

DRAFT FINAL DRAINAGE REPORT  
FOR  
STATE ROUTE 51  
THUNDERBIRD ROAD  
TO  
BELL ROAD

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Volume 1 of 2  
Main Report

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**PREPARED FOR:**  
ARIZONA DEPARTMENT OF TRANSPORTATION

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## I. INTRODUCTION

### A. Project Location

The State Route 51, Squaw Peak Highway begins at the south at Interstate 10, south of Sky Harbor Airport and will eventually terminate at the Loop 101, Pima Freeway east of the Central Arizona Project (CAP) Canal. This metropolitan freeway is a controlled access facility providing efficient travel to north Phoenix, Paradise Valley, North Scottsdale, and eventually to Carefree and Cave Creek. This facility is completed to Shea Boulevard. The segment of SR-51 from Shea Blvd. to Thunderbird Road is currently being designed by another consultant. HDR is extending the freeway design from Thunderbird Road to Bell Road. At the southern end of the HDR segment, SR-51 crosses a major flood control facility called Indian Bend Wash. This facility was developed and constructed by the U.S. Army Corps of Engineers and is a paragon for urban flood control systems. The SR-51 watershed is a significant portion of the tributary area of the Indian Bend Wash watershed. Because this segment will also serve as the outlet for the storm water collected along the SR-51 freeway between Bell Road and the Central Arizona Project (CAP), the off-site hydrologic analysis includes all the area south of the CAP.

### B. Description of Improvements

The State Route 51 (SR-51) is a multi-lane, limited access, divided metropolitan freeway providing access to major east-west arterials. The SR-51 segment between Thunderbird and Bell Roads is a depressed freeway with a rolling profile. The runoff collected by the proposed drainage facilities along SR-51 is currently tributary to the Indian Bend Wash drainage system. The drainage concept for the SR-51 roadway is to collect the off-site storm water runoff in a storm drain trunk line parallel to and along the east side of the roadway. The storm drain will be designed for the larger of the 50-year off-site and 50-year on-site peak flow rate. For most of the length of the design section (Thunderbird to Bell) this trunk line will be below the mainline profile gradeline to provide for the collection and conveyance of on-site runoff also. Off-site flows will be collected in the existing street network in curb inlets, area inlets, and in existing storm drains. The outlet for the SR-51 off-site storm drain trunk line will be in the wingwall of the Indian Bend Wash box culvert under SR-51 north of Thunderbird Road. Downstream of this headwall the wash flows are contained in an engineered channel and are conveyed under Thunderbird Road in a multi-celled box culvert. The consultant for the segment between Shea and Thunderbird is designing the channel, box culverts, and the headwall structure.

North of Bell Road (outside the HDR design section) the freeway will stay depressed to a point immediately north of Union Hills Drive where the roadway profile rises over the Central Arizona Project Canal. The depressed nature of the roadway profile requires off-site storm water which currently crosses the freeway alignment to be collected and conveyed to the south to Indian Bend Wash, a regional flood control facility. These flows have been accounted for in the design of the off-site drainage system for the HDR design section between Bell Road and Thunderbird Road.

### C. Concept Plans

Concept plans were updated for the new hydrology developed by HDR for the 30% design. Following the 30% submittal a value engineering committee suggested the elimination of the Greenway Road pump station. An on-site gravity storm drain trunk line was required in lieu of the pump station.

### D. Discussion of Drainage Improvements performed by HDR

As part of the drainage design performed by HDR, the off-site drainage system analysis was extended to Union Hills Drive in order to provide a storm water outlet for the Union Hills Drive underpass. These flows will eventually drain by gravity into the off-site drainage storm drain being provided between Thunderbird Road and Bell Road. Other drainage improvements are the interconnect between the Greenway Road storm drain, the future Bell Road storm drain, and the existing 36th Street storm drain.

### E. Approval of Plans by ADOT

Prior to the 30% submittal, ADOT reviewed the hydrologic analysis. At the reviewers suggestion an independent review of the watershed and model be performed to verify modeling assumptions. This quality control activity was performed by Dr. Jerry Zovne (HDR) and the results of his review have been evaluated and are reflected in the hydrologic analysis.

The 30% submittal, September, 1995, was reviewed by ADOT, the City of Phoenix, and the Flood Control District of Maricopa County. The Flood Control District comments were concerning the watershed modeling and the design frequency used for the off-site collector. HDR met with the district on two occasions and their concerns were satisfied. The City of Phoenix comments were concerning the pump station and Hearn Road drainage. The pump station has been removed from the plans and Hearn Road has been redesigned to slope to Indian Bend Wash to reduce the large flows in 34th Way. HDR met with ADOT Bridge Drainage Section and discussed their comments on the 30% report and analysis. Each comment was discussed and an understanding was reached on each point. Comments from ADOT construction were concerning using precast and cast-in-place options for the design. In a subsequent meeting the following criteria was agreed upon to identify candidates for the cast-in-place option.

- Open Channel Flow Condition Only (i.e. non-pressure flow)
- Fill Heights Less Than 15 Feet
- Long Pipe Runs
- Straight Pipe Runs
- Native Material Can Stand Vertically (no sandy or loose gravelly soils)

Cast-in-place pipe is not an option for pipes under the SR-51 pavement.

Cast-in-place pipes will be evaluated using a Manning n value of 0.014 while reinforced concrete pipe (RCP) was design using a Manning n value of 0.012. The box culvert Manning n is the same for both cast-in-place and pre-cast (0.013).

The remainder of the ADOT comments were from the Roadway Design Section. Their comments followed the theme of 'make sure the drainage works', 'drainage for connector roads and detours

need to be looked at', and 'need special details at transitions'. These concerns have been, or will be integrated into the final drainage design. Connector road drainage has been provided for in the 60% design. The detour drainage will be handled by the existing storm drains and temporary retention basins within the right-of-way. Only one transition structure is required in this design, between the 10x6 and 8x6 RCB, and it will be designed by HDR's structural design section as part of the 90% submittal.

## II. DRAINAGE AREA AND HYDROLOGY

### A. General Discussion

The drainage area to SR-51 north of Thunderbird is part of the Indian Bend Wash watershed. Storm water runoff typically is conveyed across the proposed alignment in the street network north of Union Hills Drive. Storm water runoff patterns south of Bell Road are generally to the south in the existing storm drains and street sections in 40th and 36th Streets. The City of Phoenix has designated the north-south one mile and half mile arterials and collectors for storm water runoff. These flows are discharged into Indian Bend Wash where the street crosses this facility. There is also a storm drain in Greenway Road. This storm drain terminates in a manhole at 36th Street. Collected storm water is introduced into the 36th Street storm drain and is conveyed to the south. A short, small diameter storm drain (24") exists between 36th and 32 Street which conveys initial flows to the west. The City of Phoenix is planning to a new storm drain in Bell Road as part of the proposed improvements. The existing design plans do not consider the SR-51 drainage system and will have to be redesigned to be compatible with the SR-51 storm water collection and conveyance system.

### B. Drainage Area Characteristics

The natural drainage area contributing storm water runoff to the SR-51 alignment between the Central Arizona Project (CAP) and Thunderbird Road has been nearly completely replaced by residential and commercial development. Where shallow braided washes once conveyed storm water runoff, the network of city streets now performs this function. Newer developments are required to retain the storm water runoff from the 100-year 2-hour rainfall event. This reduces the amount of runoff the street network is required to convey. For the older, developed areas, storm water retention was not provided. Newer developments are clustered at the north end of the project near Union Hills Drive. The older developments are in the southern end of the project between Greenway and Thunderbird Roads. Several of the local collector streets were constructed as inverted crown streets specifically to convey large runoff events. Specifically, 43rd Place, 36th Street, and Gelding Drive impact the runoff patterns for larger events because they are inverted crown streets. The general slope of the land is to the southwest while the greater street gradients are along the north-south streets. Along the major east-west streets typically, first flows are to the west while larger events overtop the roadway crown and are conveyed to the south in the street network. At several locations the major east-west streets have dip sections which allow storm water to cross the street to the south unimpeded. Dip sections exist along Union Hills Drive and Bell Road but not in Greenway Road. Greenway Road is developed with a raised median which confines storm water to the north half of the street. When the flow gets deep enough the median is overtopped and the runoff is conveyed to the next north-south street where it is then conveyed to the south. At 36th Street a majority of the Greenway Road flows are routed to the south along the major storm sewer route. Three dip sections are also provided along 40th Street between Union Hills Drive and Greenway Road. They are at Helena Drive, Grovers Avenue, and at about the Wagner Road alignment (immediately south of Union Hills Drive).

Four adjustments to the 30% hydrologic analysis have occurred in the modeling of the SR-51 watershed. The pump station at Greenway Road has been replaced by an on-site storm drain and

therefore has been removed from the hydrologic model. The storm water runoff being conveyed in Tierra Buena Lane will be picked up by the existing storm drain in 36th Street and not be introduced into the off-site storm drain culvert. The design discharge for the 36th Street storm drain at Tierra Buena Lane is 142 cfs. The 50-year runoff peak at Tierra Buena Lane is 134 cfs. All of the flows in the 36th Street storm drain upstream of Tierra Buena Lane are being diverted into the off-site storm drain culvert upstream of Tierra Buena Lane and therefore, the 36th Street storm drain has the capacity to convey the 50-year peak flow rate in Tierra Buena Lane.

The drainage area along 36th Street (west of SR-51) between Bell Road and Tierra Buena Lane has been added to the 50-year storm water runoff model. The final change was the outlet location. The consultant for the SR-51 design section between Shea Blvd. and Thunderbird moved the outlet location and is now providing a bank protected open channel for the combined Indian Bend Wash and the HDR design section discharges. This change requires that the storm water entering the right-of-way near Ludlow Drive will have to be conveyed to the lined channel in a drainage swale and will not be introduced into the off-site culvert. These changes eliminated the need for the 12x6, and most of the 10x6 RCB which were included in the 30% design.

#### C. Hydrology Received From Management Consultant

The Final Drainage Report provided to HDR was dated November, 1988 and was revised by the Management Consultant in May, 1989 in what was issued as Squaw Peak General Plan Drainage Report. The hydrology for SR-51 north of Thunderbird Road is based on the preliminary hydrology prepared as part of the location study in the mid 1980's by AN West. The drainage areas used in the location study have been altered significantly by the development over the past 10 years. The storm water runoff has increased due to increased imperviousness. The 1988 location study hydrologic analysis was not intended to be used for final design as large drainage areas and a broad brush approach was used in the analysis to determine general flow trends within the Indian Bend Wash watershed. Therefore, the location study hydrology for SR-51 between Northern Avenue and Thunderbird Road was revised significantly by the Management Consultant. The TR-20 analysis from the location study was replaced with a HEC-1 computer model analysis. Off-site drainage areas were dissected to provide design information for the engineer-designer. This effort was not extended north of Thunderbird Road.

Initially it was thought that a re-analysis of the SR-51 drainage area would reduce the design discharges along the alignment because it was observed that a significant amount of the runoff is being conveyed in the north-south streets. Other factors influencing the decision to re-examine the watershed was that the ADOT hydrologic procedures had changed significantly, the model did not provide design information for the final design of the off-site drainage features, and the off-site drainage concept did not allow for the Union Hills Drive underpass to be drained by gravity into the storm drain. There appeared to be sufficient gradient to drain the Union Hills Drive but no provisions had been made for the runoff.

In essence, the hydrology provided in the two 1988 & 1989 reports was not very reliable for this segment of freeway and it was agreed that the hydrology should be revisited as part of the 30% design effort.

#### D. Additional Studies by HDR

Thus as part of the design effort for the off-site storm water collection system along SR-51, HDR remodeled the watershed from the Central Arizona Project (CAP) to Thunderbird Road. The **drainage area** was established by driving the area, reviewing Bell Road and Greenway Road improvement plans, and surveying 24 street intersections. It was found that the area contributing runoff to this segment of SR-51 was more than two times larger than that modeled in the previous study. This watershed was divided into 23 drainage areas ranging in size from 10 to 109 acres.

Arizona Department of Transportation (ADOT) hydrologic procedures for determining frequency based **point rainfall volumes** were used to verify the values used in the previous studies. Values used in the previous hydrologic studies were very close to those determined by HDR so for consistency they were adopted for this study. Rainfall values for the 100-year, 24-hour storm, the 100-year 2-hour storm, the 50-year, 24-hour storm, and the 2-year 24-hour storm were used in the HDR analysis. The 100-year 2-hour storm is the regulatory storm for on-site retention, and the 2-year 24-hour storm was used for the 36th Street storm drain evaluation. The 50-year 24-hour storm was used for the design of the off-site storm drain trunk line.

Rainfall losses are based on the Green and Ampt infiltration loss equation. Parameters required for this analysis are soil infiltration loss rate parameters, initial abstraction, and effective imperviousness. Effective imperviousness is a product of development densities.

The 1993 ADOT hydrologic procedures requires an evaluation of the types of soils in the watershed. The **Green and Ampt Soil infiltration loss rate** parameters were derived from the Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona, issued in April 1986. Soil within the SR-51 watershed are sandy loam, gravely sand, and loams. From the soils mapping, ADOT hydrologic procedures manual Table 3.2 was used to determine loss rate parameters. For subareas where more than one soil type exists, a composite value was calculated per the ADOT procedures. For this analysis Equation 3-1 and Figure 3-3 were used.

**Development densities and land-use** were determined using the City of Phoenix zoning maps and a 1995 aerial photograph. The majority of the area is residential development on lots of about 7000 square feet. Commercial developments exist mainly along Union Hills Drive and Bell Road. Several medical facilities are located near 40th Street and Bell Road. There are two areas of large lot residential. One is located between Bell and Greenway Roads, east of 40th Street and the other between 36th and 38th Streets between Greenway Road and Paradise Lane. **Initial abstraction** (surface retention loss) values were estimated from Table 3-1. **Effective impervious percent** values were determined using Table 3-3 from the ADOT manual.

The Clark Unit Hydrograph procedures are specified for use in determining the shape and peak of the runoff hydrograph. Two interrelated parameters are required for the Clark Unit Hydrograph procedure, time of concentration and a watershed storage coefficient. A third parameter is the time-area relationship.

The **time of concentration** is based on one of three equations which are differentiated by the type of watershed being analyzed. For the SR-51 watershed only the desert and urban equations were used (Equations 4-1 and 4-3). The watershed parameters used in these equations are the drainage area (square miles), the travel length from the most hydraulically remote location in the subarea (miles), the distance along the travel length to a point perpendicular to the watershed centroid (miles), and the slope of the travel path (feet/mile). The effective impervious area (percent) is also required for the urban equation.

The HEC-1 model has a choice of **modeling time steps**. The ADOT hydrologic procedures manual suggests using a minimum time step of 5 minutes. Because of the size of some of the smaller drainage areas and some short routing reaches, the HEC-1 model requires a time step of 2 minutes in order to completely define the shape and peak of the resultant runoff hydrograph. A 2 minute time step was used for this modeling effort.

For determining the **watershed storage coefficient**, Equation 4-4 was used. Parameters used in the equation are the time of concentration (hours), the travel length from the most hydraulically remote location in the subarea (miles), and the drainage area (square miles).

There are three dimensionless synthetic **time-area relations** provided in the ADOT hydrologic procedures manual. These curves define the percent of the drainage area which contributes runoff as a function of the travel time. This parameter governs the peakedness the runoff hydrograph. Guidance is provided for the selection of which curve to use. Curve A is specified for urban areas and Curve C is for desert and agricultural area. Curve B is the default for the HEC-1 model and is more of the average of the other two extreme curves. The default curve was used in this analysis because past experience in using these curves has shown that Curve A produces very high peak discharges and in the judgment of the modeler shape of the subareas for this analysis were better represented by the bell shaped curve provided by Curve B.

Routing within the watershed model were by two methods. The **Normal Depth Routing** method as suggested in the ADOT procedures manual was used for street routing. For routing along the SR-51 off-site storm drain the **Kinematic Wave Routing** was used because no attenuation of the hydrograph peak is expected once the storm water is in the pipe.

**On-site retention** was observed for the newer developments in the northern portion of the watershed and lacking in the southern portion of the watershed near Thunderbird Road. To conservatively account for 100-year 2-hour retention, two aerial maps were compared, one from 1988 and the other from 1995. All development which occurred after the 1988 photo was modeled with 100-year, 2-hour retention volumes. All development which existed prior to 1988 was modeled without retention. This demarcation represented field observations of the watershed. The City of Phoenix park between 38th and 40th Street along Paradise Lane was modeled as non-contributing. In order to account for the impact of the retention policy, subarea runoff hydrographs were **routed through an imaginary detention basin** which would retain the regulatory storm runoff volume from the first of the hydrograph and then outlet the remainder of the inflow hydrograph. The regulatory retention volumes were generated by running the

hydrologic model for the 100-year 2-hour rainfall event. The volume of the runoff hydrograph from this model was used to account for the provided regulatory retention.

As observed during field trips through the drainage area, significant split flows were observed at many street intersections. To better evaluate the impact of these split flows, 24 street intersections were field surveyed. Data from the surveys were used to determine the parameters used in the hydrograph diversion routines used in the hydrologic modeling. Hydrograph diversion routines were used at 9 locations within the watershed and are identified as:

- Hills Drive and 40th Street,
- Paradise Valley High School and Bell Road,
- Bell Road and 38th Street,
- Bell Road and 40th Street,
- Greenway Road and 40th Street,
- Greenway Road and 38th Street,
- Greenway Road and 36th Street,
- Gelding Drive and 35th Street, and
- Ludlow Drive and 34th Place.

The design storm for the off-site drainage system is the 50-year 24-hour storm per the Urban Highway Design Procedures Manual for storm drain design. The on-site design storm is also the 50-year storm because SR-51 is a depressed highway. The duration of these two storms is not the same as the collection system for the on-site flows will be based on the rational analysis where the duration of the rainfall event is the same as the time of concentration. Because the design storm for the on-site and off-site are the same frequency and the off-site peak flow rate north of Union Hills is small, an on-site 50-year 24-hour (time step of 5 minute) analysis was modeled to compare the peak flowrates between the on-site and off-site areas. In the areas where on-site peak flowrate exceeds the off-site, the on-site flowrate will be used. The on-site peak flow into the Greenway Pump Station was also evaluated in this on-site model. Table II.D.1 summarizes the design peak flow rates to be used to design the off-site storm drain.

TABLE II.D.1  
SUMMARY OF DISCHARGES ALONG SR-51

Location	HEC-1 Model ID	Off-site Q50	On-site Q50	Design Q50
Union Hills Drive	COMB1 UHSR51	19 cfs	92 cfs	92 cfs
Sta. 461+00	COMB2	198 cfs		198 cfs
Bell Road	COMB7	241 cfs	190 cfs	241 cfs
Paradise Lane	COMB9	241 cfs		241 cfs
36th Street SD	COMB9B	73 cfs		73 cfs
So. of Paradise Ln.	COMB9C	282 cfs		282 cfs
Tierra Buena	COMB10	278 cfs	220 cfs	278 cfs
Greenway Road	COMB19	361 cfs	250 cfs	361 cfs
Blanche Dr.	COMB20	368 cfs		368 cfs
Gelding Dr.	COMB21	409 cfs	293 cfs	409 cfs
Ludlow Dr.*	COMB22	490 cfs		490 cfs
Thunderbird Road (East)	COMB23	125 cfs		125 cfs

\* Combined flow entering the lined channel designed by others.

The results of the 30% hydrologic model and the modeling assumptions were reviewed by ADOT informally in order to keep the project on schedule. ADOT review comments were to document the reason for the short modeling time step, and the need for so many subareas in the watershed.

A **Quality Control** review of the hydrologic analysis and modeling assumptions was conducted by Dr. Jerry Zovne, as senior water resources engineer to verify the reasonableness of the model and watershed analysis. At his suggestion a test model was created to determine the impact of additional area east of the watershed boundary contributing to the SR-51 alignment. The increased area between Bell Road and the CAP, 0.167 square miles, increased the peak flow rate along SR-51 by less than 15 cfs. This represents less than 2 % of the flowrate and was considered negligible. It was agreed that the hydrologic model would not be revised for the questioned contribution area.

The changes in the hydrologic model required for the 60% design effort are consistent with the previous modeling effort and therefore the modeling effort should still be acceptable to the Department of Transportation.

### III. ON-SITE DRAINAGE

#### A. General Discussion

The design storm for the on-site drainage design is the 50-year rainfall event. The embankment section at the south end of the project is also designed for this event since overflow from the collection system for this area would impact the drainage system for the depressed roadway section to the north. On-site storm water runoff has been introduced into the off-site drainage system whenever the energy gradeline (EGL) in the off-site system would allow. Where the EGL precludes using the off-site system (south of Greenway Road), it is introduced into the on-site storm drain system. The on-site storm drain will be used to collect and convey storm water runoff from the Greenway Road underpass and from the west ramp areas. The underpass at Greenway Road is too deep to be drained by the off-site storm drain.

The on-site drainage analysis is complete and is provided in the appendix of this report. The on-site drainage map is also included in the report appendix. The rational procedure, as outlined in the ADOT Highway Drainage Design Manual - Hydrology (1993), was used for this analysis. This is an iterative procedure as the time of concentration is a function of the rainfall intensity, which is a product of the time of concentration. The 10- and 50-year rainfall frequencies were analyzed to see which condition controlled. The on-site storm water runoff was also evaluated for both the design condition and for a future roadway condition where the median area was replaced by an additional traffic lane. The purpose for this second condition is to insure that the on-site drainage facilities will handle future runoff conditions. The design condition for the pavement drainage is the most restrictive to these two conditions.

