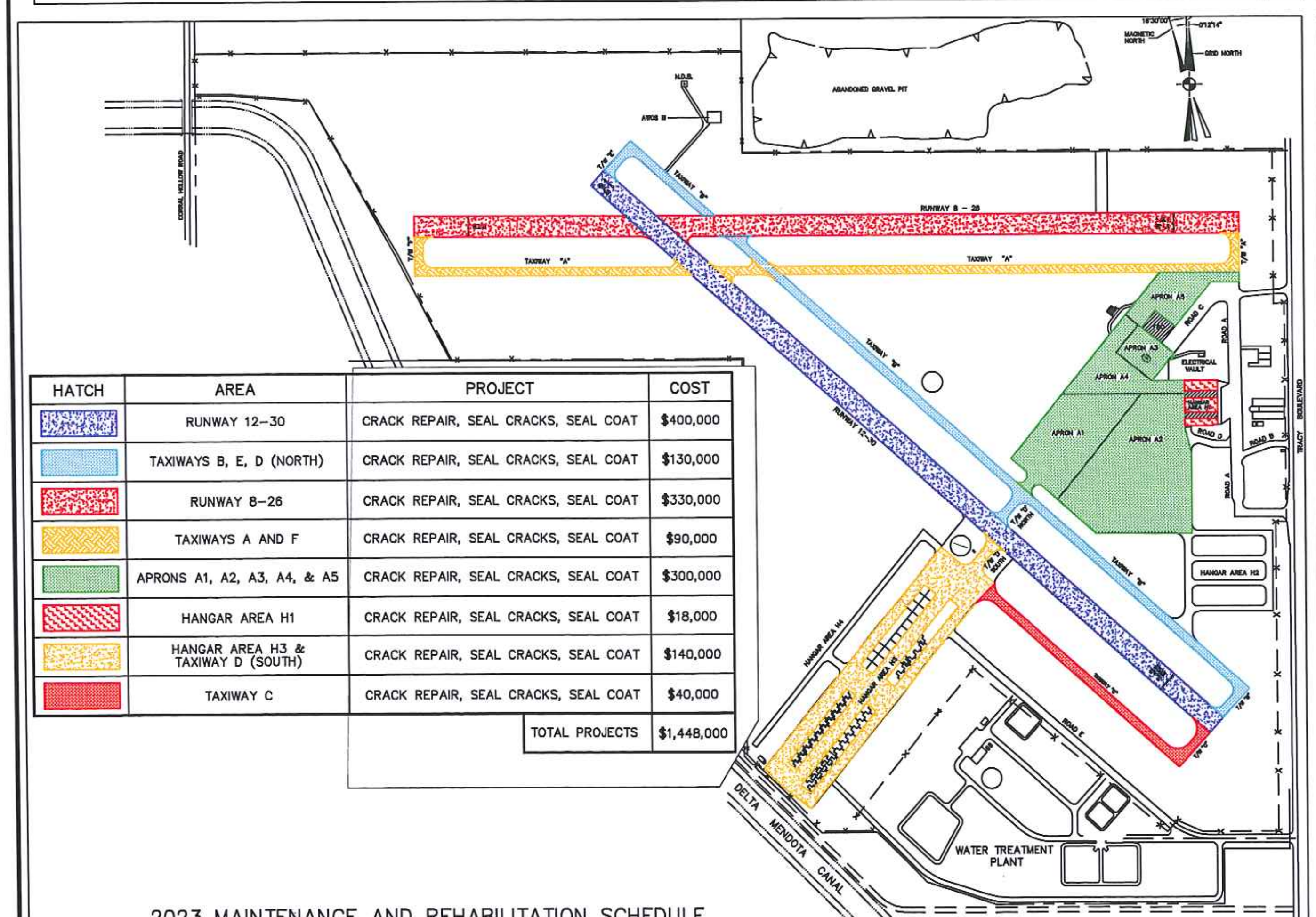
HATCH	AREA	PROJECT	COST
	ROAD E	REHABILITATE EXISTING SECTION	$253,000
		TOTAL PROJECTS	$253,000