ON-SITE STORM DRAIN DISCHARGE SUMMARY

Station	Sub-basins	Area (ac.)	Tc	i (in/hr)	Inflow (cfs)	Design Q (cfs)
9+50 Ramp C	Pavement Flow GRC9	0.93	10 (min.)	6.4	4.2	4
384+82+-	GC11, GRC11, GRC12	2.41	10 (min.)	6.4	8.3	13
382+00	Above + W382	3.16	10 (min.)	6.4	3.36	16
381+00	Above + SB381	4.47	10 (min.)	6.4	5.8	22
379+40	Above + NB381, E379, W379	7.63	10 (min.)	6.4	2.64	24
378+00	Above + SB378, NB378	8.43	10 (min.)	6.4	3.3	28
376+60.73	Above + SB376, NB376, W376	9.66	10 (min.)	6.4	31.49	59
375+25	Above + SB375, NB375, E376	11.17	10 (min.)	6.4	3.3	62
373+00	Above + SB373, NB373, W373, E373	15.79	10 (min.)	6.4	20.0	82
366+40+-	Above + GRA5, GRA7, GA5	17.98	12.8	5.6	9.5	92
363+45+-	Above	Same as Above	14.3	5.3	0.0	92
363+15+-	Above	Same as Above	14.6	5.3	0.0	92
360+50	Above + SB360, NB360, GB6	21.04	16.0	5.1	13.3	105
357+00	Above + SB357, W357, E357	22.61	17.7	4.8	6.0	111
352+42.06	Above + SB352, NB352, NB354, NB356, SB354, W352, E352	24.02	19.9	4.5	16.5	128
350+00	Above + SB350, NB349, NB351	27.61	21.0	4.3	4.8	133
348+00	SB348	28.00	21.9	4.2	1.6	134
340+00	Above + SB340	28.32	25.5	3.9	2.6	137
338+00	Above + SB338, NB338	Same as Above	26.4	3.8	17.7	154
328+20+-	Above	33.50	30.8			

### B. Inlet\Catch Basin (CB) Spacing Design

Pavement drainage is collected in the standard freeway drainage grated catch basins. Slotted drains are added to the catch basins where additional capacity is required. The locations for these inlets are dictated by the maximum allowable spread. The maximum allowable spread for the 10-year event is the gutter plus one half lane and for the 50-year event was the gutter plus one lane. For the ramp areas where only a single lane is striped, the equivalent width of a lane is being kept dry for the design event. Pavement inlets are also provided at changes in superelevation, and at roadway sump areas. Median and off pavement drainage is collected in standard median catch basins. The following two tables summarizes the pavement inlet design

**NORTHBOUND MAINLINE AND RAMP PAVEMENT INLETS  
SUMMARY TABLE**

Inlet Station	Q (cfs)		Inlet Design	Flowby (cfs)	Slotted Drain	Intercept. (cfs)	Flowby (cfs)	Grate Elev.	Notes
	Interim	Ultimate							
338+00	11.7	14.9	Ultimate	0.0	20 ft.	13.7	1.2	1416.08	Begin Project
340+00	1.5	1.9	Ultimate	1.2	10 ft.	3.1	0.0	1410.67	Super Changes D/S
345+00	3.8	4.7	Interim	0.0		3.2	0.6	1411.88	
348+00	2.3	2.8	Interim	0.6		2.4	0.5	1410.52	
350+00	1.6	2.0	Interim	0.5	5 ft.	2.1	0.0	1410.00	
352+42	3.4	4.2	Interim	0.1		3.5	0.0	1409.78	Inlet at Sag
354+00	3.0	3.6	Interim	0.2	10 ft.	3.1	0.1	1409.87	
357+00	3.7	4.3	Interim	0.2	5 ft.	3.7	0.2	1410.58	
360+50	3.9	4.6	Interim	0.0	5 ft.	3.7	0.2	1412.17	
373+00	6.3	8.0	Ultimate	0.0		5.9	2.1	1408.53	
375+25	1.6	2.1	Ultimate	2.1		3.3	0.9	1407.43	
376+61	1.6	2	Ultimate	1.7		3.7	0.0	1407.24	Inlet at Sag
378+00	1.7	2.3	Ultimate	1.8		3.3	0.8	1407.43	
381+00	6.0	7.6	Ultimate	0.0		5.8	1.8	1409.19	
5+52 Ramp A	2.0	2.0	Ultimate	0.6		2.6	0.0	1413.60	Inlet at Sag
7+00 Ramp A	5.7	5.7	Ultimate	0.0	20 ft.	5.1	0.6		
9+50 Ramp C	5.4	5.4	Ultimate	0.0		4.2	1.2		
11+42 Ramp C	1.1	1.1	Ultimate	1.3		2.4	0.0	1418.69	Inlet at Sag
12+50 Ramp C	1.6	1.8	Ultimate	0.3		2.0	0.1	1419.06	
390+00	4.9	5.9	Ultimate	0.0	10 ft.	5.6	0.3	1421.94	
395+25	7.8	9.5	Ultimate	0.0	15 ft.	9.5	0.0	1427.66	
404+00	8.1	9.9	Ultimate	0.0	10 ft.	9.9	0.0	1432.05	
413+10	2.7	3.2	Interim	0.0	5 ft.	2.7	0.0	1438.86	Super Changes D/S
420+00	4.3	5.1	Interim	0.0	5 ft.	4.1	0.2	1438.25	
422+80	2.6	3.4	Interim	0.2	5 ft.	2.8	0.0	1437.24	Super Changes D/S
426+00	2.3	3.0	Ultimate	0.0		2.1	0.9	1435.38	
427+09	1.3	2.2	Ultimate	1.8		4.0	0.0	1435.27	Inlet at Sag
428+40	4.2	5.4	Ultimate	0.0	5 ft.	4.5	0.9	1435.43	
8+47 Ramp A	0.9	0.9	Ultimate	0.8		1.7	0.0	1440.53	Inlet at Sag
10+00 Ramp A	8.1	8.1	Ultimate	0.0	35 ft.	7.3	0.8	1441.60	
5+00 Ramp C	5.2	5.2	Ultimate	0.0	20 ft.	5.2	0.0		No flowby allowed.

**SR-51 NORTHBOUND MAINLINE AND RAMP PAVEMENT INLETS  
SUMMARY TABLE**

Inlet Station	Q (cfs)		Inlet Design	Flowby (cfs)	Slotted Drain	Intercept. (cfs)	Flowby (cfs)	Grate Elev.	Notes
	Interim	Ultimate							
338+00	11.7	14.9	Ultimate	0.0	20 ft.	13.7	1.2	1416.08	Begin Project
345+00	5.1	6.5	Ultimate	1.2		5.6	2.1	1410.67	
349+00	2.9	3.7	Ultimate	2.1	5 ft.	5.2	0.6	1409.01	
351+00	1.5	1.9	Ultimate	0.6		2.1	0.4	1408.64	
352+42	2.2	2.8	Ultimate	1.0		3.8	0.0	1408.57	Inlet at Sag
354+00	5.7	1.9	Ultimate	1.2		2.5	0.6	1408.66	
356+00	3.3	4.1	Ultimate	1.1		4.0	1.2	1409.05	
360+50	9.1	13.4	Ultimate	0.0	15 ft.	12.3	1.1	1410.37	
373+00	6.3	8.0	Ultimate	0.0		5.9	2.1	1408.53	
375+25	1.6	2.1	Ultimate	2.1		3.4	0.8	1407.43	
376+61	1.6	2.0	Ultimate	1.8		3.8	0.0	1407.24	Inlet at Sag
378+00	1.8	2.3	Ultimate	2.2		3.5	1.0	1410.96	
381+00	6.6	8.5	Ultimate	0.0		6.3	2.2	1409.19	
390+00	1.5	1.9	Ultimate	0.0		1.9	0.0	1422.50	
395+25	3.8	5.3	Interim	0.0	10 ft.	3.8	0.0	1429.19	Super Changes D/S
400+00	3.6	4.8	Interim	0.0	5 ft.	3.6	0.0	1432.07	
404+00	5.4	6.6	Interim	0.0	10 ft.	5.4	0.0	1434.25	
410+00	5.1	6.3	Ultimate	0.0	15 ft.	6.3	0.0	1436.71	Super Changes D/S
426+00	4.2	5.3	Ultimate	0.0	5 ft.	4.5	0.8	1435.38	
427+09	1.8	2.2	Ultimate	1.7		3.9	0.0	1435.27	Inlet at Sag
428+40	4.2	5.4	Ultimate	0.0	5 ft.	4.5	0.9	1435.43	
11+00 Ramp D	4.9	4.9	Ultimate	0.0	10 ft.	4.9	0.0		
13+29 Ramp D	1.5	1.5	Ultimate	0.4		1.9	0.0	1422.33	Inlet at Sag
14+80 Ramp D	3.7	4.4	Ultimate	0.0	5 ft.	4.0	0.4	1423.10	
5+00 Ramp B	2.3	2.8	Ultimate	0.0	5 ft.	2.8	0.0	1435.96	
6+86 Ramp B	3.6	4.0	Ultimate	0.1	5 ft.	4.1	0.0	1435.12	Inlet at Sag
10+00 Ramp B	6.5	6.5	Ultimate	0.0	45 ft.	6.4	0.1		
4+80 Ramp C	3.5	3.5	Ultimate	0.0		3.5	0.0		Flowby not allowed.

The median inlets are located where cross culverts are necessary for pavement drainage, where future inlets will be required and where medians end.

SR-51 Median Inlet  
Summary Table

Area No.	Station	Subbasin Data			Slope	Slope	Tc	i	Design Storm	Q	Grate Elev.	Notes
		W	L	Area	Ave	@ Inlet						
		ft	ft	Ac	%	%	min.	in/hr		cfs		
M338	338+00	30	1600	1.10	0.7	0.7	10	6.4	50-yr.	4.9	1415.29	
M345	345+00	30	700	0.48	0.7	0.5	10	6.4	50-yr.	2.2	1410.47	
M352	352+42	30	1200	0.83	0.3	0.0	10	6.4	50-yr.	3.7	1407.91	@ Sag
M357	357+00	30	744	0.51	0.3	0.4	10	6.4	50-yr.	2.3	1408.70	
M373	373+00	30	856	0.59	0.4	0.6	10	6.4	50-yr.	2.6	1407.93	
M376	376+61	30	400	0.28	0.4	0.0	10	6.4	50-yr.	1.2	1406.65	@ Sag
M381	381+00	30	1100	0.76	1.2	1.0	10	6.4	50-yr.	3.4	1408.60	
M390	390+00	30	1000	0.69	0.9	1.7	10	6.4	50-yr.	3.1	1421.91	
M400	400+00	30	500	0.34	0.6	0.5	10	6.4	50-yr.	1.5	1430.20	
M405	405+75	30	1002	0.69	0.3	0.5	10	6.4	50-yr.	3.1	1433.34	
M422	422+80	30	703	0.48	0.3	0.4	10	6.4	50-yr.	2.2	1435.37	
M427	427+09	30	1280	0.88	0.3	0.0	10	6.4	50-yr.	4.0	1434.47	@ Sag

Off pavement inlets, located in the v-ditch or swale adjacent to outside of the roadway curb, are located where other culverts are required and where the swale is at capacity.

SR-51 V-Ditch on West Side of Mainline  
Summary Table

Area No.	Station	Subbasin Data			Slope	Slope	Tc	i	Design Storm	Q	Grate Elev.	Notes
		W	L	Area	Ave	@ Inlet						
		ft	ft	ac	%	%	min	in/hr		cfs		
W352	352+42	Varies	1300	0.82	0.3	0.0	10	6.4	50-yr.	3.7	1411.59	@ Sag
W357	357+00	Varies	470	0.34	0.2	0.4	10	6.4	50-yr.	1.5	1412.65	
GA5	5+52 Ramp A	Varies	1400	0.87	0.1	0.0	10	6.4	50-yr.	3.9	1413.60	@ Sag
W373	373+00	Varies	985	0.81	0.4	0.6	10	6.4	50-yr.	3.6	1408.53	
W376	376+61	Varies	400	0.53	0.1	0.0	10	6.4	50-yr.	2.4	1407.24	@ Sag
W379	379+40	Varies	320	0.59	0.8	0.6	10	6.4	50-yr.	2.6	1408.03	Intercept 100%
W382	382+00	Varies	700	0.75	1.6	1.1	10	6.4	50-yr.	3.4	1410.19	
GC11	11+42 Ramp C	Varies	1050	0.98	1.4	0.0	10	6.4	50-yr.	4.4	1418.69	@ Sag
W390	390+00	Varies	1000	0.98	0.9	1.4	10	6.4	50-yr.	4.4	1421.93	
W400	400+00	Varies	400	0.35	0.5	0.5	10	6.4	50-yr.	1.6	1429.87	
W404	404+00	Varies	600	0.52	0.5	0.5	10	6.4	50-yr.	2.3	1432.05	
W410	410+00	Varies	600	0.41	0.3	0.5	10	6.4	50-yr.	1.8	1436.71	
BA8	8+46 Ramp A	Varies	1400	0.99	0.1	0.0	10	6.4	50-yr.	4.4	1441.45	@ Sag
W427	427+09	Varies	1040	0.99	0.3	0.0	10	6.4	50-yr.	4.4	1435.27	@ Sag

SR-51 V-Ditch on East Side of Mainline  
Summary Table

Area No.	Station	Subbasin Data			Slope Ave	Slope Inlet	Tc	i	Design Storm	Q	Grate Elev.	Notes
		W	L	Area								
		ft	ft	ac	%	%		in/hr		cfs		
E345	345+00	Varies	245	0.11	0.7	0.5	10	6.4	50-yr.	0.5	1410.67	
E352	352+42	Varies	1200	1.01	0.3	0.0	10	6.4	50-yr.	4.5	1408.57	@ Sag
E357	357+00	Varies	450	0.48	0.1	0.4	10	6.4	50-yr.	2.2	1409.37	
GB4	4+50 Ramp B	Varies	1460	0.93	1.2	0.4	10	6.4	50-yr.	4.2	1411.30	
E373	373+00	Varies	950	1.03	0.4	0.6	10	6.4	50-yr.	4.6	1408.53	
E376	376+61	Varies	400	0.79	0.1	0.0	10	6.4	50-yr.	3.5	1407.24	@ Sag
E379	379+40	Varies	1185	1.09	1.4	0.6	10	6.4	50-yr.	4.9	1408.03	Intercept 100%
BD13	13+29 Ramp D	Varies	980	0.76	0.9	0.0	10	6.4	50-yr.	3.4	1422.33	@ Sag
GD14	14+80 Ramp D	Varies	1015	0.79	0.1	0.4	10	6.4	50-yr.	3.5	1423.10	
E400	400+00	Varies	580	0.35	0.5	0.5	10	6.4	50-yr.	1.6	1434.97	
E405	405+80	Varies	425	0.33	0.5	0.5	10	6.4	50-yr.	1.5	1437.16	
E410	410+00	Varies	570	0.56	0.3	0.5	10	6.4	50-yr.	2.5	1436.71	
BB6	6+86 Ramp B	Varies	625	0.80	0.9	0.0	10	6.4	50-yr.	3.6	1435.09	@ Sag
BB9	9+00 Ramp B	Varies	800	0.54	2.9	1.8	10	6.4	50-yr.	2.4	1435.27	
E426	426+00	Varies	375	0.50	0.4	0.1	10	6.4	50-yr.	2.2	1435.39	
E427	427+09	Varies	500	0.81	0.1	0.0	10	6.4	50-yr.	3.6	1435.28	@ Sag

### C. Storm Sewer Design

The on-site storm drain is required to provide an outlet for the storm water which collects in the underpass at Greenway Road. This storm drain is located along the west edge of pavement from Greenway Road south to about Hearn Drive. The storm drain crosses under the freeway and is located between the mainline gutter (east side) and the off-site drainage box culvert south of Hearn Drive. Both the on-site and off-site drainage system outlet at the wingwall of the Indian Bend Wash cross culvert. At the southern end, the on-site storm drain is 84" diameter reinforced concrete pipe (RCP) and is designed on a very flat slope (0.006'/ft) in order to be able to collect mainline pavement drainage at Greenway Road. The velocities in this pipe are above 4 feet per second for the design event. In order to maintain cover on the pipe near the upstream end of the storm drain, the springlines of the pipes are matched when a pipe reduction occurs. This allows a larger pipe slope and therefore a greater conveyance capacity. The first pipe diameter reduction occurs a couple hundred feet south of Greenway Road. At storm drain station 74+85.75, 300 feet north of Greenway Road, the pipe is reduced to a 24" diameter RCP. This portion of the storm drain provides an outlet for the storm water runoff from Greenway Road Ramp C. The storm sewer analysis was performed using a computer program called StormCAD, a product of Haestad Methods. The design parameters for the storm sewer are provided in the following table.

**ON-SITE STORM SEWER DESIGN DATA  
SUMMARY TABLE**

Station	Location	Pipe Size		Length ft.	Q cfs	Vel fps	Elevation			
		Dia	Type				Invert	Soffit	HGL	EGL
19+95	Begin On-site Storm Drain						1397.065	1304.065	1402.14	1402.46
		84"	RCP	490.65	154	5.13	1397.36	1304.36	1402.46	1402.87
24+86	Manhole									
		84"	RCP	490.65	154	5.11	1397.65 <sup>†</sup>	1304.65	1402.77	1403.18
29+76	On-Site Inflow - Sta 338+00									
		84"	RCP	269.30	137	4.32	1397.82	1304.82	1403.17	1403.46
32+46	On-Site Inflow - Sta 340+00									
		84"	RCP	403.57	134	4.13	1398.06	1305.06	1403.53	1403.80
36+49	Manhole									
		84"	RCP	403.57	134	4.19	1398.30	1305.30	1503.69	1403.97
40+53	On-Site Inflow - Sta 348+00									
		84"	RCP	202.69	133	4.05	1398.42	1305.42	1403.96	1404.22
42+56	On-Site Inflow - Sta 350+00									
		84"	RCP	246.36	128	3.83	1398.57	1305.57	1404.22	1404.45
45+02	On-Site Inflow - 352+42									
		84"	RCP	465.81	111	3.29	1398.85	1305.85	1404.50	1404.67
49+68	On-Site Inflow - 357+00									
		84"	RCP	356.32	105	3.11	1399.06	1306.06	1404.69	1404.85
53+24	On-Site Inflow - 360+61									
		84"	RCP	262.90	90	2.68	1399.22	1306.22	1404.84	1405.96
55+87	Manhole									
		84"	RCP	99.54	90	2.68	1399.28	1306.28	1404.94	1405.05
56+86	Manhole									
		84"	RCP	249.94	90	2.68	1399.43	1306.43	1404.06	1405.17
59+36	On-Site Inflow - Greenway Ramp A									
		84"	RCP	650.32	82	2.50	1399.82	1306.82	1405.22	1405.32
65+87	On-Site Inflow - Sta 373+00									
		72"	RCP	224.74	62	2.51	1400.45	1406.45	1405.33	1405.43
68+11	On-Site Inflow - Sta 375+25									
		48"	RCP	135	62	6.64	1402.53	1436.53	1404.91	1405.90
69+46	On-Site Inflow - 376+61									
		36"	RCP	139.27	31	5.11	1403.23	1406.23	1405.89	1406.22
70+86	On-Site Inflow - 378+00									
		36"	RCP	65.93	28	4.76	1403.61	1406.61	1406.14	1406.43
71+52	Manhole									
		36"	RCP	74.07	28	5.85	1404.03	1407.03	1406.30	1406.66
72+26	On-Site Inflow - 379+40									
		36"	RCP	160	22	5.99	1405.19	1408.19	1406.70	1407.30
73+86	On-Site Inflow - Sta 381+00									
		36"	RCP	100	16	4.77	1406.19	1409.19	1407.48	1407.97
74+86	On-Site Inflow - Sta 382+00									
		24"	RCP	284.60	13	5.70	1410.61	1412.61	1411.91	1412.47
77+70	On-Site Inflow - Greenway Ramp C									
		24"	RCP	191.86	9	4.37	1413.40	1415.40	1414.46	1414.88
79+62	Manhole									
		24"	RCP	53.80	9	5.56	1414.59	1516.59	1415.65	1416.07
80+16	On-Site Inflow - Greenway Ramp C									
		24"	RCP	108.14	2	1.37	1415.06	1417.06	1416.07	1416.10
81+24	End of Design Section - Greenway Ramp C									

REF: StormCAD v1.0, Haestad Methods, Inc.

#### D. Main Storm Sewers

The on-site main storm sewer was described in the previous section.

#### E. Outlet Design

The outlet for the on-site storm water is the wingwall of the Indian Bend Wash cross culvert. The hydraulic condition at this location was given to HDR by the design consultant of the Shea to Thunderbird Road section of SR-51. This design consultant will be responsible for the design of the headwall and wingwall for this structure.

#### F. Pump Station

The pump station shown on the conceptual plans at 30% has been replaced by an on-site storm sewer system. There will be no pump station for the SR-51 design section between Thunderbird and Bell Roads.

#### G. Special Problems

Two major interchanges are within this design section. The mainline elevation at the Greenway Road interchange is substantially below the off-site drainage system and therefore, the on-site storm drain is required. The mainline elevation had to be raise over two feet in order to get the on-site storm drain to function.

#### IV. OFF-SITE DRAINAGE

The off-site storm drain system is designed to collect all the off-site storm water runoff which enters the SR-51 right-of-way. In addition, the off-site storm drain collects on-site storm water from the pavement north of Greenway (Sta. 390+00). Where the energy gradeline (EGL) allows, on-site runoff south of Greenway is collected in the off-site storm drain.

##### A. General Discussion

The off-site drainage will be collected along the east right-of-way of SR-51. The existing streets convey runoff from the developed areas. Existing storm drains that cross the SR-51 alignment at Greenway Road and 36th Street will be collected in the off-site storm drain. The future Bell Road storm drain will also be integrated into the SR-51 off-site storm drain system. The major arterials, Bell Road and Greenway Road, cross over the depressed freeway mainline. The Greenway Road arterial is being designed such that storm water will runoff to the east into 36th Street. Runoff from the Greenway Road structure will be collected in the 36th Street storm drain. As part of the Bell Road improvements, the City of Phoenix plans to install a storm drain. The current plans will have to be updated as there is no consideration for the SR-51 facility. The storm drain will have to be re-designed to account for SR-51 and the proposed drainage system. As part of that re-design, catch basin inlets should be installed at the sump location created by the Bell Road structure. The Bell Road storm drain east of the SR-51 alignment will be collected into the off-site drainage system for SR-51 via the 36th Street storm drain.

##### B. Inlet/Catch Basin (CB) Spacing Design

Storm water inlets are provided at locations where off-site drainage enters the SR-51 right-of-way and where small local right-of-way areas concentrate storm water within the right-of-way. A table is provided which summarizes the design data used at these off-site locations.

Station	Location	Inlet Type	Design Discharge
337+00	North of Hearn Road	Area	14.3
344+60	Gelding Drive	Curb & Area	66
355+00	South of Claire Drive	Area	7.2
363+00	South of Nisbet Drive	Area	1.3
367+00	North of Blanche Drive	Area	62.3
373+00	North of Greenway Lane	Area	3.4
380+35	South of Beck Lane	Area	6.7
384+50	North of Betty Elyse Lane	Area	4.2
393+00	North of Tierra Buena Ln.	Area	21.2
405+75	Paradise Lane	Area	8.5
416+00	Kings Avenue	Area	3.6

##### C. Coordination with Adjacent Design Sections and Local Agencies

The SR-51 section to the south of the HDR section is currently under design by another Consultant. Significant coordination is required with this consultant as they are designing the outlet channel for the HDR section storm drain. A section designer for the section north of Bell

Road has not been selected. HDR is, however, providing for the storm water runoff from this section so that the Union Hills Drive under pass can be drained by gravity and so that conveyance capacity is available for the off-site storm water runoff.