2021 MAINTENANCE AND REHABILITATION SCHEDULE



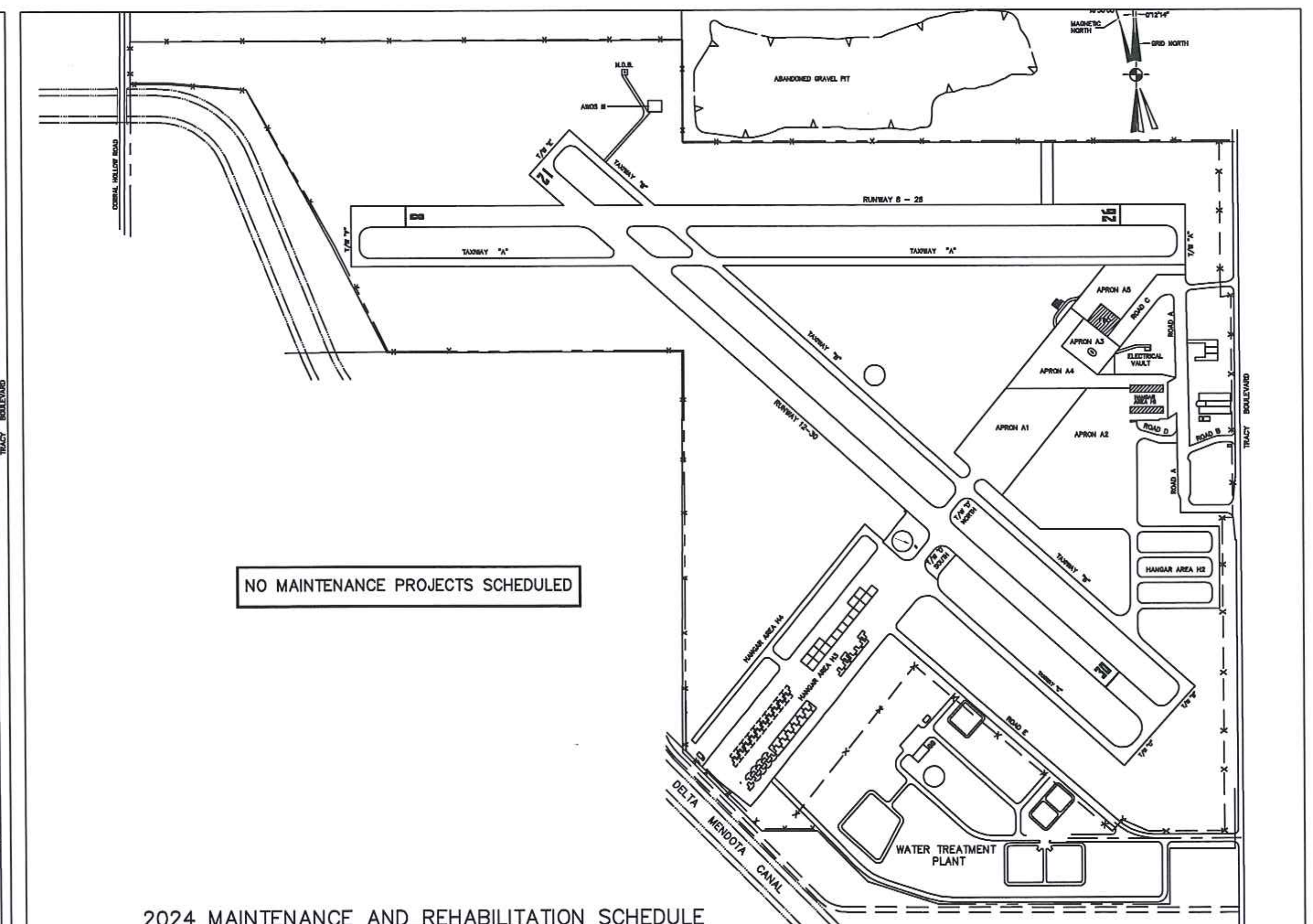
HATCH	AREA	PROJECT	COST
	HANGAR AREA H2	CRACK REPAIR, SEAL CRACKS	$25,000
	HANGAR AREA H4	CRACK REPAIR, SEAL CRACKS	$15,000
	ROAD A	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$52,800
	ROAD B	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$4,800
	ROAD C	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$24,000
	ROAD D	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$6,000
		TOTAL PROJECTS	$127,600

2022 MAINTENANCE AND REHABILITATION SCHEDULE



HATCH	AREA	PROJECT	COST
	RUNWAY 12–30	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$400,000
	TAXIWAYS B, E, D (NORTH)	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$130,000
	RUNWAY 8–26	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$330,000
	TAXIWAYS A AND F	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$90,000
	APRONS A1, A2, A3, A4, & A5	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$300,000
	HANGAR AREA H1	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$18,000
	HANGAR AREA H3 & TAXIWAY D (SOUTH)	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$140,000
	TAXIWAY C	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$40,000
		TOTAL PROJECTS	$1,448,000

2023 MAINTENANCE AND REHABILITATION SCHEDULE



NO MAINTENANCE PROJECTS SCHEDULED

2024 MAINTENANCE AND REHABILITATION SCHEDULE

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TRACY MUNICIPAL AIRPORT

TRACY, CALIFORNIA

PAVEMENT EVALUATION

REHABILITATION SCHEDULR 2021-2024

DESIGN BY: DB
DRAWN BY: DMB
CHK'D BY: RWB
DATE: MARCH 18, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=400'