Coordination with the City of Phoenix for the re-design of the Bell Road storm drain remains a critical issue.

#### D. Channel Design

There are no major channels within HDR's design section. A shallow channel will be required between the outlet channel for the SR-15 drainage system (approximately at Ludlow Drive) and Friess Drive. This channel will collect flows from the neighborhood drainage swales which flow between the residences along the west side of 34th Place. These flows will be introduced into the lined Indian Bend Wash channel immediately downstream of the outlet location for the storm drain system.

#### E. Detention Basin Design

There are no major detention basins within HDR's design section.

#### F. Outfall Design

The outfall for the off-site storm drain is Indian Bend Wash, north of Thunderbird. The outlet is being designed by another consultant.

#### G. Box Culvert

The lower segment of the off-site storm drain between Thunderbird Road and Paradise Lane is designed as a box culvert because of the large concentrated discharge and is discussed in a later section of this report.

#### H. Pipe Culvert

North of the 36th Street storm drain inflow location (Paradise Lane), the off-site storm drain discharge reduces to the rate where a circular pipe can be used economically to convey the concentrated flows. This pipe is a 72 inch reinforced concrete pipe and does not reduce in size until upstream of the Bell Road storm drain inflow location. The HDR project design limits end about 350 feet north of Bell Road. The storm drain will be extended to Station 435+65 where a manhole will terminate the design section. A 72 inch pipe will be used for this extension in order not to limit the upstream section designers ability to convey runoff to this system.

#### I. Special Problems

A special problem exists on 34th Place and Ludlow Drive, just north of Thunderbird Road. Two shallow channels collect runoff from 34th Place and convey it into the right-of-way. The capacity of these two channels is not large and at flow depths of a few tenths of a foot, storm water breaks to the south and gets in Thunderbird Road. These flows will have to be collected by the Consultant designing the Thunderbird crossing.

There are some specific design constraints which were considered in the design of the off-site storm drain system. The following table outlines these design constraints.

## SR-51 OFF-SITE STORM DRAIN DESIGN CONSTRAINTS

Existing Facility	SR-51 Station	Elevation Limitation
Indian Bend Wash cross culvert headwall	328+18 (129' east)	Inv. Elev. = 1397.065
12" Sanitary Sleeve Crossing	336+73	
Greenway Road Storm Drain (24" RCP)	378+80 (180' east)	Inv. Elev. = 1421.42
Waltann Lane Sanitary Sewer (42")	387+41 (169' east)	Inv. Elev. = 1409.87
36th Street Storm Drain (42" RCP)	400+00 (C/L)	Pv'mnt Elev. = 1432.42
36th Street Storm Drain (42" RCP)	400+00 (120' west)	Inv. Elev. = 1429.13
Bell Road	427+09.1 (C/L)	Pv'mnt Elev. = 1436.18

There is another significant special problem which must be accounted for in the roadway design. Three local streets terminate at the SR-51 east right-of-way which will require special consideration in order to effectively and efficiently remove collected storm water runoff to the off-site drainage facility. These streets are Beck Lane, north of Greenway Road and Janice Way and Blanche Drive, south of Greenway. Curb depression and scuppers are required at the west terminus of these three streets in order to allow runoff to reach adjacent area inlets. Both Beck Lane and Janice Way have minor flows which can be conveyed in scuppers. Blanche Drive is a local drainage collector and has a discharge of 60 cfs. This magnitude of flow requires a depressed curb section along the north quarter of the cul-de-sac. Bollards or other access restriction devices will be required in order to prevent vehicular access to the right-of-way area north of Blanche Drive. The following table summarizes the required street design parameters.

Location	Design Discharge	Gutter Elevation	Length of Opening
Blanche Drive	60		65 ft.
Janice Way	5.5		6 ft.
Beck Lane	1.5		2 ft.

### J. Storm Drain Summary

The storm drain was designed to convey the off-site storm water runoff from the area south of the Central Arizona Project. This storm drain collects and conveys this runoff to the Indian Bend Wash flood control channel at Thunderbird Road. The design allows for on-site runoff to be collected in this storm drain also. The design of the system is based on the 50-year water surface elevation in Indian Bend Wash, north of Thunderbird Road. The storm drain sizes are summarized in the following table. The southern end of the storm drain is sized as a pressure culvert. As the flows decrease in an upstream direction, the culvert size is decreased and the storm drain is designed as open channel flow.

**SR-51 OFF-SITE STORM DRAIN CULVERT  
SUMMARY TABLE**

Sta.	Location	Pipe Size		L	Q	V	Elevation		
		W	H				Invert	HGL	EGL
9+95	Begin Off-site SD						1397.07	1402.14	1402.46
		10	6	855	409	10	1399.63	1403.53	1405.24
18+50	12" Sanitary Sleeve							1403.81	1405.54
		8	6	762	409	10	1401.92	1406.77	1408.49
26+12	Gelding Drive							1407.20	1408.85
		8	6	2332	368	10	1408.91	1413.41	1415.06
49+44	Blanche Drive							1413.49	1415.12
		8	6	1098	361	10	1413.02	1416.62	1418.26
60+42	Greenway Road							1417.67	1418.98
		8	6	2262	282	9	4118.99	1422.82	1424.13
83+04	36th St. SD							1423.00	1424.59
		72"	RCP	196	241	10	1419.60	1424.49	1426.07
85+00	Angle Point							1424.57	1426.15
		72"	RCP	70	241	10	1419.81	1424.78	1426.37
85+70	Angle Point							1424.86	1426.45
		72"	RCP	192	241	10	1420.41	1425.46	1427.04
87+62	Paradise Lane							1425.54	1427.12
		72"	RCP	438	241	10	1421.77	1426.64	1428.23
92+00	Local Off-site							1426.72	1428.30
		72"	RCP	300	241	10	1422.70	1427.57	1429.16
95+00	On-Site							1427.65	1429.23
		72"	RCP	2441	241	10	1423.44	1428.30	1429.89
97+41	Kings Avenue							1428.38	1429.97
		72"	RCP	255	241	10	1424.23	1429.11	1430.69
99+96	On-Site							1429.19	1430.77
		72"	RCP	184	241	10	1424.80	1429.76	1431.34
101+80	On-Site							1430.15	1431.74
		72"	RCP	215	241	10	1425.47	1430.33	1431.91
103+93	On-site & Off-site							1430.65	1432.23
		72"	RCP	49	241	10	1425.62	1430.80	1432.38
104+44	On-Site & Off-site							1431.12	1432.70
		72"	RCP	435	241	10	1426.97	1431.85	1433.43
108+79	On-Site - Bell Sump							1432.24	1433.83
		72"	RCP	551	241	10	1428.68	1433.54	1435.12
114+30	Bell Road							1433.91	1435.44
		72"	RCP	230	198	10	1429.39	1433.50	1435.03
116+60	End Pvm't - Ramp D							1433.81	1435.34
		72"	RCP	75	198	10	1429.62	1434.04	1435.57
117+35	End Design Section							1434.35	1435.87

Off-site storm water inlets, curb openings and area inlets will be located through-out the design reach to collect both concentrated off-site runoff and also local right-of-way runoff. Several of the small local drainage areas could be sold to others which would eliminate the need to provide

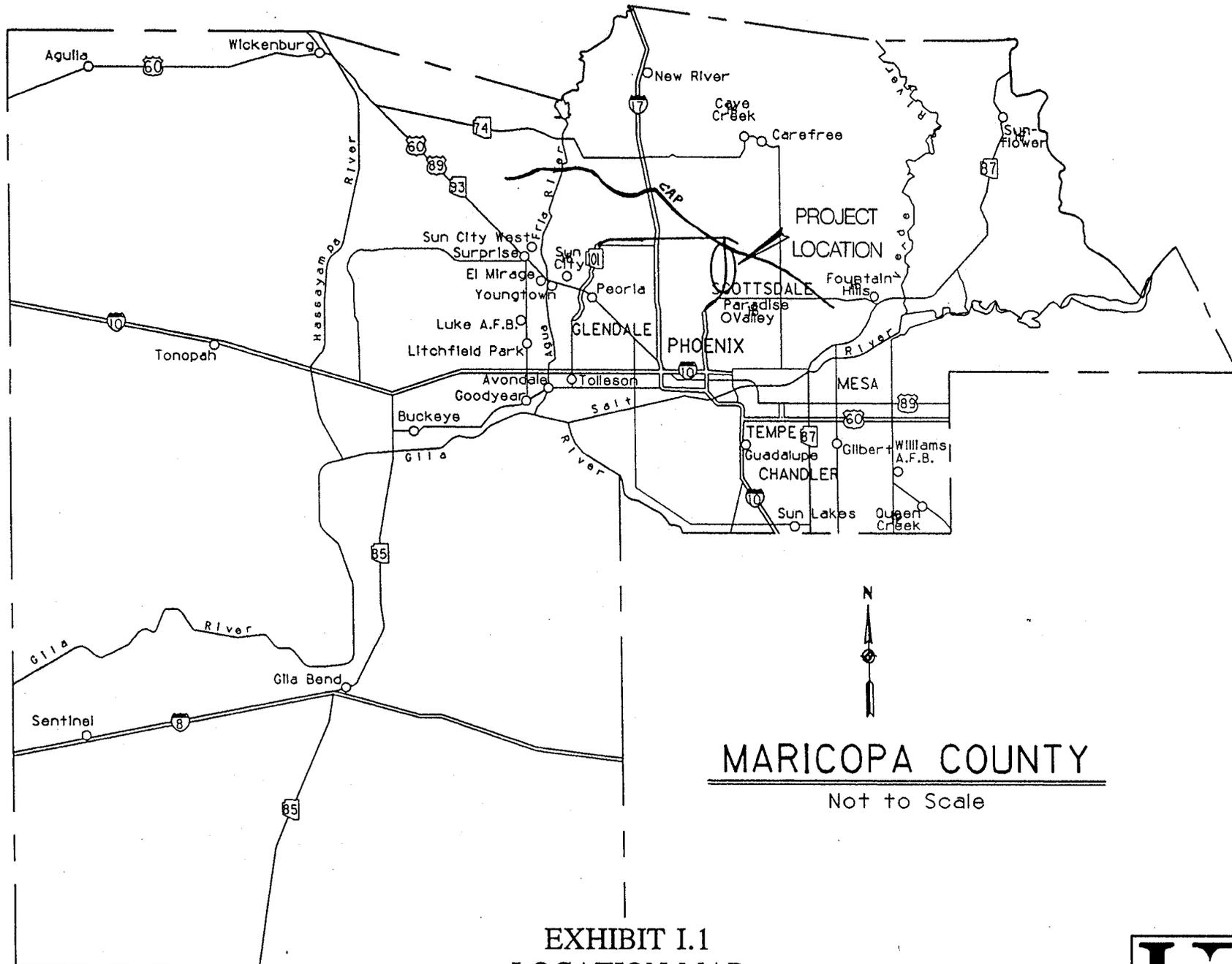
drainage conveyance into the SR-51 off-site drainage system. HDR will meet with ADOT property management to determine which inlets will be removed because of the liquidation of excess property.

In addition to the locations identified above, three storm drains will also discharge into the off-site storm drain system. The three are the Greenway Road storm drain, the 36th Street storm drain, and the proposed Bell Road storm drain. The existing 24" storm drain in Greenway Road will be connected to the off-site storm drain near the east right-of-way. The storm drain is located about 20 feet north of the Greenway Road monument line and flows to the west. A new manhole will be added about 18 feet east of the off-site storm drain and will be connected to this reinforced concrete box culvert. The existing storm drain will be used to collect storm water from east of the SR-51 alignment near 36th Street. The section of existing storm drain between Greenway Road Stations 19+00 and 22+44 will be removed. Interchange runoff from the west side of Greenway Road overpass bridge and the immediate ramp areas is conveyed to the mainline drainage system via Ramps A and C.

An existing storm drain in 36th Street will also be connected into the off-site storm drain. The storm drain is located about 4 feet west of the 36th Street monument line and flows to the south. The existing 60" storm drain in 36th Street will be connected near the east right-of-way and will have to be conveyed under the SR-51 mainline. A new manhole will be added at SR-51 Station 401+35 and will be connected to the reinforced concrete box culvert by a pipe segment. An area inlet will be added in 36th Street at the new manhole. This inlet will collect storm water runoff from 36th Street. The section of existing storm drain between SR-51 station 401+35 and 392+30 (Tierra Buena Lane East) will be removed.

A 36" storm drain is proposed in the Bell Road improvement plans east of the SR-51 alignment. It is proposed to be located 4 feet north of the Bell Road monument line. A pipe size change, from a 24", occurs at 37th Court to account for future inflow from what was an undeveloped parcel at the time of the design. The property is being developed with 100-year 2-hour retention and therefore, for the design frequency of the storm drain, no additional inflow will occur at this location. East of the off-site storm drain This storm drain (36") will be introduced into the off-site storm drain for SR-51. Only the section of storm drain from the off-site storm drain east of SR-51 to the profile sag location (Bell Road Overpass Station 25+25) created by the Bell Road overpass will be constructed by the SR-51 project.

EXHIBITS



**MARICOPA COUNTY**

Not to Scale

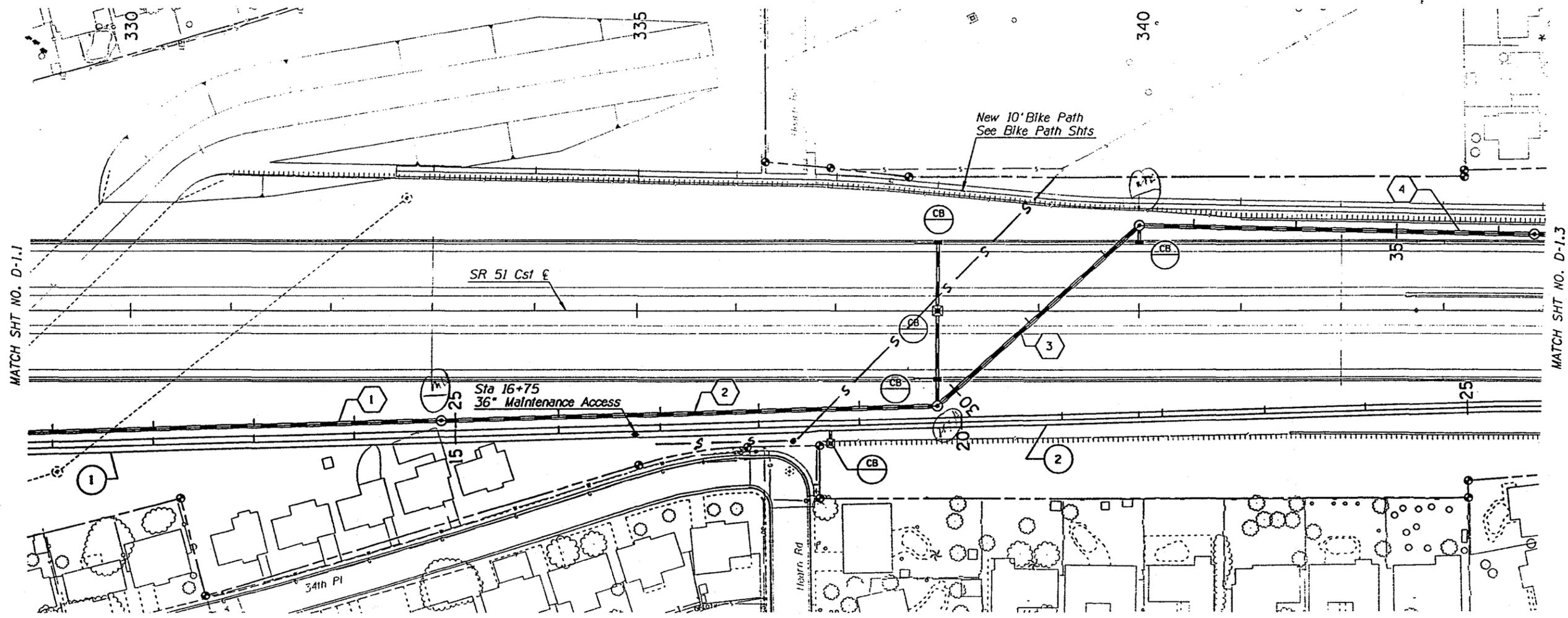
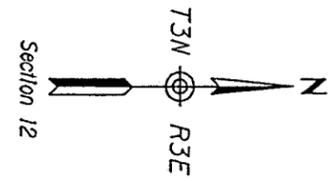
EXHIBIT I.1  
LOCATION MAP





F.A.R.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					

SOCCER FIELD



MATCH SHT NO. D-1.1

MATCH SHT NO. D-1.3

**EXHIBIT L2  
REDUCED DRAINAGE PLANS**

60% SUBMITTAL

DESIGN	JJ	DATE	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
DRAWN	WH			
CHECKED				
<b>HDR</b> HDR Engineering, Inc.			SR 51 DRAINAGE PLAN Sta 329+00 to 344+00	
ROUTE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD	SHEET D-1.2 OF



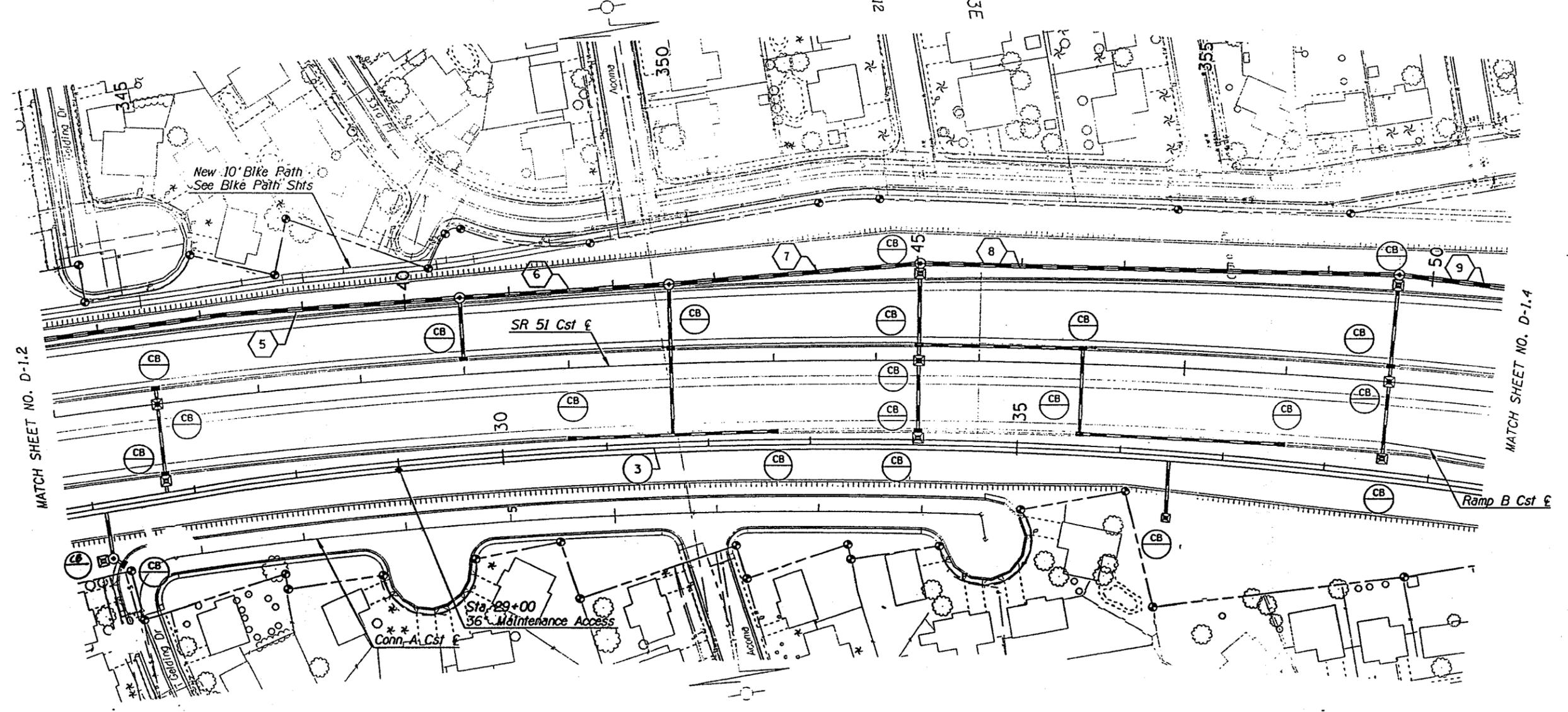
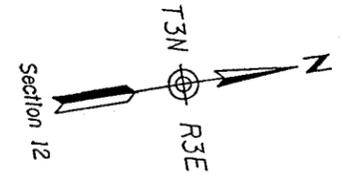
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9	ARIZ.	600-2-522			

051-MA-011



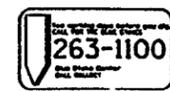
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MATCH SHEET NO. D-1.4