SHEET NUMBER
PLATE No. 4-4

VERIFY SCALES
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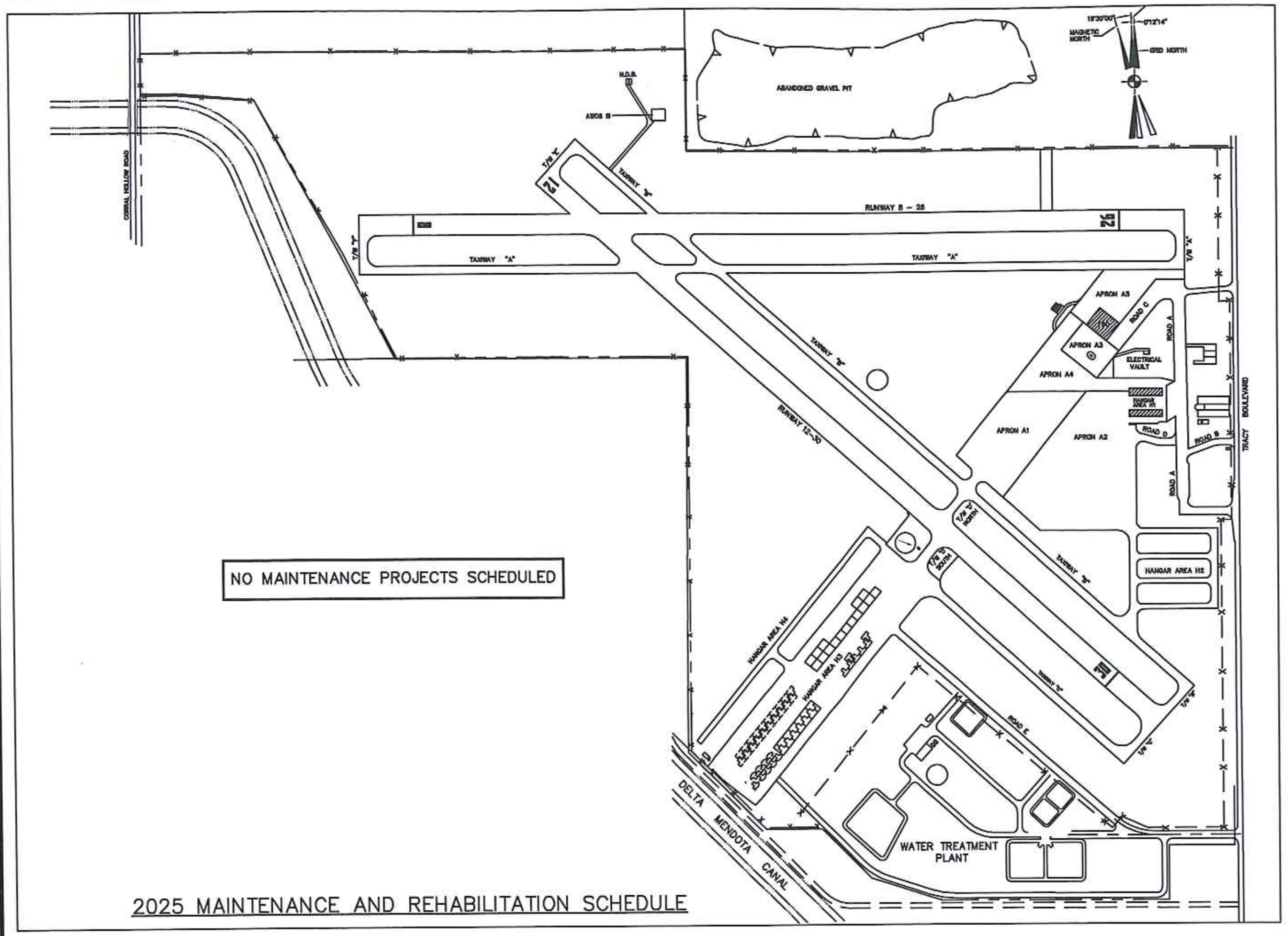
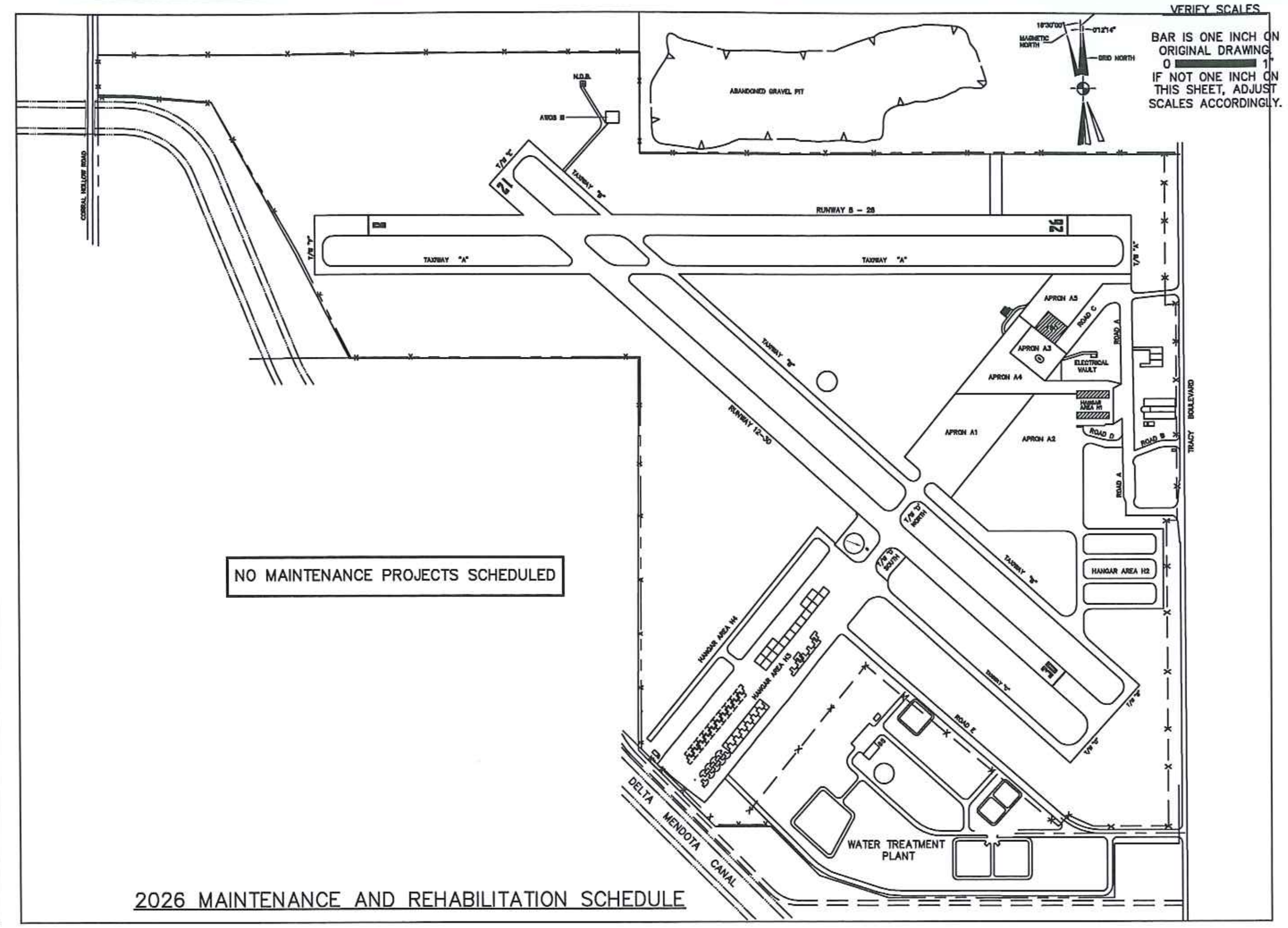
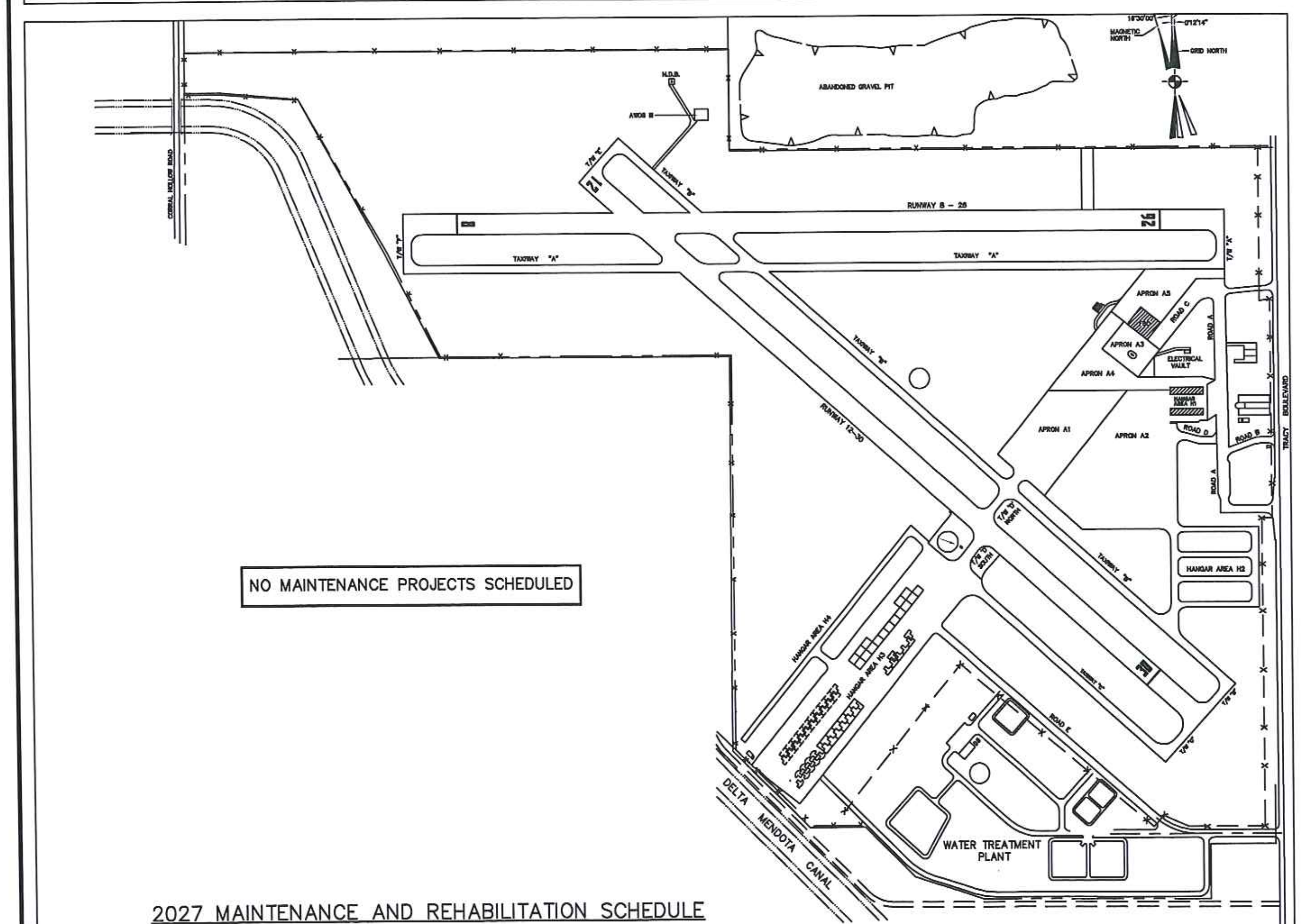


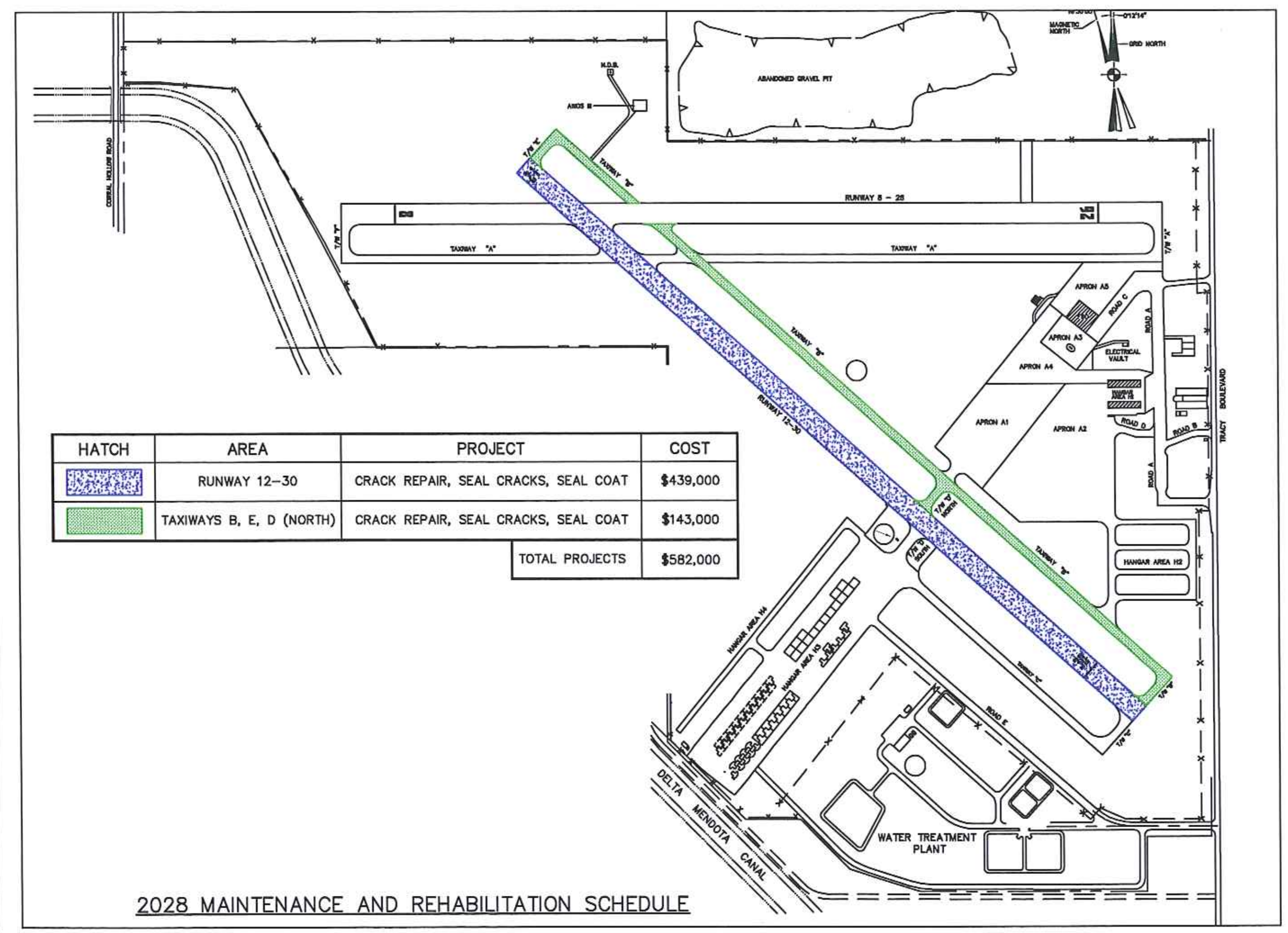
2025 MAINTENANCE AND REHABILITATION SCHEDULE



2026 MAINTENANCE AND REHABILITATION SCHEDULE



2027 MAINTENANCE AND REHABILITATION SCHEDULE



HATCH	AREA	PROJECT	COST
(blue hatch)	RUNWAY 12–30	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$439,000
(green hatch)	TAXIWAYS B, E, D (NORTH)	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$143,000
		TOTAL PROJECTS	$582,000

2028 MAINTENANCE AND REHABILITATION SCHEDULE

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CONSULTING AIRPORT ENGINEER
6125 King Road, Suite 201 • Loomis, California 95650-8004 • (916) 652-4725

ENGINEER OF RECORD

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TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION
REHABILITATION SCHEDULR 2025-2028

DESIGN BY: DB
DRAWN BY: DMB
CHK'D BY: RWB
DATE: MARCH 18, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=400'
SHEET NUMBER
PLATE No. 4-5