**EXHIBIT I.2  
REDUCED DRAINAGE PLANS**

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CHECKED					
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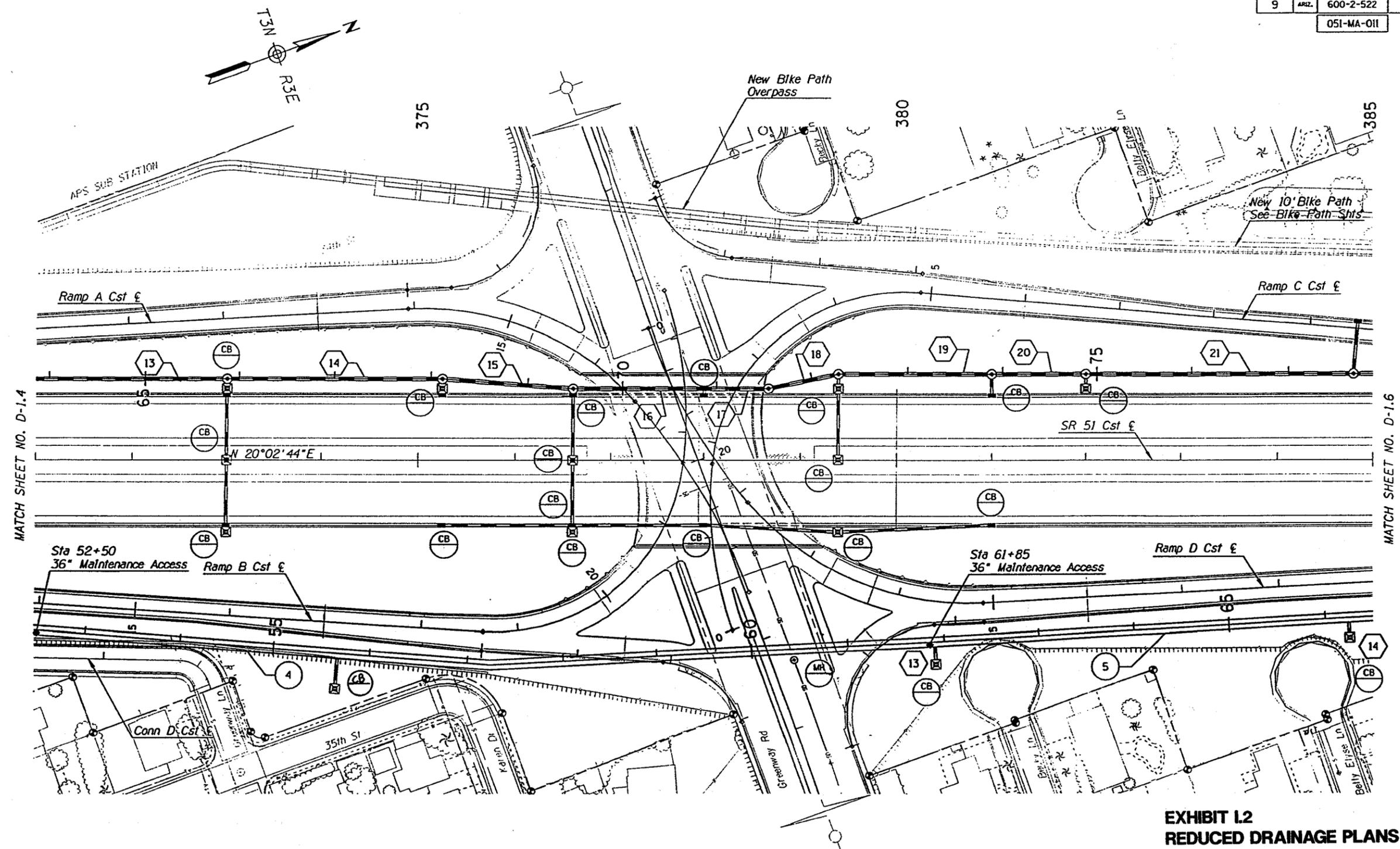
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051-MA-011					



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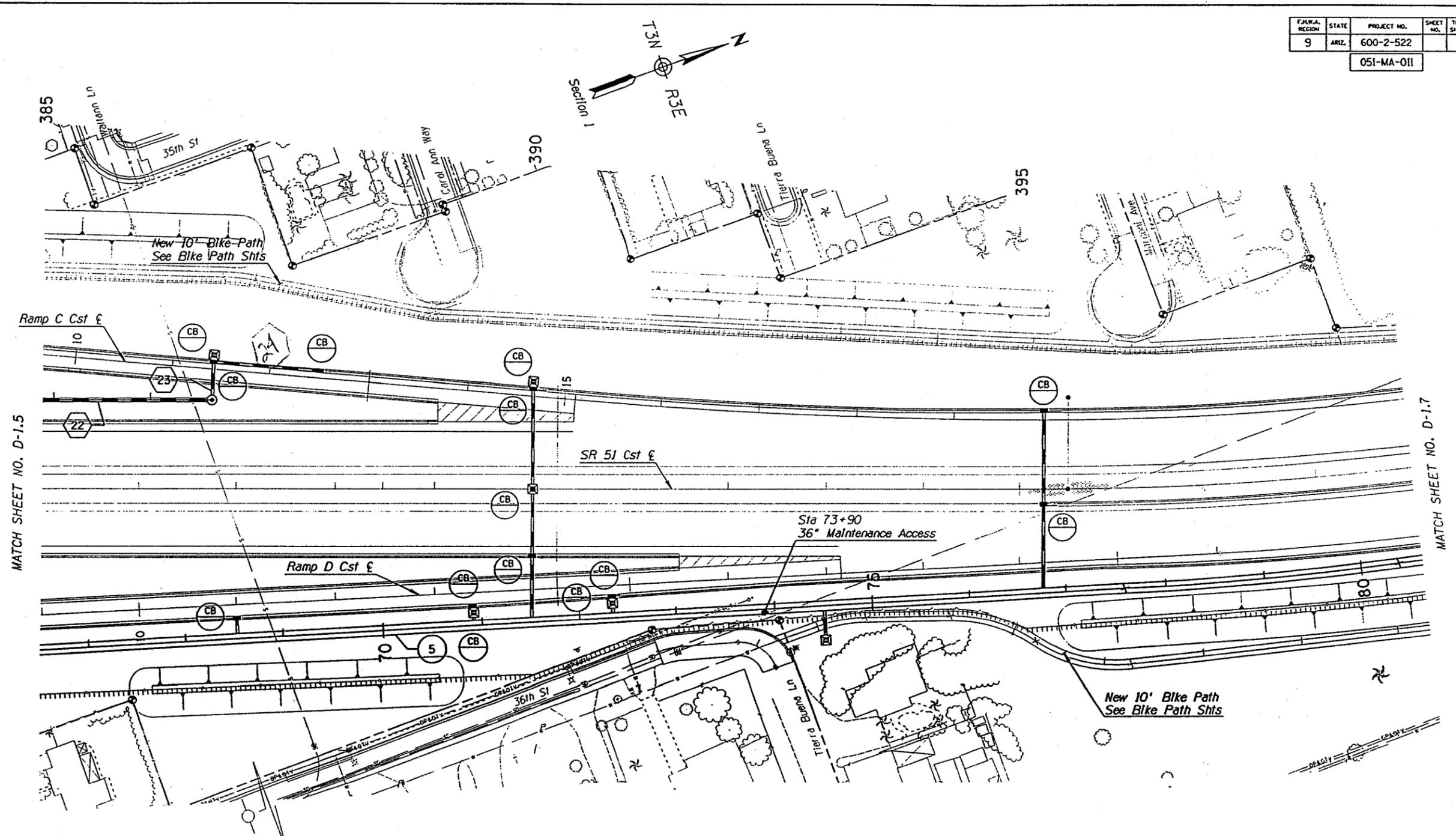
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TRACS NO. H 4047 OIC			600-2-522	SHEET D-15 OF <u>  </u> OF <u>  </u>	

FALWA REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			

051-MA-011



MATCH SHEET NO. D-1.5

MATCH SHEET NO. D-1.7

**EXHIBIT 1.2  
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60% SUBMITTAL

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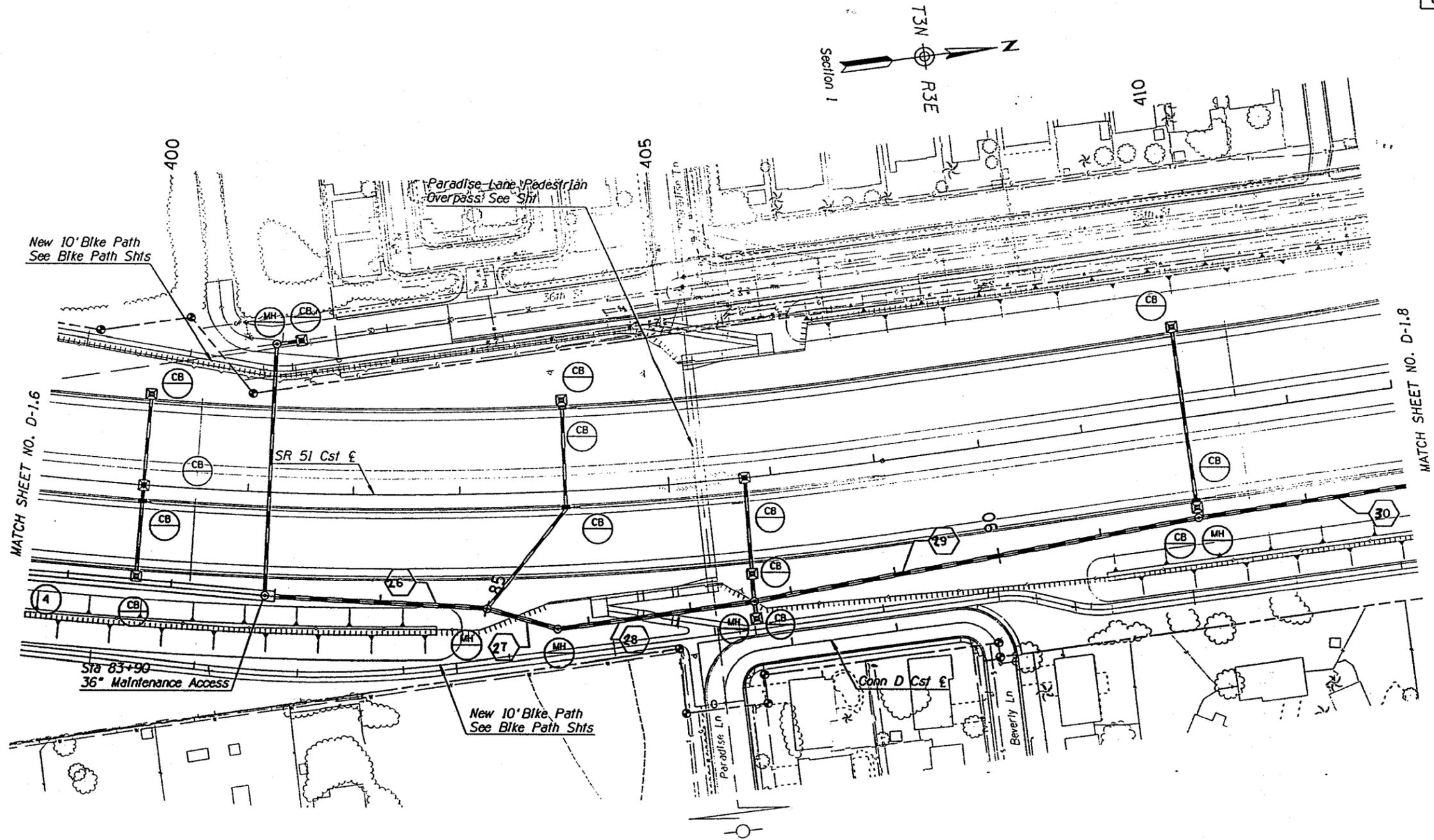


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051-MA-011					



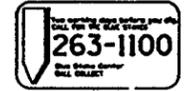
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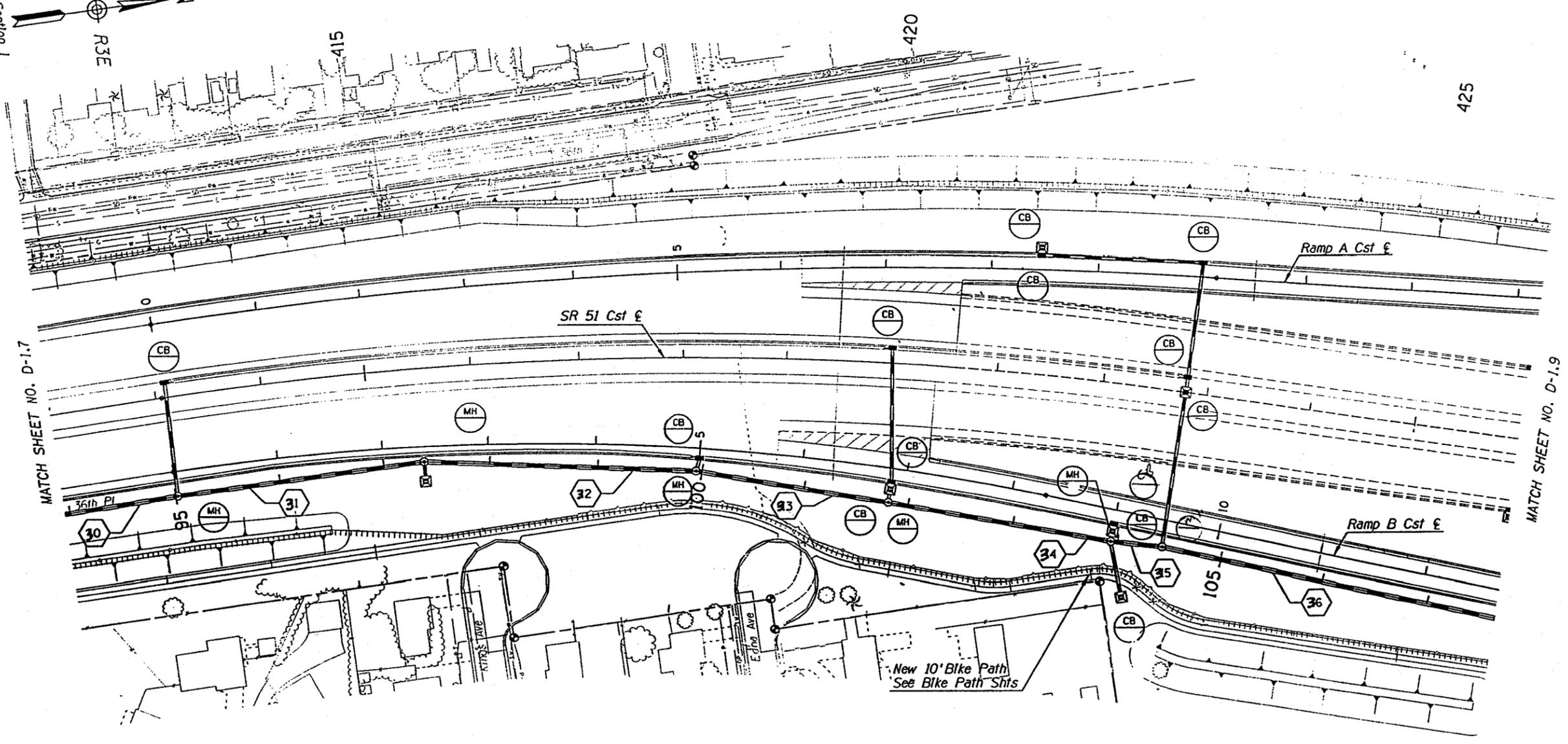
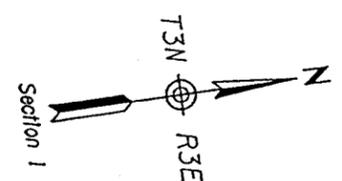
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SR 51	THUNDERBIRD ROAD TO BELL ROAD			



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051-MA-011					



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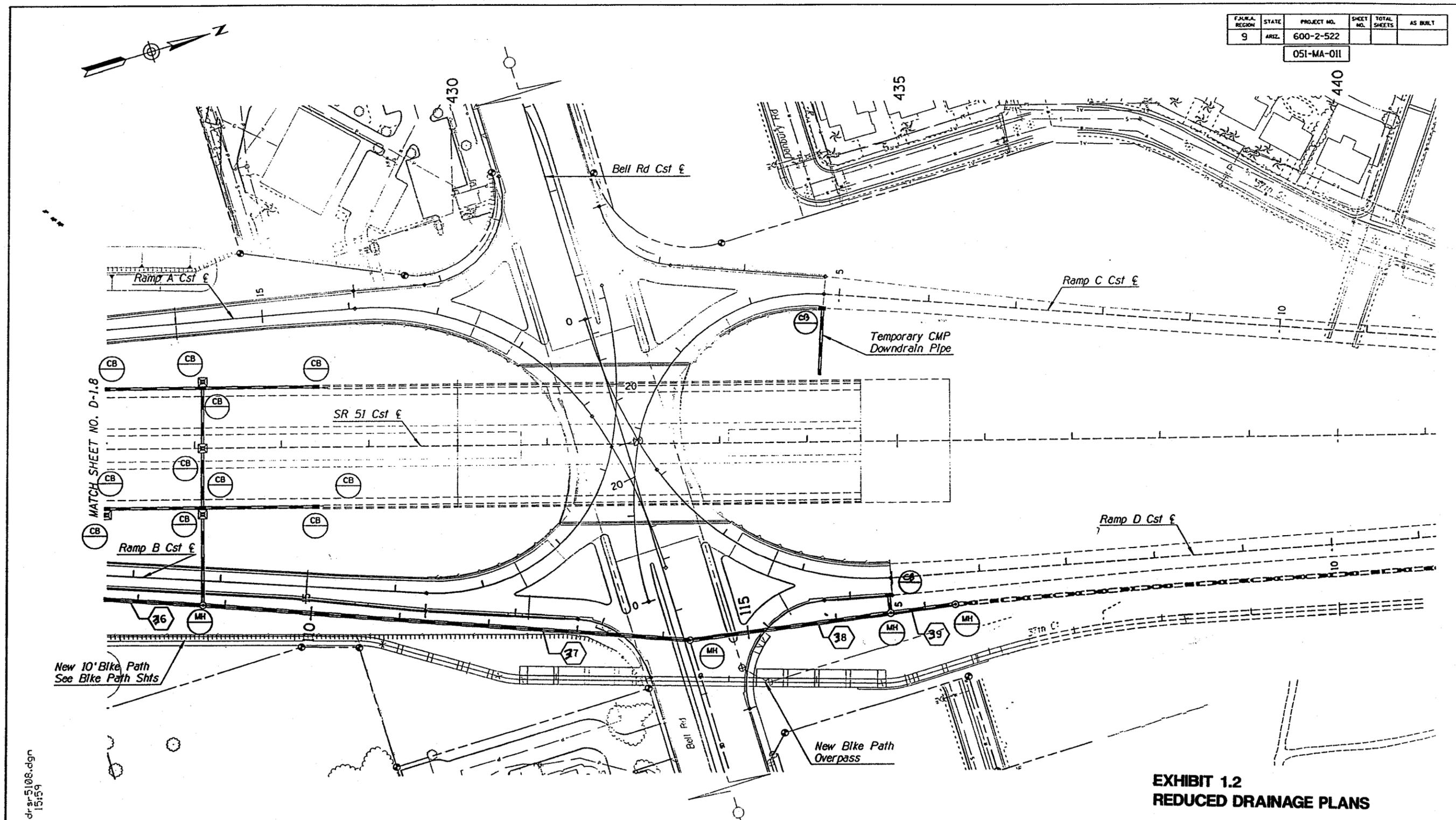
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ROUTE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD		



TRACS NO. H 4047 OIC      600-2-522      OF

DATE	LOCATION	DATE

FEDERAL REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
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051-MA-011					



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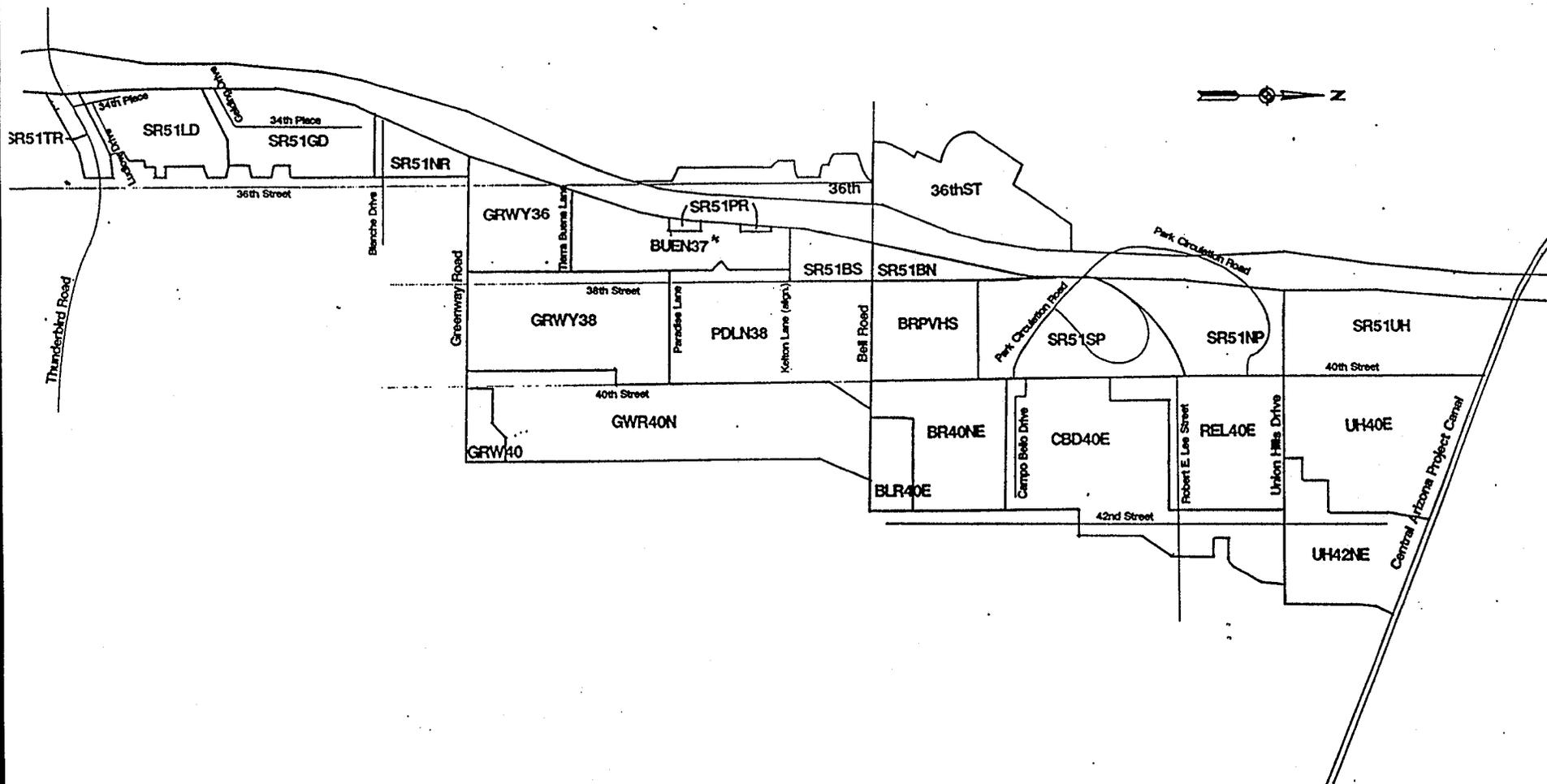
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ROUTE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD		



TRACS NO. H 4047 OIC	600-2-522	OF
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DATE	
TIME	
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DESCRIPTION	

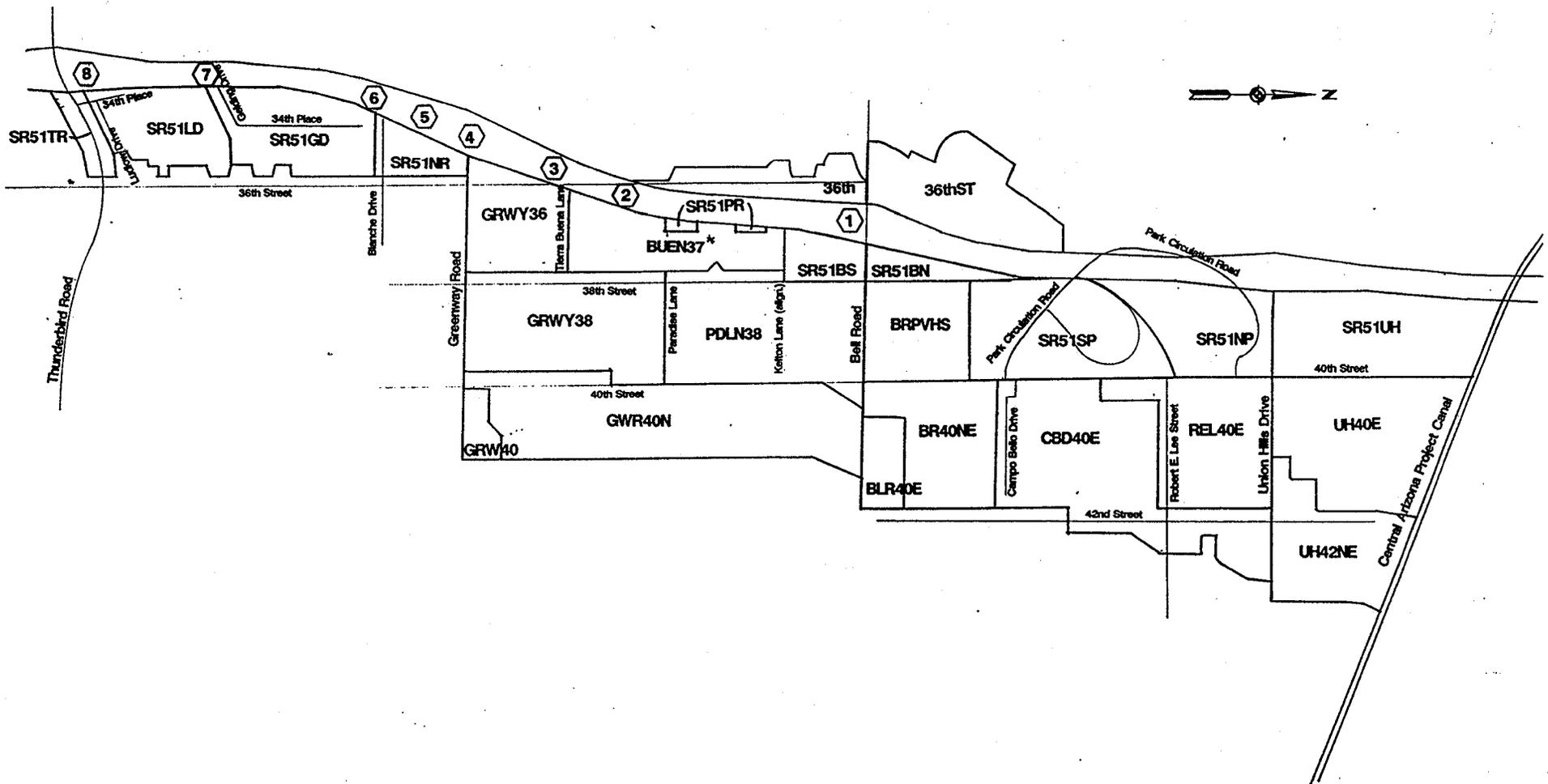
\*\*\*\*\*OEM-SPECIFICATION\*\*\*\*\*  
\*\*\*\*\*SYSTEM\*\*\*\*\*



\* E:EN37 Flows Into 36th Street Storm Drain at Tierra Buena

## EXHIBIT II.1 OFF-SITE DRAINAGE AREA MAP





\* BUEN37 Flows into 36th Street Storm Drain at Tierra Buena

LOCATION  
DISCHARGE (cfs)

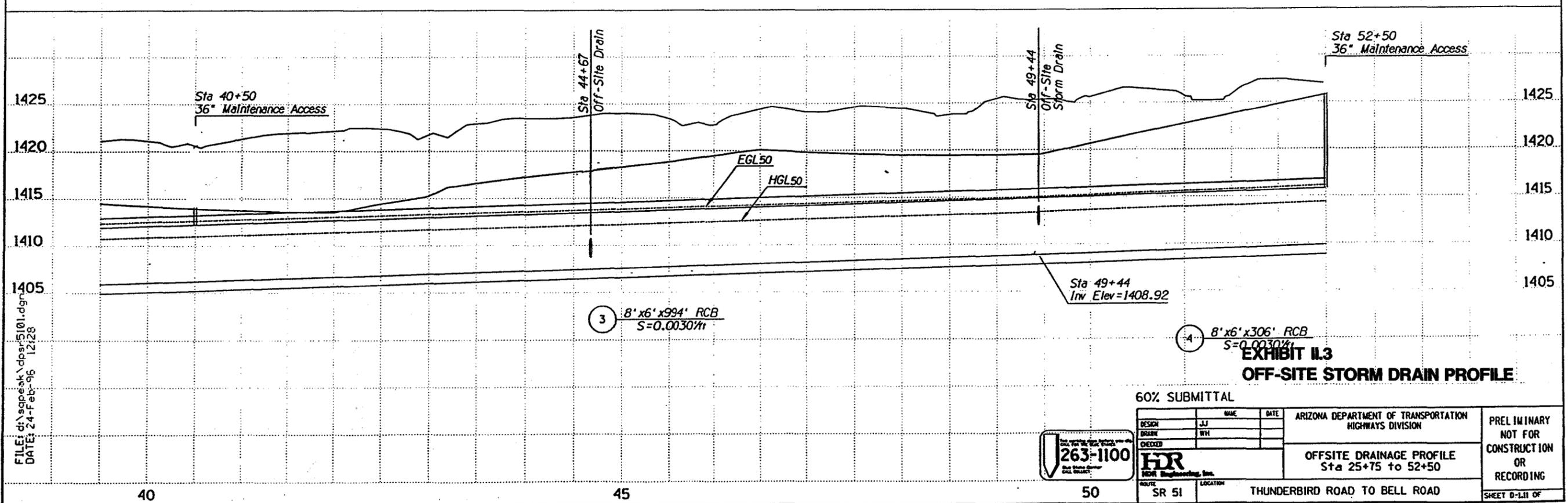
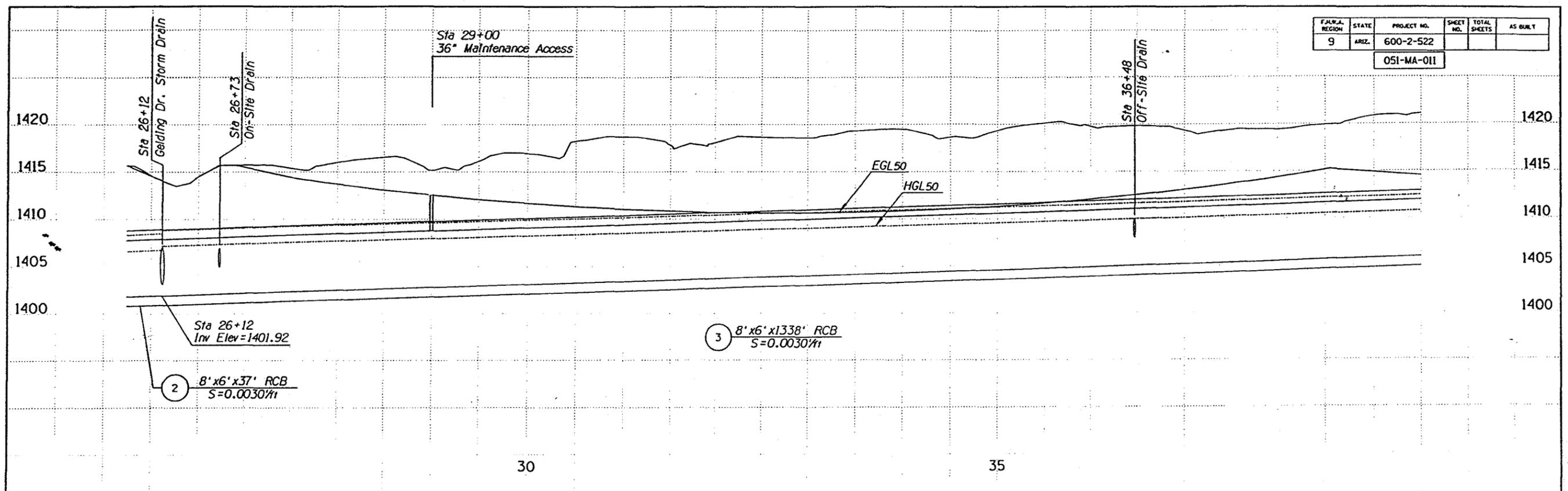
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241	282	282	361	268	368	409	490

## EXHIBIT II.2 OFF-SITE PEAK FLOW SUMMARY MAP





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9	ARIZ.	600-2-522			
051-MA-011					

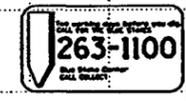


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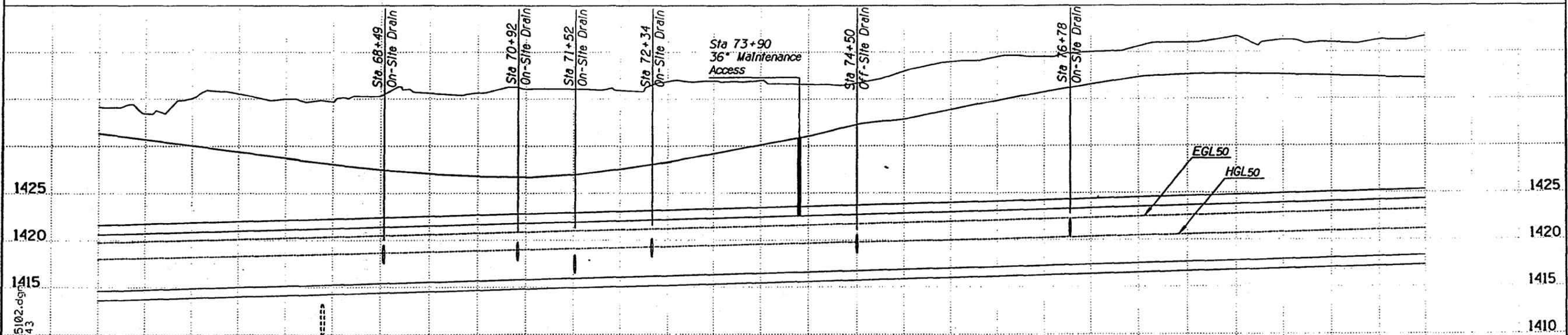
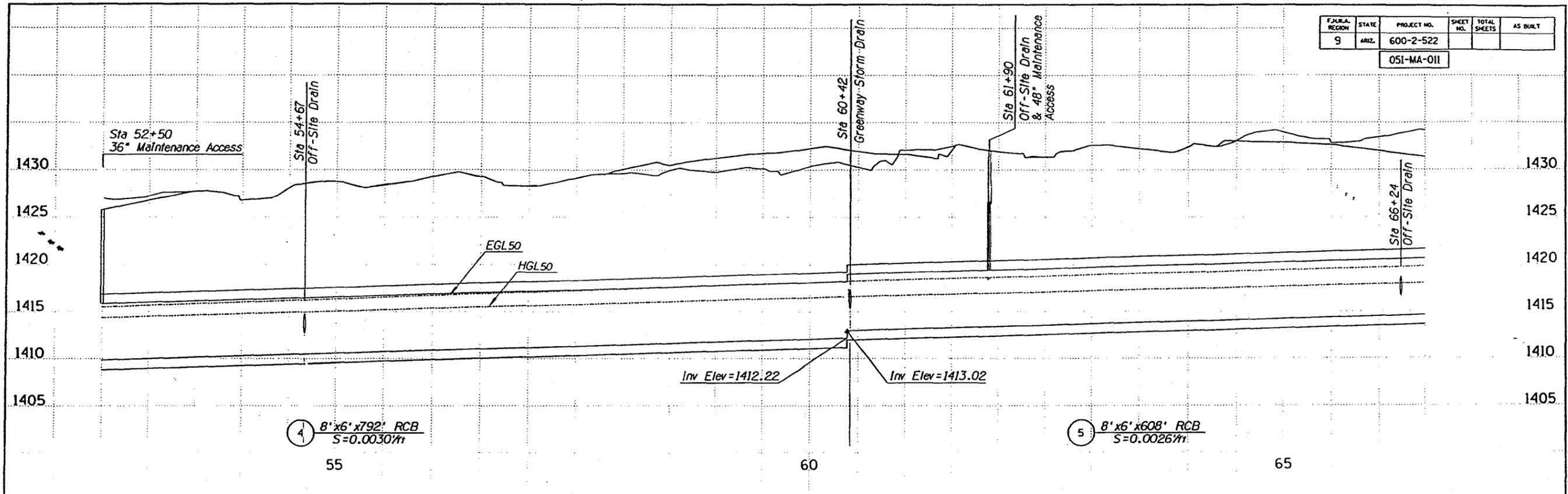
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CHECKED					
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ROUTE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD		



F.A.R.M.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



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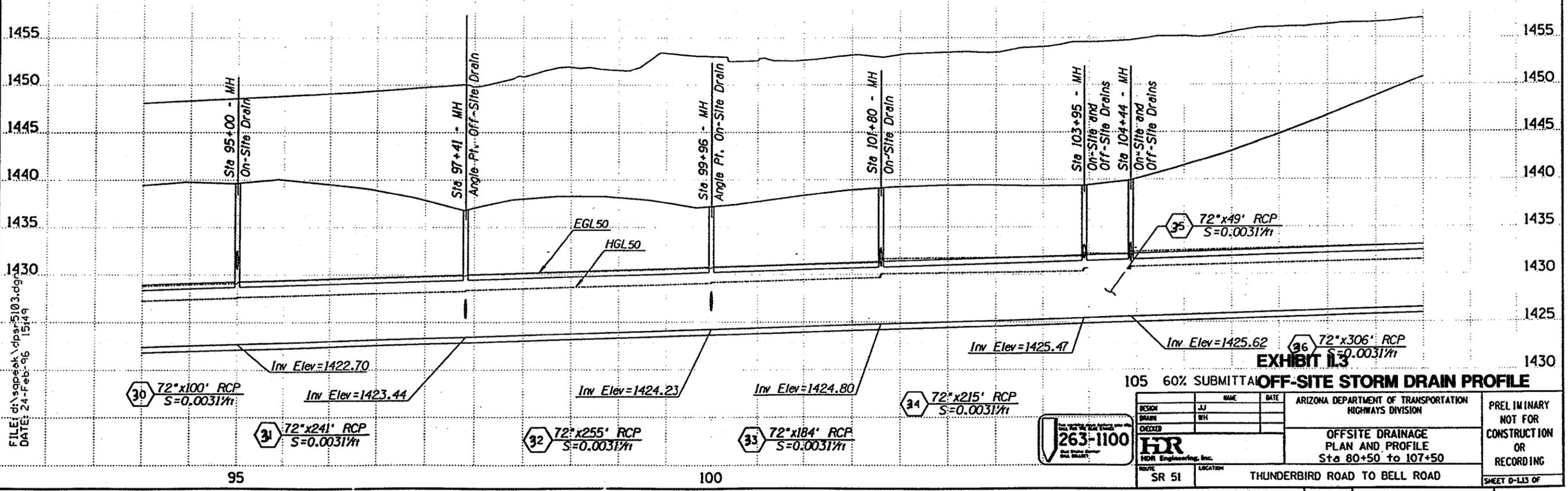
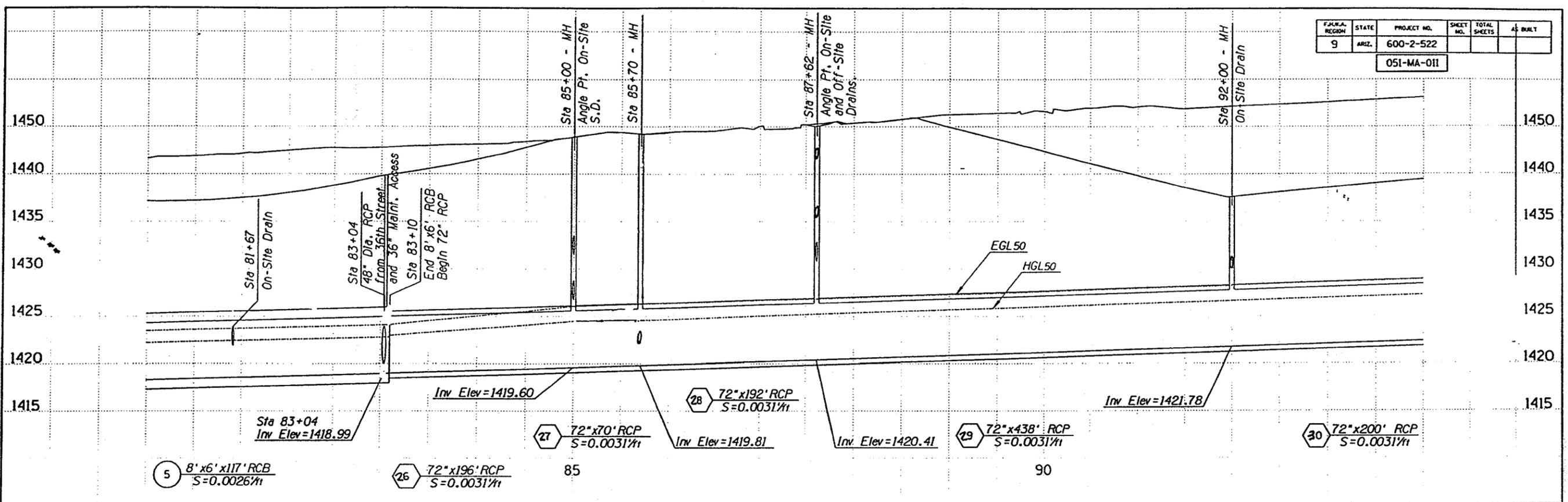
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OFF-SITE STORM DRAIN PROFILE**

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		PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING	
ROUTE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD
TRACS NO. H 4047 OIC		600-2-522	
		SHEET D-112 OF	



\*\*\*\*\*NON-SPECIFICATION\*\*\*\*\*  
\*\*\*\*\*SYSTEM\*\*\*\*\*

F.P.C.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



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**EXHIBIT I.3 OFF-SITE STORM DRAIN PROFILE**

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CHECKED			
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263-1100

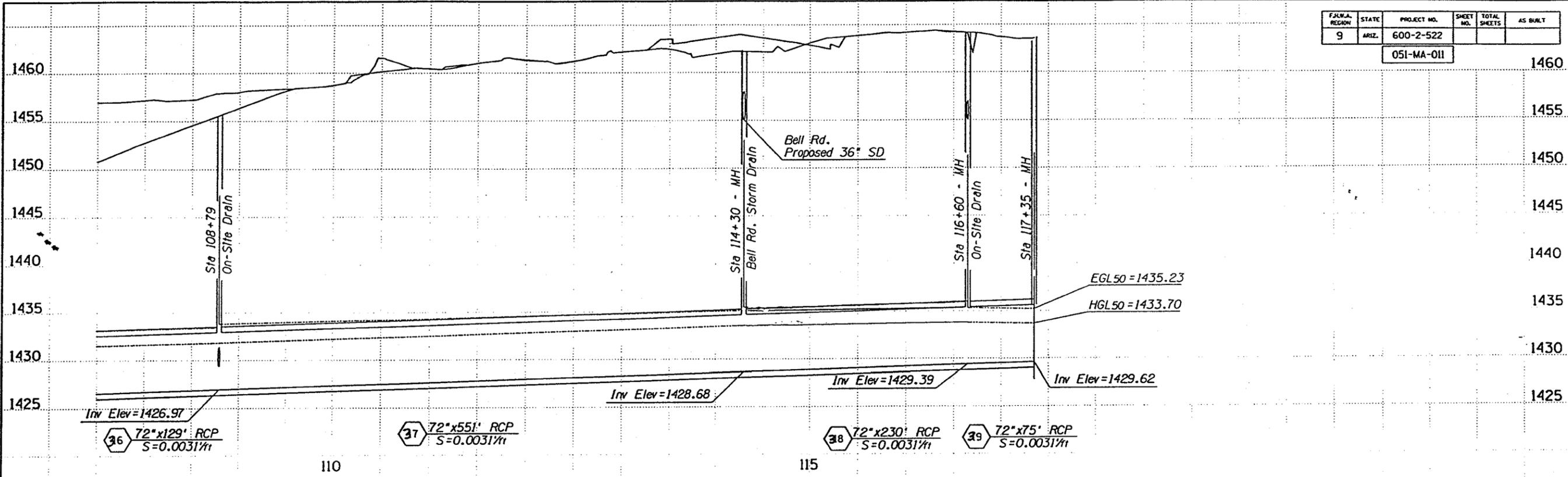
105 60% SUBMITTAL

ARIZONA DEPARTMENT OF TRANSPORTATION  
HIGHWAYS DIVISION

OFFSITE DRAINAGE  
PLAN AND PROFILE  
Sta 80+50 to 107+50

PRELIMINARY  
NOT FOR  
CONSTRUCTION  
OR  
RECORDING

F.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
					051-MA-011



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DATE	TIME	BY	REVISION	LOCATION	DATE