VERIFY SCALES
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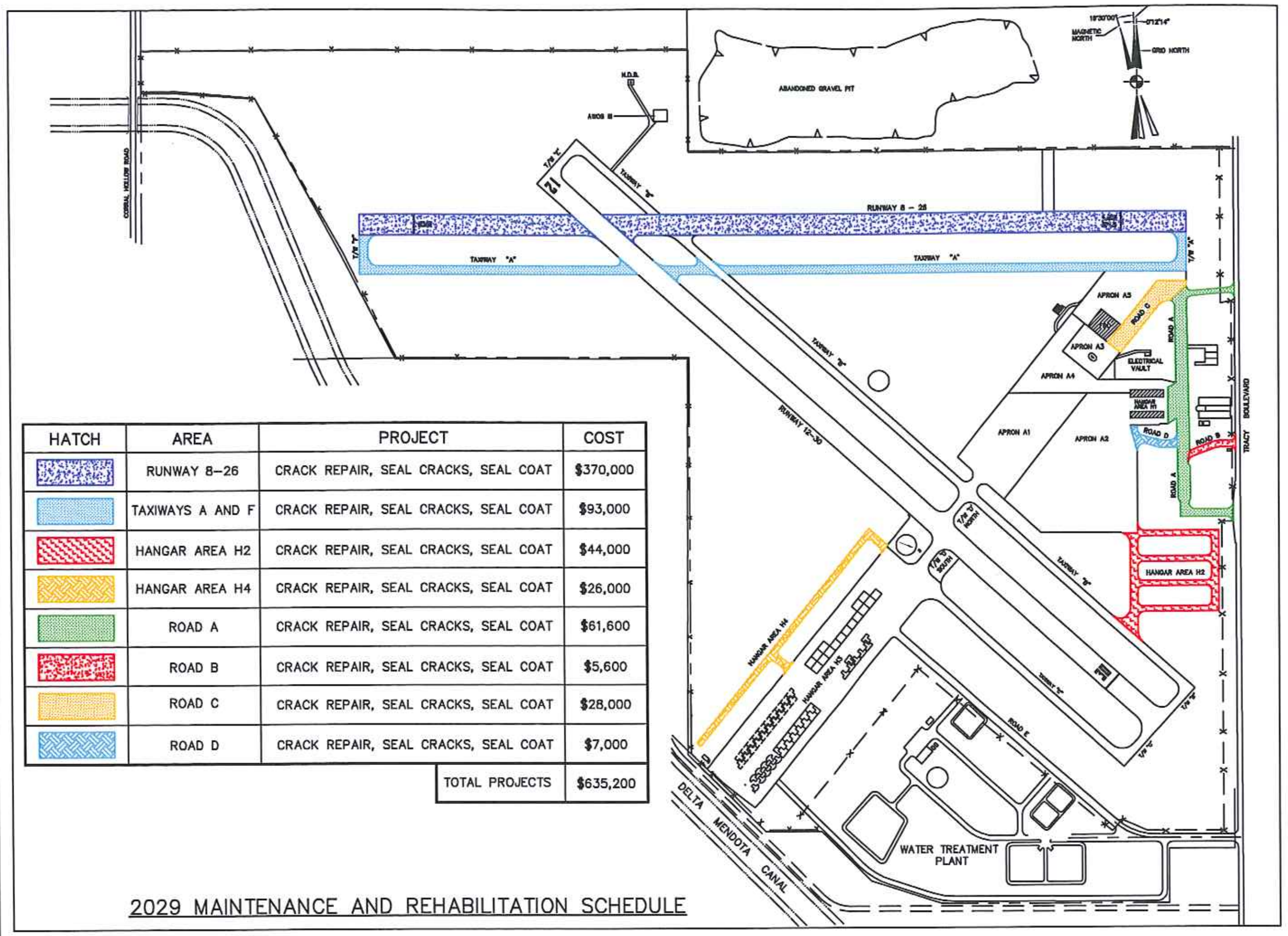
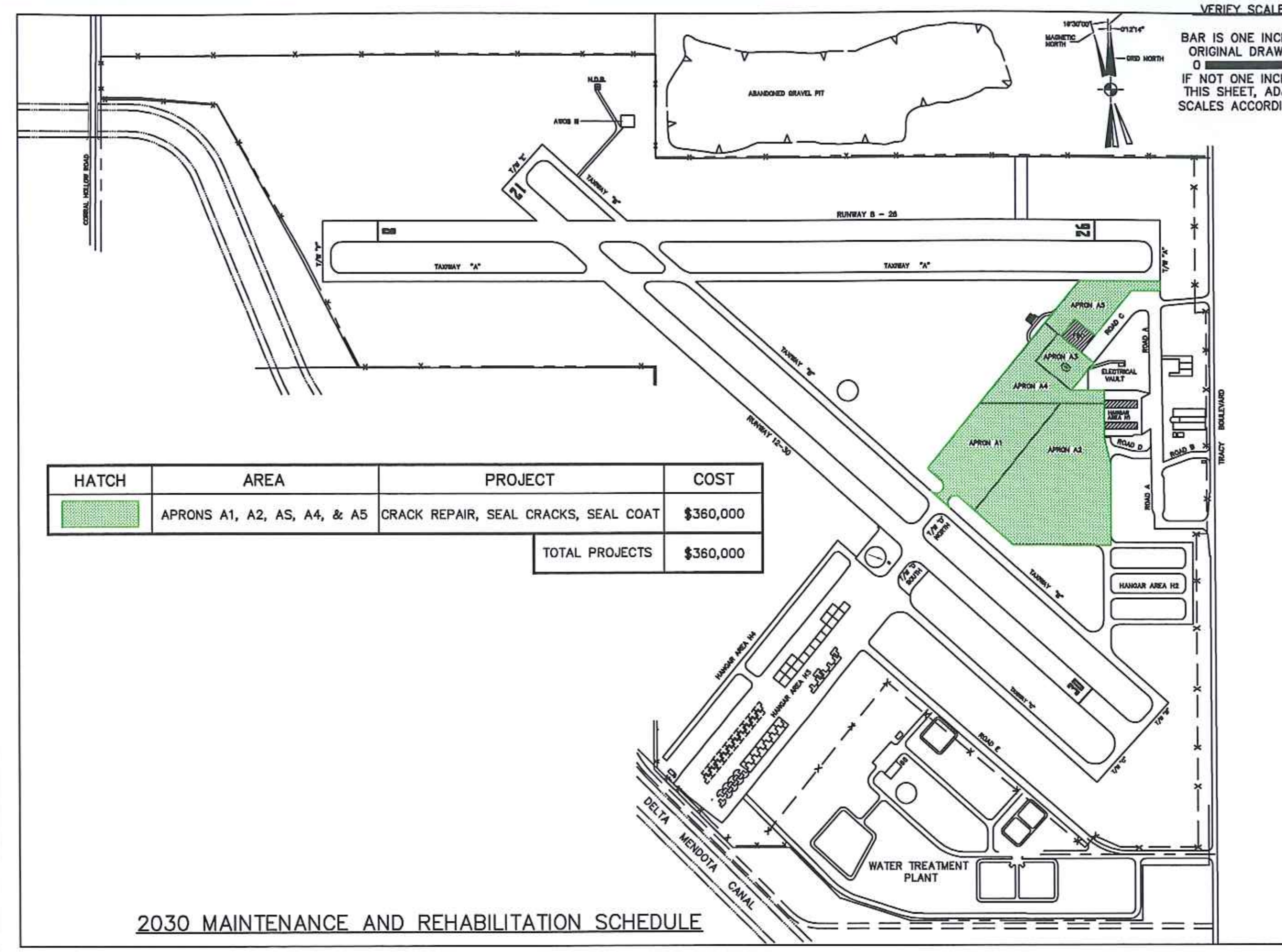