**EXHIBIT II.3  
OFF-SITE STORM DRAIN PROFILE**

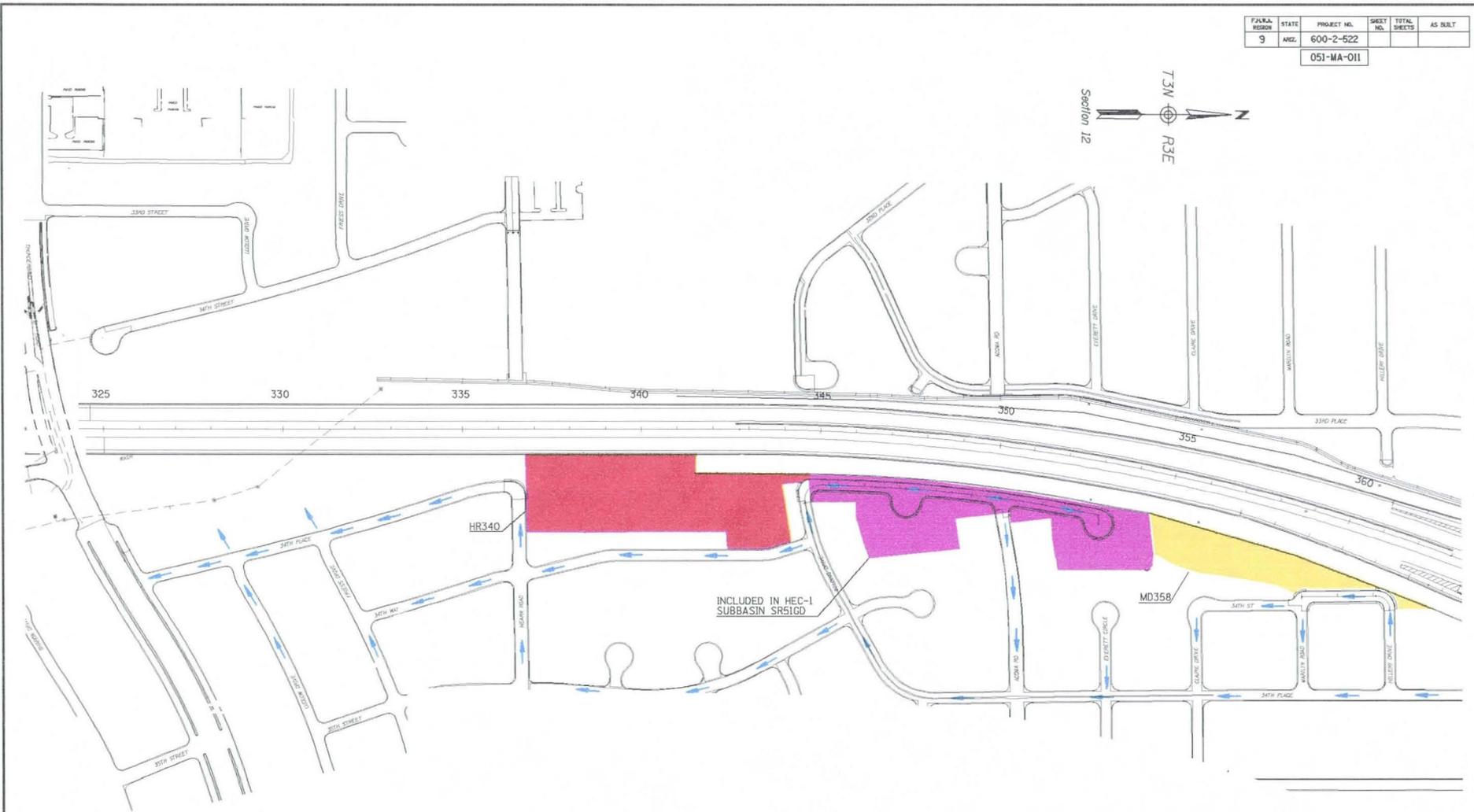
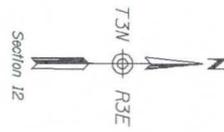
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ROUTE SR 51	LOCATION THUNDERBIRD ROAD TO BELL ROAD		

TRACS NO. H 4047 OIC      600-2-522      OF

FALSA REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



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NO.	DESCRIPTION	DATE

**EXHIBIT II.4  
OFF-SITE DRAINAGE AREA MAP FOR IMMEDIATE AREAS**

60% SUBMITTAL

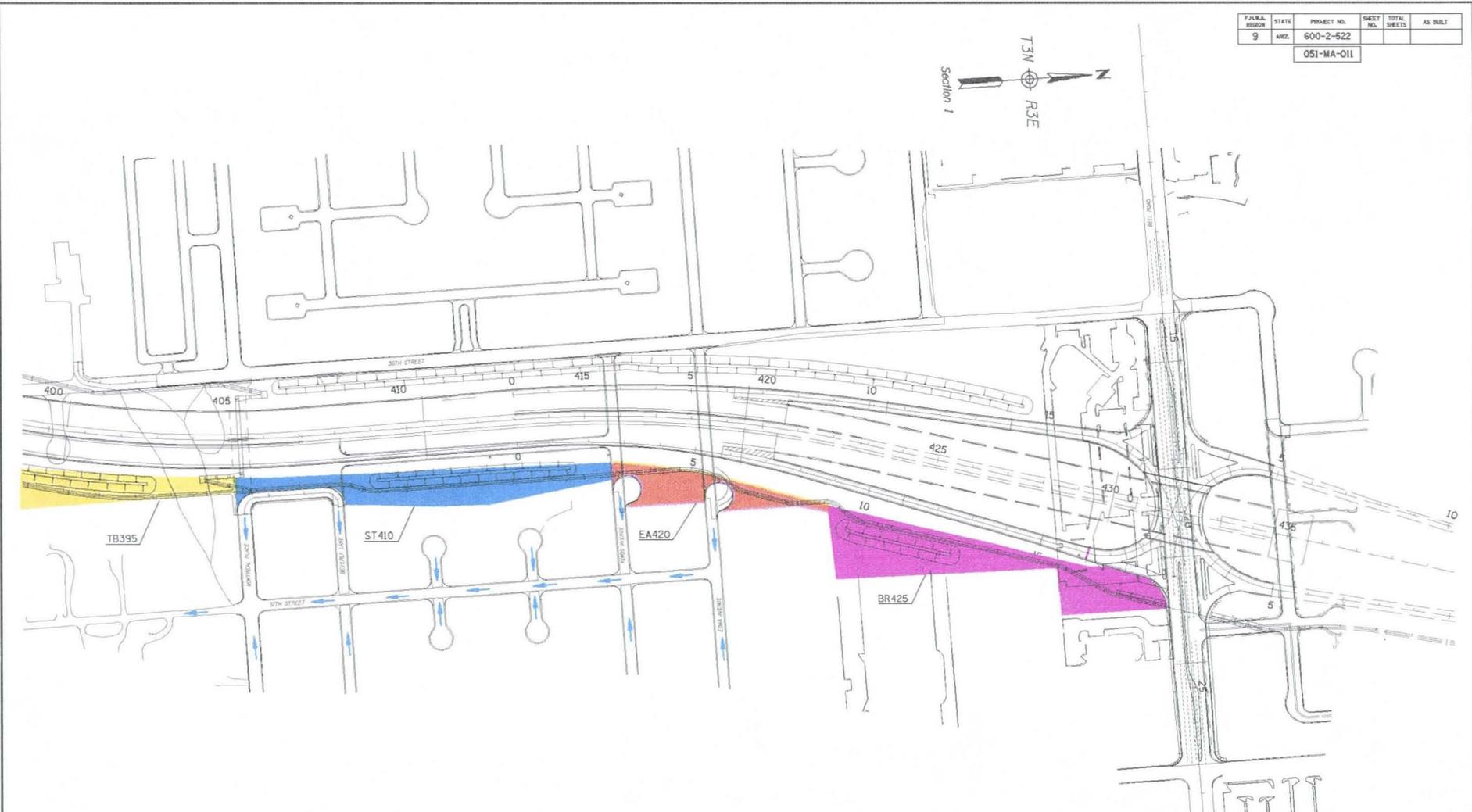
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CHECKED				
HR Engineering, Inc.				
ROUTE	LOCATION			
SR 51	THUNDERBIRD ROAD TO BELL ROAD			
				SHEET D- OF

TRACS NO. H 404T OIC      600-2-522      OF



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DATE	LOCATION	REVISIONS



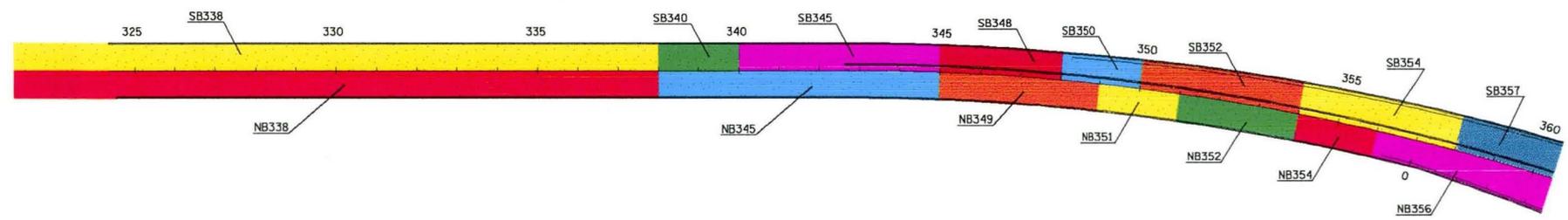
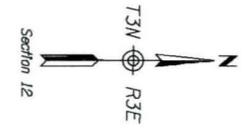
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9	ARIZ.	600-2-522			

051-MA-011

60% SUBMITTAL

DESIGN	SM	DATE	2-96	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
DRAWN	KJ	DATE	2-96		
CHECKED				SR 51 PAVEMENT DRAINAGE SUBBASINS Sta 400+00 to 438+00	
DATE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD		SHEET 0- OF

F.A.R.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



**EXHIBIT III.1  
ON-SITE DRAINAGE AREA MAP FOR PAVEMENT AREAS**

60% SUBMITTAL

REGION	NAME	DATE	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
DESIGN				
CHECKED			SR 51 PAVEMENT DRAINAGE SUBBASINS Sta. 322+00 to 360+50	SHEET 0- OF
DATE				
ROUTE	LOCATION		SR 51 THUNDERBIRD ROAD TO BELL ROAD	

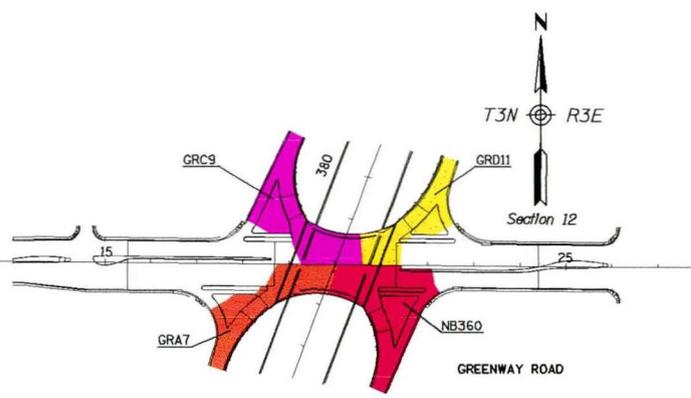
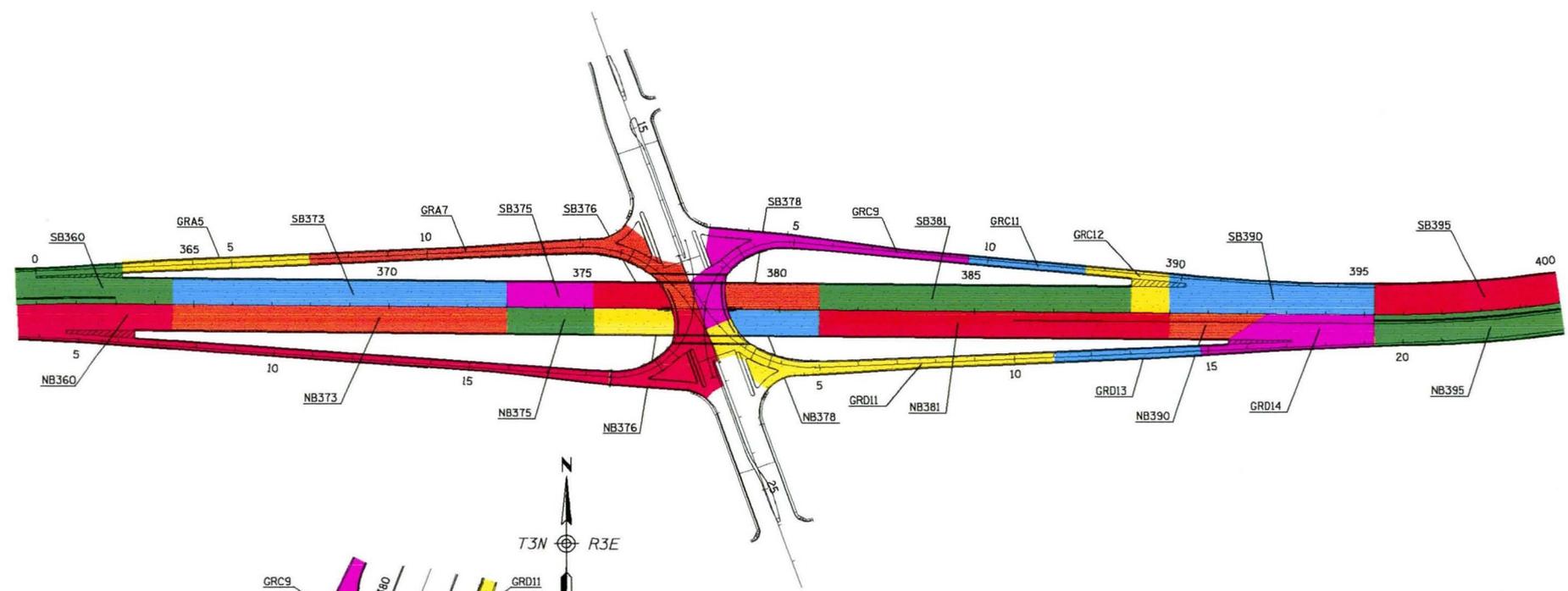
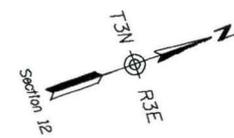
TRACS NO. H 4047 01C      600-2-522      0F

DATE	
LOCATION	
REVISION	
PREPARED BY	
DATE	

FILE: d:\workspace\drain\sr51\09.dgn  
DATE: 1/18/98 12:56

\*\*\*\*\*COMSPEC\*\*\*\*\*  
\*\*\*\*\*SYTIME\*\*\*\*\*

FED. AID REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



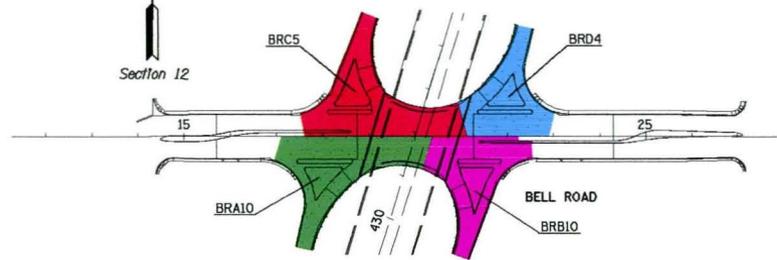
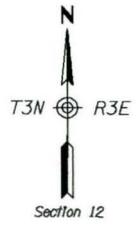
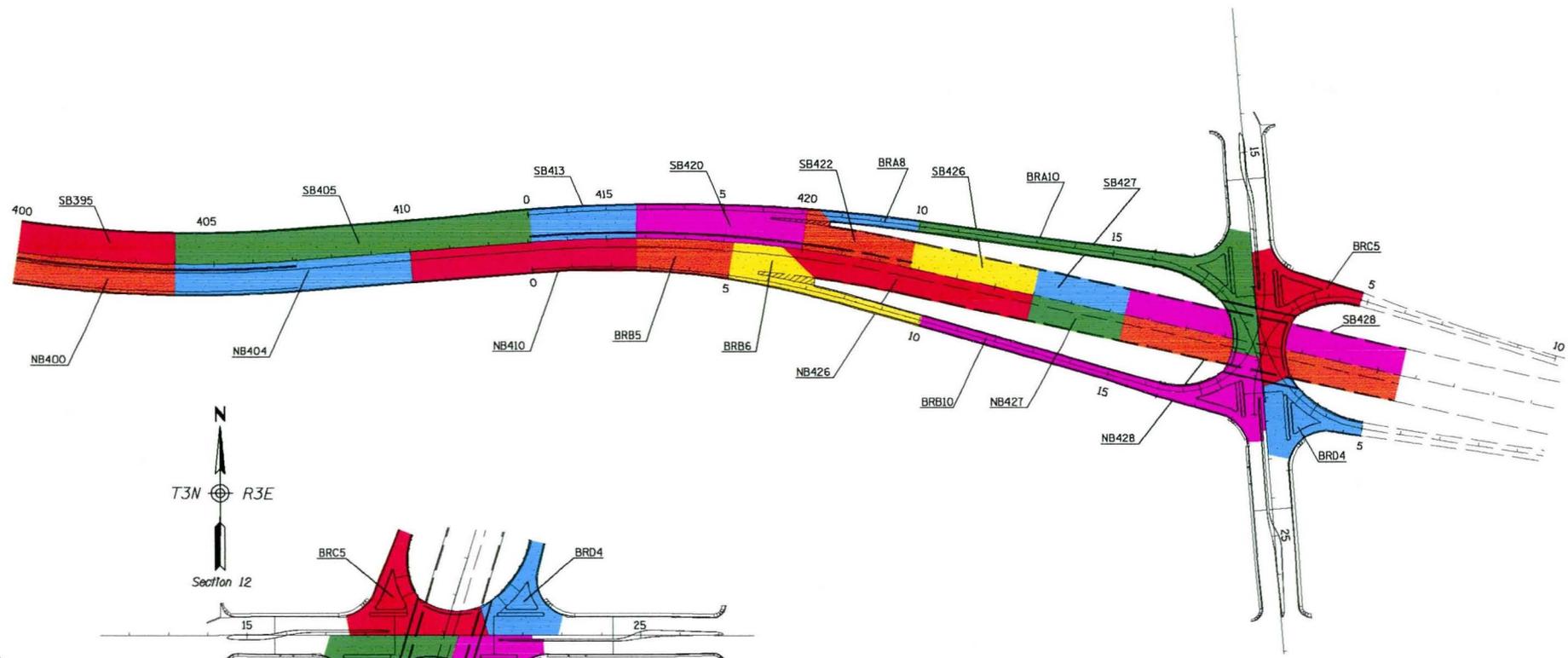
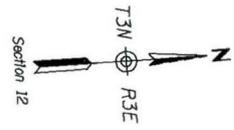
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DATE: 1-Mar-96 12:51

REVISION	DATE

60% SUBMITTAL

DESIGN	DATE	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
BY			
CHECKED		SR 51 PAVEMENT DRAINAGE SUBBASINS Sta. 360+50 to 400+00	SHEET 0- OF
DATE			
ROUTE	LOCATION	TRACS NO. H 4047 01C 600-2-522 0F	
SR 51	THUNDERBIRD ROAD TO BELL ROAD		

FEDERAL HIGHWAY DISTRICT	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



60% SUBMITTAL

DESIGN	JLJ	DATE	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
DRAWN	WAI		SR 51 PAVEMENT DRAINAGE SUBBASINS Sta 400+00 to 438+00	
CHECKED			SR 51 THUNDERBIRD ROAD TO BELL ROAD	
				SHEET D OF

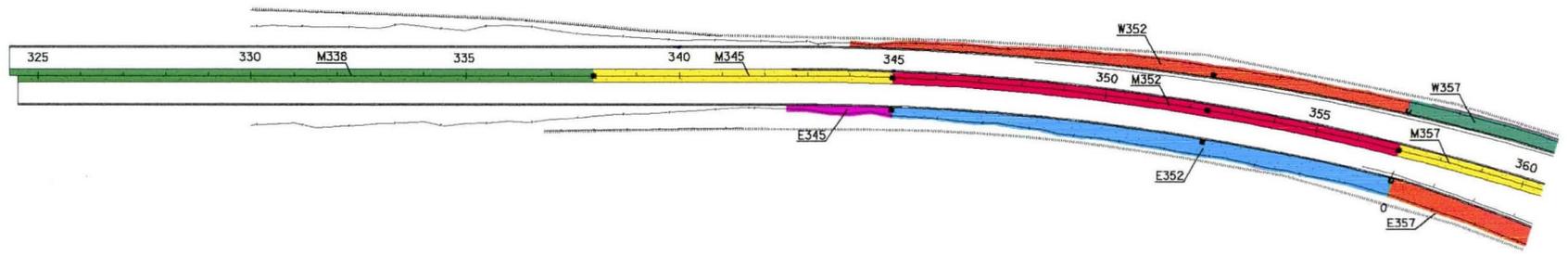
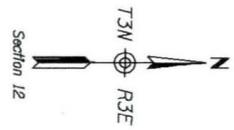
TRACS NO. H 4047 OIC 600-2-522 OF

DATE	
LOCATION	
SECTION	
PROJECT NAME	
SHEET NO.	