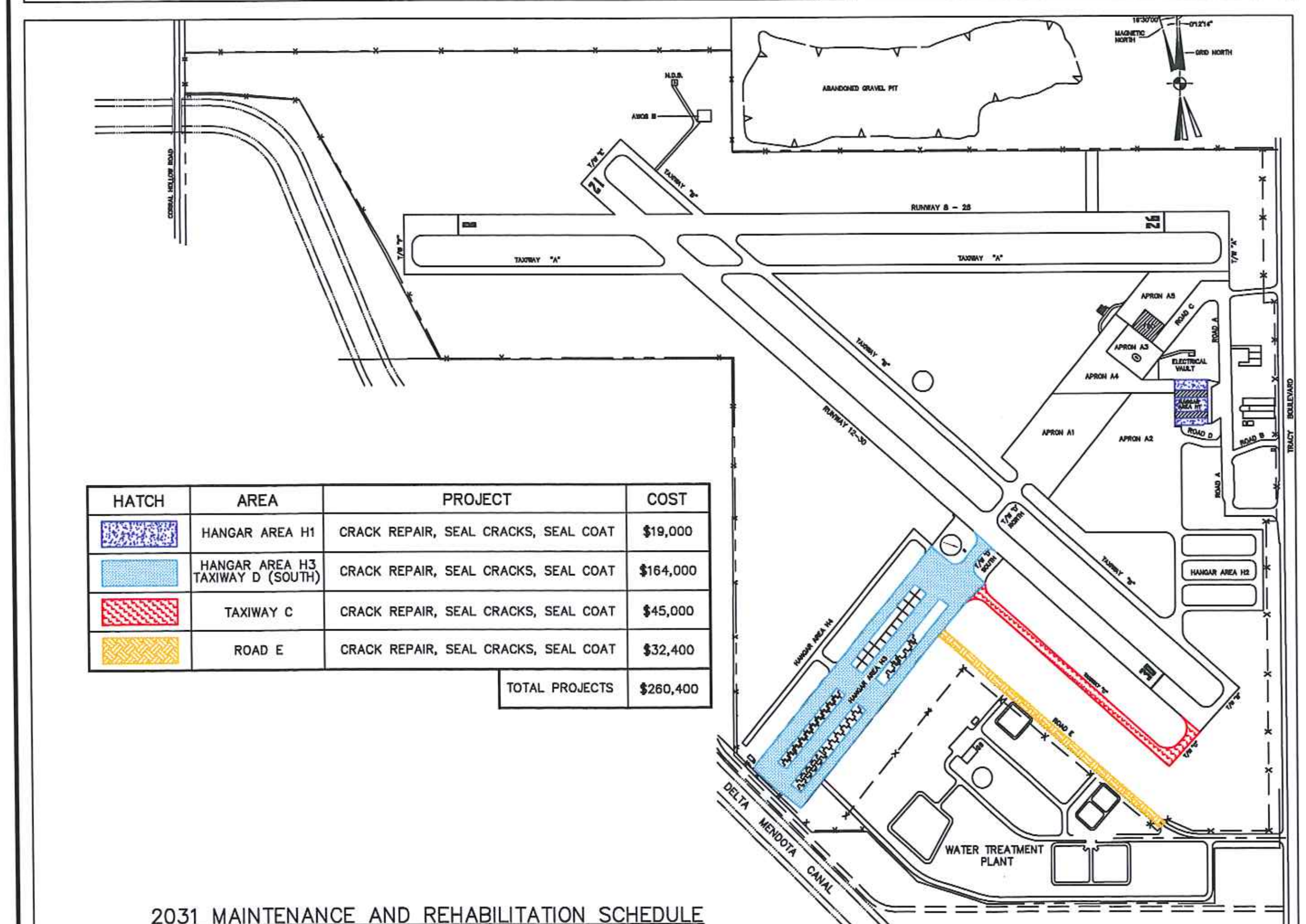
HATCH	AREA	PROJECT	COST
	RUNWAY 8–26	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$370,000
	TAXIWAYS A AND F	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$93,000
	HANGAR AREA H2	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$44,000
	HANGAR AREA H4	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$26,000
	ROAD A	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$61,600
	ROAD B	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$5,600
	ROAD C	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$28,000
	ROAD D	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$7,000
		TOTAL PROJECTS	$635,200