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DATE: 1-Mar-96 12:51

\*\*\*\*\*SPECIFICATION\*\*\*\*\*  
\*\*\*\*\*SHEET\*\*\*\*\*

FEDERAL REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-NA-011					



**EXHIBIT III.2  
ON-SITE DRAINAGE AREA MAP FOR OFF PAVEMENT AREAS**

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DATE: 1-Mar-96 12:52

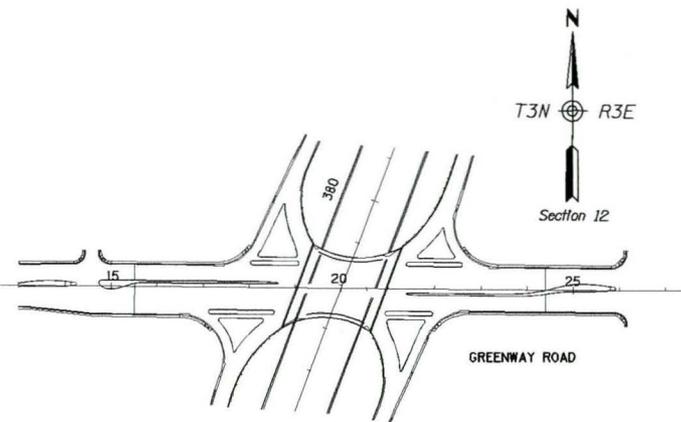
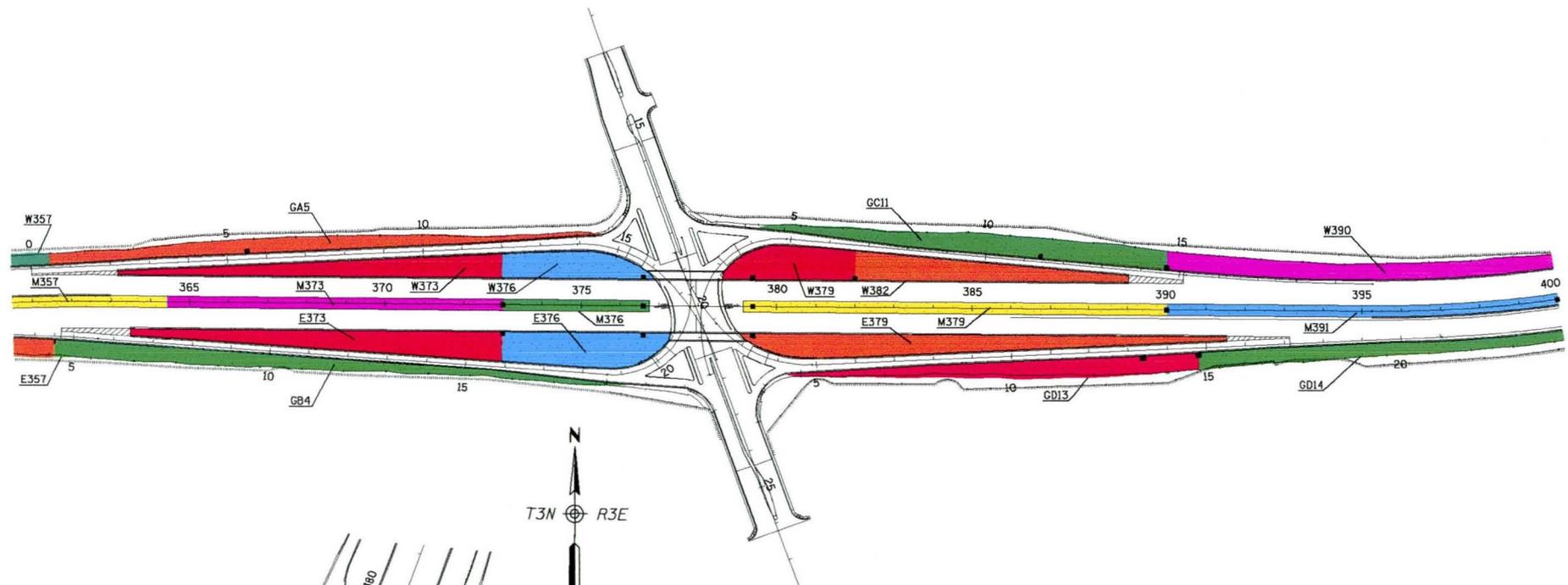
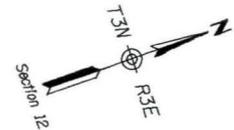
DATE	DESCRIPTION

60% SUBMITTAL

DESIGN	JJ	DATE		ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
DRAWN	WH				
CHECKED					
<b>FR</b> Engineering, Inc.				SR 51	ON-SITE DRAINAGE SUBBASINS Sta. 322+00 to 360+50
SR 51				THUNDERBIRD ROAD TO BELL ROAD	

TRACS NO. H 4047 OIC      600-2-522      OF

F.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



DATE	BY	CHKD	DATE	BY	CHKD

FILE: e:\aspeck\drpr5113.dgn  
DATE: 1-Mar-96 12:52

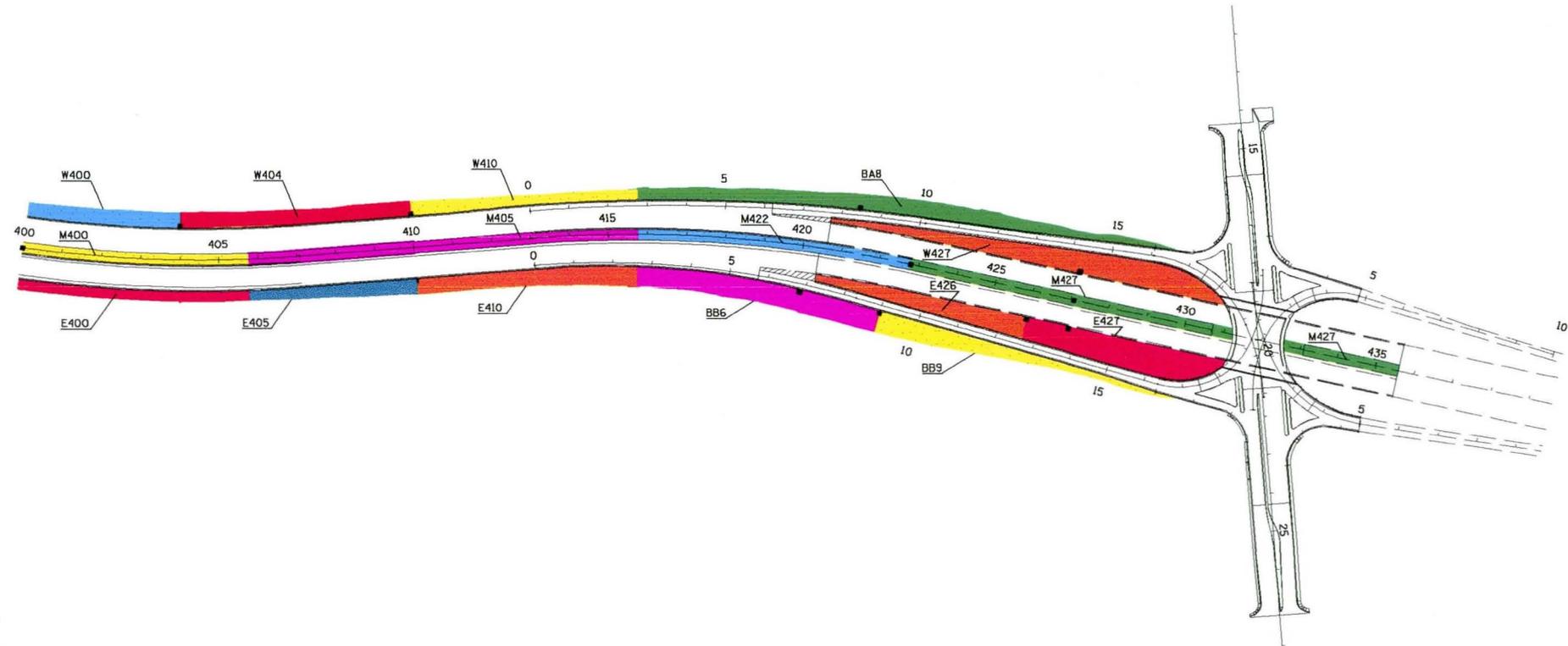
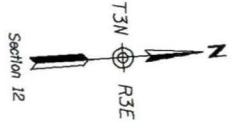
\*\*\*\*\*GRAPHIC STANDARD\*\*\*\*\*  
\*\*\*\*\*SYTIME\*\*\*\*\*

60% SUBMITTAL

DESIGN	DATE	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
BY			
CHECKED		SR 51 ON-SITE DRAINAGE SUBBASINS Sta. 360+50 to 400+00	
ROUTE	LOCATION	SR 51	THUNDERBIRD ROAD TO BELL ROAD

TRACS NO. H 4047 01C      600-2-522      OF

FED. A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
051-MA-011					



SHEET NO.	DATE	REVISION	LOCATION	BY

FILE: d:\space\adrs\5114\dgn  
DATE: 1-Mar-96 12:53

60% SUBMITTAL

DESIGN	JJ	DATE	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
DRAWN	WH		SR 51 ON-SITE DRAINAGE SUBBASINS Sta 400+00 to 438+00	
CHECKED			FILED HFR HFR Engineering, Inc.	
PROJECT	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD	SHEET 0- OF

TRACS NO. H 4047 01C 600-2-522 0F

# EXHIBIT III.3

SR-51  
Summary Table  
Pavement Inlets - Southbound Mainline and Ramps

2/29/96

Area Desig.	Inlet Station	Offset	Q (cfs)		Inlet Design	Carryover (cfs)	Design Event		Design Q (cfs)	Inlet Std.	Slotted Drain		Intercept. (cfs)	Flowby (cfs)	Grate Elev.	Notes
			Interim	Ultimate			Location	Size			Length	Dia.				
SB338	338+00	69' LT.	11.7	14.9	Ultimate	0.0	10-year	50-year	14.9	C-15.91	20 ft.	24"	13.7	1.2	1416.08	Begin Project - 320+00
SB340	340+00	69' LT.	1.5	1.9	Ultimate	1.2	10-year	50-year	3.1	C-15.91	10 ft.	24"	3.1	0.0	1410.67	Super Changes D/S of Inlet
SB345	345+00	15' LT.	3.8	4.7	Interim	0.0	50-year	50-year	3.8	C-15.91	0 ft.	n/a	3.2	0.6	1411.88	
SB348	348+00	15' LT.	2.3	2.8	Interim	0.6	50-year	50-year	2.9	C-15.91	0 ft.	n/a	2.4	0.5	1410.52	
SB350	350+00	15' LT.	1.6	2.0	Interim	0.5	50-year	50-year	2.1	C-15.91	5 ft.	24"	2.1	0.0	1410.00	
SB352	352+42.06	15' LT.	3.4	4.2	Interim	0.1	50-year	50-year	3.5	C-15.91	0 ft.	n/a	3.5	0.0	1409.78	Inlet at Sag Location
SB354	354+00	15' LT.	3.0	3.6	Interim	0.2	50-year	50-year	3.2	C-15.91	10 ft.	24"	3.1	0.1	1409.87	
SB357	357+00	15' LT.	3.7	4.3	Interim	0.2	50-year	50-year	3.9	C-15.91	5 ft.	24"	3.7	0.2	1410.58	
SB360	360+50	15' LT.	3.9	4.6	Interim	0.0	50-year	50-year	3.9	C-15.91	5 ft.	24"	3.7	0.2	1412.17	
SB373	373+00	69' LT.	6.3	8.0	Ultimate	0.0	50-year	50-year	8.0	C-15.91	0 ft.	n/a	5.9	2.1	1408.53	
SB375	375+25	69' LT.	1.6	2.1	Ultimate	2.1	50-year	50-year	4.2	C-15.91	0 ft.	n/a	3.3	0.9	1407.43	
SB376	376+60.73	69' LT.	1.6	2	Ultimate	1.7	50-year	50-year	3.7	C-15.91	0 ft.	n/a	3.7	0.0	1407.24	Inlet at Sag Location
SB378	378+00	69' LT.	1.7	2.3	Ultimate	1.8	50-year	50-year	4.1	C-15.91	0 ft.	n/a	3.3	0.8	1407.43	
SB381	381+00	69' LT.	6.0	7.6	Ultimate	0.0	50-year	50-year	7.6	C-15.91	0 ft.	n/a	5.8	1.8	1409.19	
GRA5	5+51.80 Ramp A	14' LT.	2.0	2.0	Ultimate	0.6	50-year	50-year	2.6	C-15.91	0 ft.	n/a	2.6	0.0	1413.60	Inlet at Sag Location
GRA7	7+00 Ramp A	14' LT.	5.7	5.7	Ultimate	0.0	50-year	50-year	5.7	C-15.91	20 ft.	24"	5.1	0.6		
GRC9	9+50 Ramp C	8.0' LT.	5.4	5.4	Ultimate	0.0	50-year	50-year	5.4	C-15.91	0 ft.	n/a	4.2	1.2		
GRC11	11+41.86 Ramp C	8.0' LT.	1.1	1.1	Ultimate	1.3	50-year	50-year	2.4	C-15.91	0 ft.	n/a	2.4	0.0	1418.69	Inlet at Sag Location
GRC12	12+50 Ramp C	8.0' LT.	1.6	1.8	Ultimate	0.3	50-year	50-year	2.1	C-15.91	0 ft.	n/a	2.0	0.1	1419.06	
SB390	390+00	103' LT	4.9	5.9	Ultimate	0.0	50-year	50-year	5.9	C-15.91	10 ft.	24"	5.6	0.3	1421.94	
SB395	395+25	81' LT.	7.8	9.5	Ultimate	0.0	50-year	50-year	9.5	C-15.91	15 ft.	24"	9.5	0.0	1427.66	
SB404	404+00	81' LT.	8.1	9.9	Ultimate	0.0	50-year	50-year	9.9	C-15.91	10 ft.	24"	9.9	0.0	1432.05	
SB413	413+10	15' LT.	2.7	3.2	Interim	0.0	50-year	50-year	2.7	C-15.91	5 ft.	24"	2.7	0.0	1438.86	Super Changes D/S of Inlet
SB420	420+00	15' LT.	4.3	5.1	Interim	0.0	50-year	50-year	4.3	C-15.91	5 ft.	24"	4.1	0.2	1438.25	
SB422	422+80	15' LT.	2.6	3.4	Interim	0.2	50-year	50-year	2.8	C-15.91	5 ft.	24"	2.8	0.0	1437.24	Super Changes D/S of Inlet
SB426	426+00	69' LT.	2.3	3.0	Ultimate	0.0	10-year	50-year	3.0	C-15.91	0 ft.	n/a	2.1	0.9	1435.38	
SB427	427+09.09	69' LT.	1.3	2.2	Ultimate	1.8	10-year	50-year	4.0	C-15.91	0 ft.	n/a	4.0	0.0	1435.27	Inlet at Sag Location
SB428	428+40	69' LT.	4.2	5.4	Ultimate	0.0	10-year	50-year	5.4	C-15.91	5 ft.	24"	4.5	0.9	1435.43	
BRA8	8+46.33 Ramp A	14' LT.	0.9	0.9	Ultimate	0.8	50-year	50-year	1.7	C-15.91	0 ft.	n/a	1.7	0.0	1440.53	Inlet at Sag Location
BRA10	10+00 Ramp A	14' LT.	8.1	8.1	Ultimate	0.0	50-year	50-year	8.1	C-15.91	35 ft.	24"	7.3	0.8	1441.60	
BRC5	5+00 Ramp C	19' LT.	5.2	5.2	Ultimate	0.0	50-year	50-year	5.2	C-15.91	20 ft.	24"	5.2	0.0		Flowby not allowed.

Filename: Sqew6/Sheet8(2)

Notes

- a. Design Q shown includes flowby from upstream inlet.
- b. Inlet spacing has been designed so that the interim and ultimate locations for a specific Inlet are at the same station with different offsets. It is assumed that inlets designed for the interim pavement section will be removed and replaced when the median area is eventually paved. Spread criteria is not violated for either the interim or ultimate pavement sections.
- c. Minimum diameter for slotted drain is 24".
- d. GRC11 = Greenway Road, Ramp C, Station 11.
- e. BRA10 = Bell Road, Ramp A, Station 10.
- e. Spread Criteria Used to Space Inlets
  - 1. Allowable ponding does not exceed the height of the curb for the 10-year or 50-year event.
  - 2. 10-Year Event: One travel lane encroachment and no left lane encroachment for roadways with more than one lane in each direction.
  - 3. 50-Year Event: One full right travel lane encroachment and no left travel lane encroachment for roadways with more than one lane in each direction.
  - 4. Ramps: 14 ft. min of dry pavement.

# EXHIBIT III.4

SR-51

Summary Table

Pavement Inlets - Northbound Mainline and Ramps

Area Design.	Inlet Station	Offset	Q (cfs)		Inlet Design	Carryover (cfs)	Design Event		Design Q (cfs)	Inlet Stnd.	Slotted Drain		Intercept. (cfs)	Flowby (cfs)	Grate Elev.	Notes
			Interim	Ultimate			Location	Size			Length	Dia.				
NB338	338+00	69' RT.	11.7	14.9	Ultimate	0.0	10-yr.	50-yr.	14.9	C-15.91	20 ft.	24"	13.7	1.2	1416.08	Begin Project - 322+00
NB345	345+00	69' RT.	5.1	6.5	Ultimate	1.2	50-yr.	50-yr.	7.7	C-15.91	0 ft.	n/a	5.6	2.1	1410.67	
NB349	349+00	69' RT.	2.9	3.7	Ultimate	2.1	50-yr.	50-yr.	5.8	C-15.91	5 ft.	24"	5.2	0.6	1409.01	
NB351	351+00	69' RT.	1.5	1.9	Ultimate	0.6	50-yr.	50-yr.	2.5	C-15.91	0 ft.	n/a	2.1	0.4	1408.64	
NB352	352+42.06	69' RT.	2.2	2.8	Ultimate	1.0	50-yr.	50-yr.	3.8	C-15.91	0 ft.	n/a	3.8	0.0	1408.57	Inlet at Sag Location
NB354	354+00	69' RT.	5.7	1.9	Ultimate	1.2	50-yr.	50-yr.	3.1	C-15.91	0 ft.	n/a	2.5	0.6	1408.66	
NB356	356+00	69' RT.	3.3	4.1	Ultimate	1.1	50-yr.	50-yr.	5.2	C-15.91	0 ft.	n/a	4.0	1.2	1409.05	
NB360	360+50	93.07' RT.	9.1	13.4	Ultimate	0.0	50-yr.	50-yr.	13.4	C-15.91	15 ft.	24"	12.3	1.1	1410.37	
NB373	373+00	69' RT.	6.3	8.0	Ultimate	0.0	50-yr.	50-yr.	8.0	C-15.91	0 ft.	n/a	5.9	2.1	1408.53	
NB375	375+25	69' RT.	1.6	2.1	Ultimate	2.1	50-yr.	50-yr.	4.2	C-15.91	0 ft.	n/a	3.4	0.8	1407.43	
NB376	376+60.73	69' RT.	1.6	2.0	Ultimate	1.8	50-yr.	50-yr.	3.8	C-15.91	0 ft.	n/a	3.8	0.0	1407.24	Inlet at Sag Location
NB378	378+00	69' RT.	1.8	2.3	Ultimate	2.2	50-yr.	50-yr.	4.5	C-15.91	0 ft.	n/a	3.5	1.0	1410.96	
NB381	381+00	69' RT.	6.6	8.5	Ultimate	0.0	50-yr.	50-yr.	8.5	C-15.91	0 ft.	n/a	6.3	2.2	1409.19	
NB390	390+00	69' RT.	1.5	1.9	Ultimate	0.0	10-yr.	50-yr.	1.9	C-15.91	0 ft.	n/a	1.9	0.0	1422.50	
NB395	395+25	15' RT.	3.8	5.3	Interim	0.0	50-yr.	50-yr.	3.8	C-15.91	10 ft.	24"	3.8	0.0	1429.19	Super Changes D/S of Inlet
NB400	400+00	15' RT.	3.6	4.8	Interim	0.0	50-yr.	50-yr.	3.6	C-15.91	5 ft.	24"	3.6	0.0	1432.07	
NB404	404+00	15' RT.	5.4	6.6	Interim	0.0	50-yr.	50-yr.	5.4	C-15.91	10 ft.	24"	5.4	0.0	1434.25	
NB410	410+00	81' RT.	5.1	6.3	Ultimate	0.0	10-yr.	50-yr.	6.3	C-15.91	15 ft.	24"	6.3	0.0	1436.71	Super Changes D/S of Inlet
NB426	426+00	69' RT.	4.2	5.3	Ultimate	0.0	10-yr.	50-yr.	5.3	C-15.91	5 ft.	24"	4.5	0.8	1435.38	
NB427	427+09.09	69' RT.	1.8	2.2	Ultimate	1.7	10-yr.	50-yr.	3.9	C-15.91	0 ft.	n/a	3.9	0.0	1435.27	Inlet at Sag Location
NB428	428+40	69' RT.	4.2	5.4	Ultimate	0.0	10-yr.	50-yr.	5.4	C-15.91	5 ft.	24"	4.5	0.9	1435.43	
GRD11	11+00 Ramp D	14' RT.	4.9	4.9	Ultimate	0.0	50-yr.	50-yr.	4.9	C-15.91	10 ft.	24"	4.9	0.0		
GRD13	13+29.47 Ramp D	14' RT.	1.5	1.5	Ultimate	0.4	50-yr.	50-yr.	1.9	C-15.91	0 ft.	n/a	1.9	0.0	1422.33	Inlet at Sag Location
GRD14	14+80 Ramp D	11.70' RT.	3.7	4.4	Ultimate	0.0	50-yr.	50-yr.	4.4	C-15.91	5 ft.	24"	4.0	0.4	1423.10	
BRB5	5+00 Ramp B	9.64' RT.	2.3	2.8	Ultimate	0.0	50-yr.	50-yr.	2.8	C-15.91	5 ft.	24"	2.8	0.0	1435.96	
BRB6	6+85.91 Ramp B	13.35' RT.	3.6	4.0	Ultimate	0.1	50-yr.	50-yr.	4.1	C-15.91	5 ft.	24"	4.1	0.0	1435.12	Inlet at Sag Location
BRB10	10+00 Ramp B	14' RT.	6.5	6.5	Ultimate	0.0	50-yr.	50-yr.	6.5	C-15.91	45 ft.	24"	6.4	0.1		
BRD4	4+80 Ramp D	15' RT.	3.5	3.5	Ultimate	0.0	50-yr.	50-yr.	3.5	C-15.91	0 ft.	n/a	3.5	0.0		Flowby not allowed.

Filename: Sqawb/Sheet8

Notes

- a. Design Q shown includes flowby from upstream inlet.
- b. Inlet spacing has been designed so that the interim and ultimate locations for a specific inlet are at the same station with different offsets. It is assumed that inlets designed for the interim pavement section will be removed and replaced when the median area is eventually paved. Spread criteria is not violated for either the interim or ultimate pavement sections.
- c. Minimum diameter for slotted drain is 24".
- d. GRD13 = Greenway Road, Ramp D, Station 13+00
- e. Spread Criteria Used to Space Inlets
  1. Allowable ponding does not exceed the height of the curb for the 10-year or 50-year event.
  2. 10-Year Event: One travel lane encroachment and no left lane encroachment for roadways with more than one lane in each direction.
  3. 50-Year Event: One full right travel lane encroachment and no left travel lane encroachment for roadways with more than one lane in each direction.
  4. Ramps: 14 ft. minimum of dry pavement for both the 10-year and 50-year events.