2029 MAINTENANCE AND REHABILITATION SCHEDULE



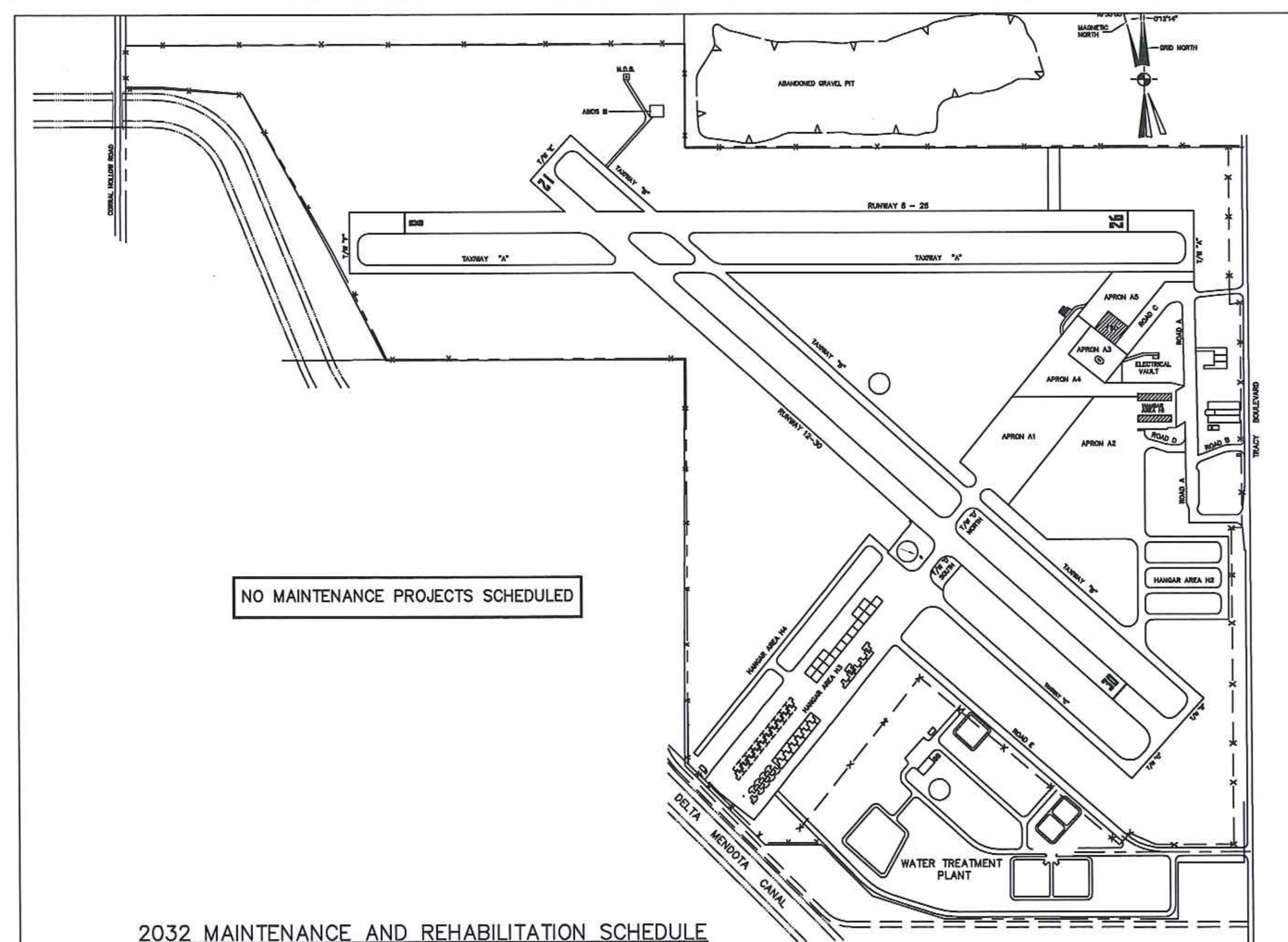
HATCH	AREA	PROJECT	COST
	APRONS A1, A2, A5, A4, & A5	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$360,000
		TOTAL PROJECTS	$360,000

2030 MAINTENANCE AND REHABILITATION SCHEDULE



HATCH	AREA	PROJECT	COST
	HANGAR AREA H1	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$19,000
	HANGAR AREA H3 TAXIWAY D (SOUTH)	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$164,000
	TAXIWAY C	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$45,000
	ROAD E	CRACK REPAIR, SEAL CRACKS, SEAL COAT	$32,400
		TOTAL PROJECTS	$260,400

2031 MAINTENANCE AND REHABILITATION SCHEDULE



NO MAINTENANCE PROJECTS SCHEDULED

2032 MAINTENANCE AND REHABILITATION SCHEDULE

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CONSULTING AIRPORT ENGINEER
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TRACY MUNICIPAL AIRPORT
TRACY, CALIFORNIA

PAVEMENT EVALUATION
REHABILITATION SCHEDULR 2029-2032

DESIGN BY: DB
DRAWN BY: DMB
CHK'D BY: RWB
DATE: MARCH 18, 2013
CONTRACT No. -
PROJECT NO: 51.04-13
DWG FILE: -
DRAWING SCALE: 1"=400'

SHEET NUMBER
PLATE No. 4-6