**EXHIBIT III.5**  
**SR-51**  
**Summary Table**  
**Median Inlets**

Feb. 29, 1996

Area Desig.	Inlet Station	Offset	Subbasin Data			Ave. Slope (%)	Slope at Inlet (%)	Tc (use)	i (in./hr.)	Design Storm
			Width (ft)	Length (ft)	Area (ac)					
M338	338+00	0' RT.	30	1600	1.10	0.7	0.7	10 min.	6.4	50-yr.
M345	345+00	0' RT.	30	700	0.48	0.7	0.5	10 min.	6.4	50-yr.
M352	352+42.06	0' RT.	30	1200	0.83	0.3	0.0	10 min.	6.4	50-yr.
M357	357+00	0' RT.	30	744	0.51	0.3	0.4	10 min.	6.4	50-yr.
M373	373+00	0' RT.	30	856	0.59	0.4	0.6	10 min.	6.4	50-yr.
M376	376+60.73	0' RT.	30	400	0.28	0.4	0.0	10 min.	6.4	50-yr.
M381	<del>379+40</del> 381+00	0' RT.	30	1100	0.76	1.2	1.0	10 min.	6.4	50-yr.
M390	390+00	0' RT.	30	1000	0.69	0.9	1.7	10 min.	6.4	50-yr.
M400	400+00	0' RT.	30	500	0.34	0.6	0.5	10 min.	6.4	50-yr.
M405	405+75	0' RT.	30	1002	0.69	0.3	0.5	10 min.	6.4	50-yr.
M422	422+80	0' RT.	30	703	0.48	0.3	0.4	10 min.	6.4	50-yr.
M427	427+09.09	0' RT.	30	1280	0.88	0.3	0.0	10 min.	6.4	50-yr.

Area Desig.	Inlet Station	Q (cfs)	Carryover (cfs)	Design Q (cfs)	Inlet Std.	Intercept. (cfs)	Flowby (cfs)	Grate Elevation	Notes
M338	338+00	4.94	0.00	4.94	C-15.80	4.94	0.00	1415.29	
M345	345+00	2.16	0.00	2.16	C-15.80	2.16	0.00	1410.47	
M352	352+42.06	3.70	0.00	3.70	C-15.80	3.70	0.00	1407.91	Sag Location
M357	357+00	2.30	0.00	2.30	C-15.80	2.30	0.00	1408.70	
M373	373+00	2.64	0.00	2.64	C-15.80	2.64	0.00	1407.93	
M376	376+60.73	1.23	0.00	1.23	C-15.80	1.23	0.00	1406.65	Sag Location
M381	381+00	3.39	0.00	3.39	C-15.80	3.39	0.00	1408.60	
M390	390+00	3.09	0.00	3.09	C-15.80	3.09	0.00	1421.91	
M400	400+00	1.54	0.00	1.54	C-15.80	1.54	0.00	1430.20	
M405	405+75	3.09	0.00	3.09	C-15.80	3.09	0.00	1433.34	
M422	422+80	2.17	0.00	2.17	C-15.80	2.17	0.00	1435.37	
M427	427+09.09	3.95	0.00	3.95	C-15.80	3.95	0.00	1434.47	Sag Location

Notes

- a. Use 50% clogging for grated inlets on grade and in sag locations.
- b. Assume maximum flow depth at median inlets is 0.4 ft. See Calculation sheet for median inlets.

HDR Engineering, Inc.

**EXHIBIT III.6**

**SR-51**

**Summary Table**

**On-Site Inlets - V-Ditch on East Side of Mainline**

Feb. 29, 1996

Area Desig.	Inlet Station	Offset	Subbasin Data			Ave. Slope (%)	Slope at Inlet (%)	Tc (use)	i (in./hr.)	Design Storm
			Width (ft)	Length (ft)	Area (ac)					
E345	345+00	75.50' RT.	Varies	245	0.11	0.7	0.5	10 min.	6.4	50-yr.
E352	352+42.06	75.50' RT.	Varies	1200	1.01	0.3	0.0	10 min.	6.4	50-yr.
E357	357+00	75.50' RT.	Varies	450	0.48	0.1	0.4	10 min.	6.4	50-yr.
GB4	4+50 Ramp B	14.50' RT.	Varies	1460	0.93	1.2	0.4	10 min.	6.4	50-yr.
E373	373+00	75.50' RT.	Varies	950	1.03	0.4	0.6	10 min.	6.4	50-yr.
E376	376+60.73	75.50' RT.	Varies	400	0.79	0.1	0.0	10 min.	6.4	50-yr.
E379	379+40	75.50' RT.	Varies	1185	1.09	1.4	0.6	10 min.	6.4	50-yr.
BD13	13+29.47 Ramp D	20.50' RT.	Varies	980	0.76	0.9	0.0	10 min.	6.4	50-yr.
GD14	14+80 Ramp D	18.20' RT.	Varies	1015	0.79	0.1	0.4	10 min.	6.4	50-yr.
E400	400+00	87.50' RT.	Varies	580	0.35	0.5	0.5	10 min.	6.4	50-yr.
E405	405+80	87.50' RT.	Varies	425	0.33	0.5	0.5	10 min.	6.4	50-yr.
E410	410+00	87.50' RT.	Varies	570	0.56	0.3	0.5	10 min.	6.4	50-yr.
BB6	6+85.91 Ramp B	20.50' RT.	Varies	625	0.80	0.9	0.0	10 min.	6.4	50-yr.
BB9	9+00 Ramp B	20.50' RT.	Varies	800	0.54	2.9	1.8	10 min.	6.4	50-yr.
E426	426+00	75.50' RT.	Varies	375	0.50	0.4	0.1	10 min.	6.4	50-yr.
E427	427+09.09	75.50' RT.	Varies	500	0.81	0.1	0.0	10 min.	6.4	50-yr.

Area Desig.	Inlet Station	Q (cfs)	Carryover (cfs)	Design Q (cfs)	Inlet Std.	Intercept. (cfs)	Flowby (cfs)	Grate Elevation	Notes
E345	345+00	0.49	0.0	0.5	C-15.80	0.49	0.0	1410.67	
E352	352+42.06	4.52	0.0	4.5	C-15.80	4.52	0.0	1408.57	Sag Location
E357	357+00	2.15	0.0	2.2	C-15.80	2.15	0.0	1409.37	
GB4	4+50 Ramp B	4.17	0.0	4.2	C-15.80	4.17	0.0	1411.30	
E373	373+00	4.61	0.0	4.6	C-15.80	4.61	0.0	1408.53	
E376	376+60.73	3.54	0.0	3.5	C-15.80	3.54	0.0	1407.24	Sag Location
E379	379+40	4.88	0.0	4.9	C-15.80	4.88	0.0	1408.03	Flow-by not Allowed.
BD13	13+29.47 Ramp D	3.40	0.0	3.4	C-15.80	3.40	0.0	1422.33	Sag Location
GD14	14+80 Ramp D	3.54	0.0	3.5	C-15.80	3.54	0.0	1423.10	
E400	400+00	1.57	0.0	1.6	C-15.80	1.57	0.0	1434.97	
E405	405+80	1.48	0.0	1.5	C-15.80	1.48	0.0	1437.16	
E410	410+00	2.51	0.0	2.5	C-15.80	2.51	0.0	1436.71	
BB6	6+85.91 Ramp B	3.58	0.0	3.6	C-15.80	3.58	0.0	1435.09	Sag Location
BB9	9+00 Ramp B	2.42	0.0	2.4	C-15.80	2.42	0.0	1435.27	
E426	426+00	2.24	0.0	2.2	C-15.80	2.24	0.0	1435.39	
E427	427+09.09	3.63	0.0	3.6	C-15.80	3.63	0.0	1435.28	Sag Location

Notes

- a. Use 50% clogging for grated inlets on grade and in sag locations.
- b. Assume maximum flow depth at median inlets is 0.4 ft. See Calculation sheet for on-site inlets on east and west side of mainline.

EXHIBIT III.7

**SR-51**  
**Summary Table**  
**On-Site Inlets - V-Ditch on West Side of Mainline**

Feb. 29, 1996

Area Desig.	Inlet Station	Offset	Subbasin Data			Ave. Slope (%)	Slope at Inlet (%)	Tc (use)	i (in./hr.)	Design Storm
			Width (ft)	Length (ft)	Area (ac)					
W352	352+42.06	80.43' LT.	Varies	1300	0.82	0.3	0.0	10 min.	6.4	50-yr.
W357	357+00	93.00' LT.	Varies	470	0.34	0.2	0.4	10 min.	6.4	50-yr.
GA5	5+51.80 Ramp A	20.50 LT.	Varies	1400	0.87	0.1	0.0	10 min.	6.4	50-yr.
W373	373+00	75.50' LT.	Varies	985	0.81	0.4	0.6	10 min.	6.4	50-yr.
W376	376+60.73	75.50' LT.	Varies	400	0.53	0.1	0.0	10 min.	6.4	50-yr.
W379	379+40	75.50' LT.	Varies	320	0.59	0.8	0.6	10 min.	6.4	50-yr.
W382	382+00	75.50' LT.	Varies	700	0.75	1.6	1.1	10 min.	6.4	50-yr.
GC11	11+41.86 Ramp C	14.50' LT.	Varies	1050	0.98	1.4	0.0	10 min.	6.4	50-yr.
W390	390+00	109.55' LT.	Varies	1000	0.98	0.9	1.4	10 min.	6.4	50-yr.
W400	400+00	87.50' LT.	Varies	400	0.35	0.5	0.5	10 min.	6.4	50-yr.
W404	404+00	87.50' LT.	Varies	600	0.52	0.5	0.5	10 min.	6.4	50-yr.
W410	410+00	87.50' LT.	Varies	600	0.41	0.3	0.5	10 min.	6.4	50-yr.
BA8	8+46.33 Ramp A	20.50' LT.	Varies	1400	0.99	0.1	0.0	10 min.	6.4	50-yr.
W427	427+09.09	75.50' LT.	Varies	1040	0.99	0.3	0.0	10 min.	6.4	50-yr.

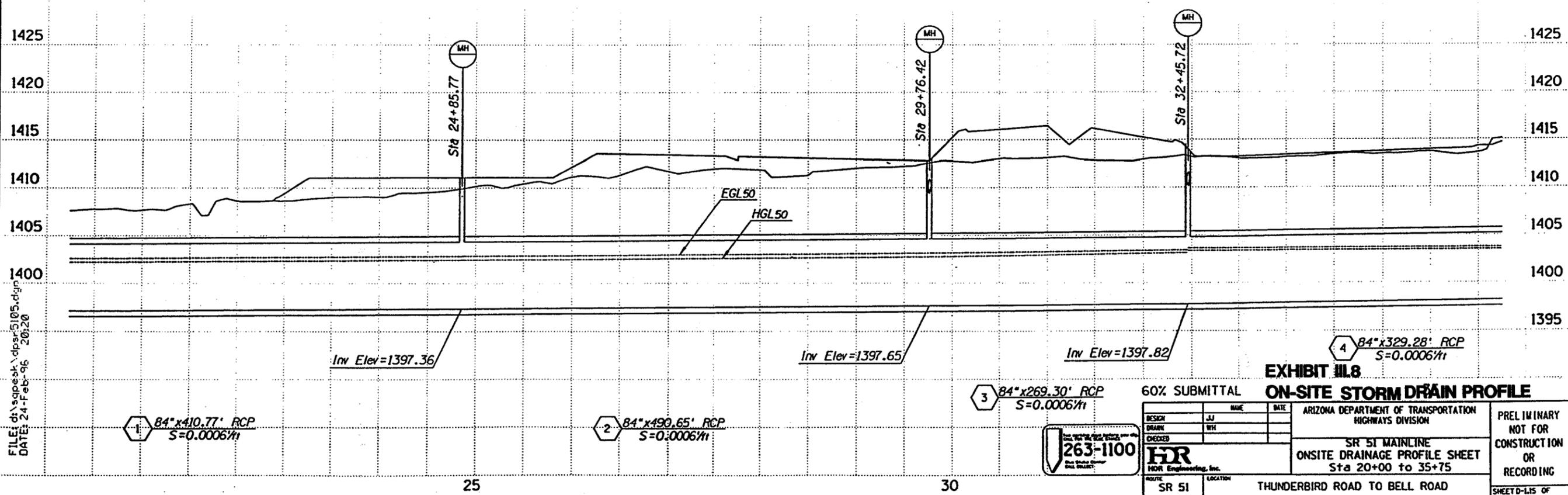
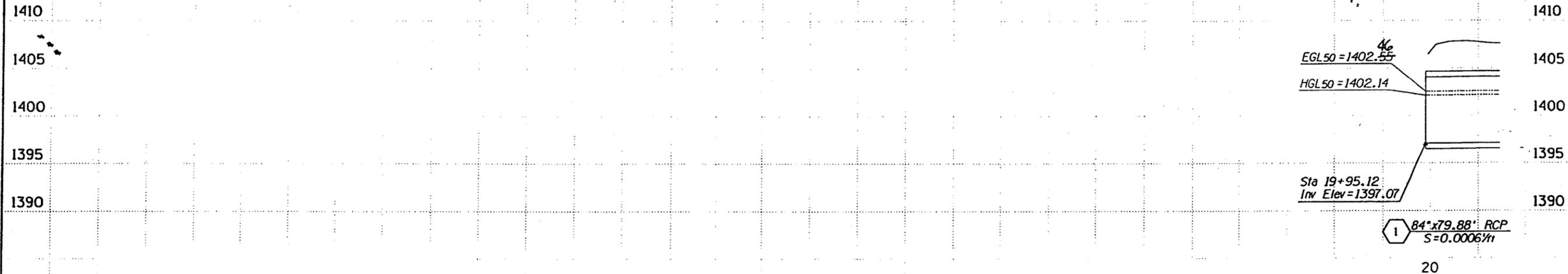
Area Desig.	Inlet Station	Q (cfs)	Carryover (cfs)	Design Q (cfs)	Inlet Std.	Intercept. (cfs)	Flowby (cfs)	Grate Elevation	Notes
W352	352+42.06	3.67	0.0	3.67	C-15.80	3.67	0.0	1411.59	Sag Location
W357	357+00	1.52	0.0	1.52	C-15.80	1.52	0.0	1412.65	
GA5	5+51.80 Ramp A	3.90	0.0	3.90	C-15.80	3.90	0.0	1413.60	Sag Location
W373	373+00	3.63	0.0	3.63	C-15.80	3.63	0.0	1408.53	
W376	376+60.73	2.37	0.0	2.37	C-15.80	2.37	0.0	1407.24	Sag Location
W379	379+40	2.64	0.0	2.64	C-15.80	2.64	0.0	1408.03	Flow-by not Allowed
W382	382+00	3.36	0.0	3.36	C-15.80	3.36	0.0	1410.19	
GC11	11+41.86 Ramp C	4.39	0.0	4.39	C-15.80	4.39	0.0	1418.69	Sag Location
W390	390+00	4.39	0.0	4.39	C-15.80	4.39	0.0	1421.93	
W400	400+00	1.57	0.0	1.57	C-15.80	1.57	0.0	1429.87	
W404	404+00	2.33	0.0	2.33	C-15.80	2.33	0.0	1432.05	
W410	410+00	1.84	0.0	1.84	C-15.80	1.84	0.0	1436.71	
BA8	8+46.33 Ramp A	4.44	0.0	4.44	C-15.80	4.44	0.0	1441.45	Sag Location
W427	427+09.09	4.44	0.0	4.44	C-15.80	4.44	0.0	1435.27	Sag Location

Notes

- a. Use 50% clogging for grated inlets on grade and in sag locations.
- b. Assume maximum flow depth at median inlets is 0.4 ft. See Calculation sheet for on-site inlets on east and west side of mainline.

F.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			

051-MA-011



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**EXHIBIT III.8  
ON-SITE STORM DRAIN PROFILE**

60% SUBMITTAL

DESIGN	JJ	DATE	
DRAWN	WH		
CHECKED			
<b>HDR</b> HCR Engineering, Inc.			
ROUTE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD

ARIZONA DEPARTMENT OF TRANSPORTATION  
HIGHWAYS DIVISION  
SR 51 MAINLINE  
ON-SITE DRAINAGE PROFILE SHEET  
Sta 20+00 to 35+75

PRELIMINARY  
NOT FOR  
CONSTRUCTION  
OR  
RECORDING  
SHEET D-LIS OF

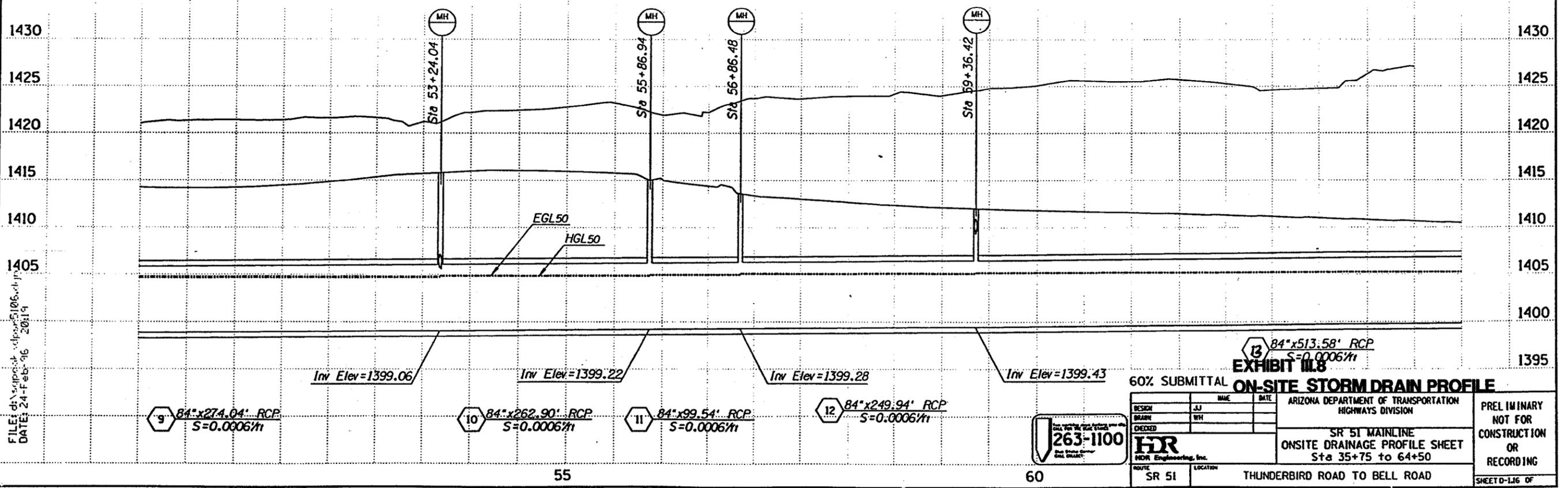
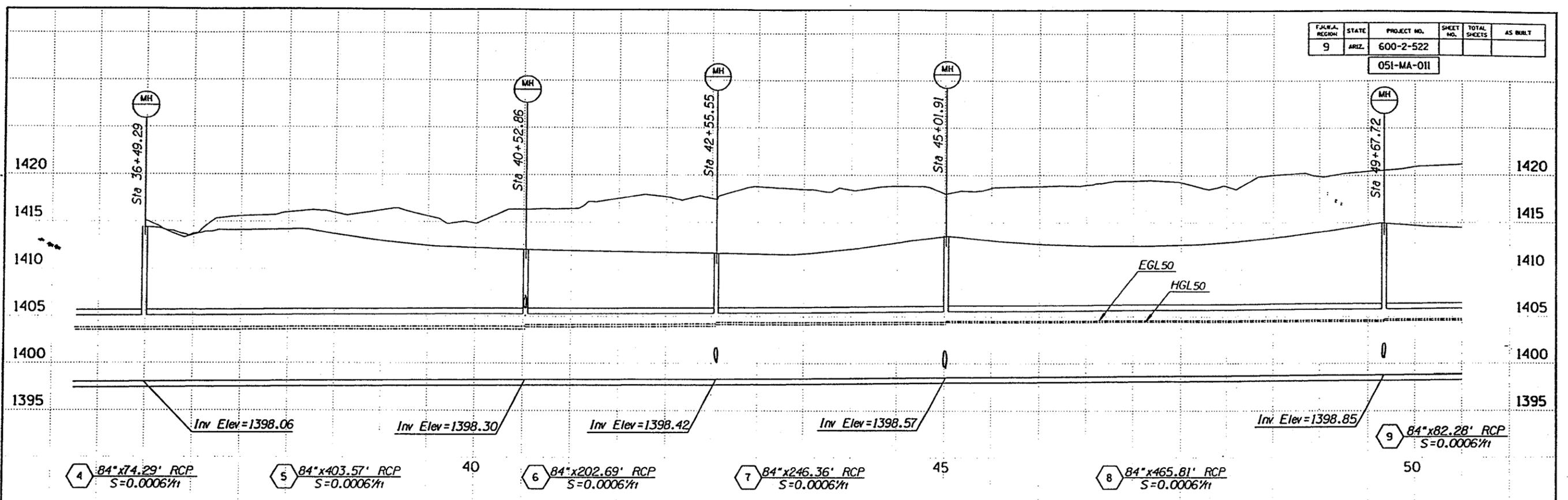
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OF

F.J.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			

051-MA-011



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60% SUBMITTAL **EXHIBIT III.8**  
**ON-SITE STORM DRAIN PROFILE**

DESIGN	JJ	DATE	
DRAWN	WH		
CHECKED			

ARIZONA DEPARTMENT OF TRANSPORTATION  
HIGHWAYS DIVISION

SR 51 MAINLINE  
ONSITE DRAINAGE PROFILE SHEET  
Sta 35+75 to 64+50

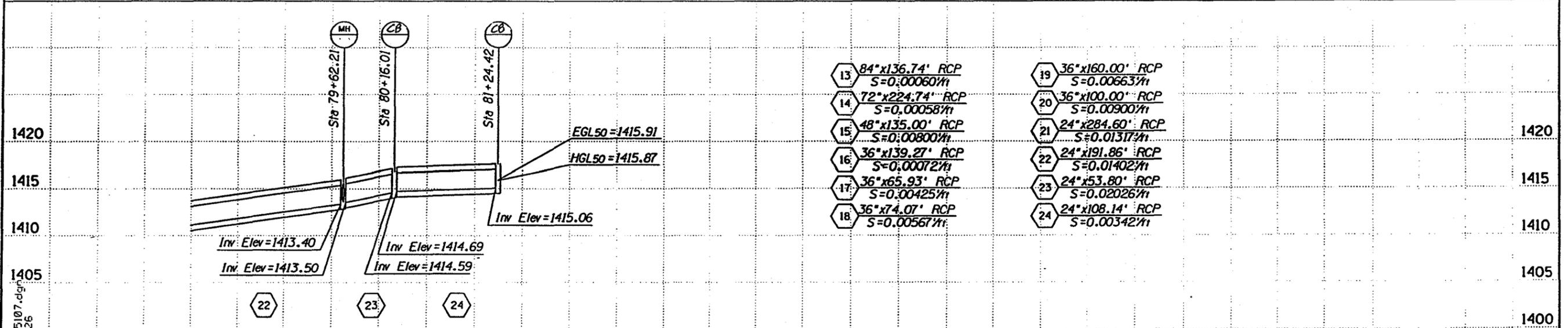
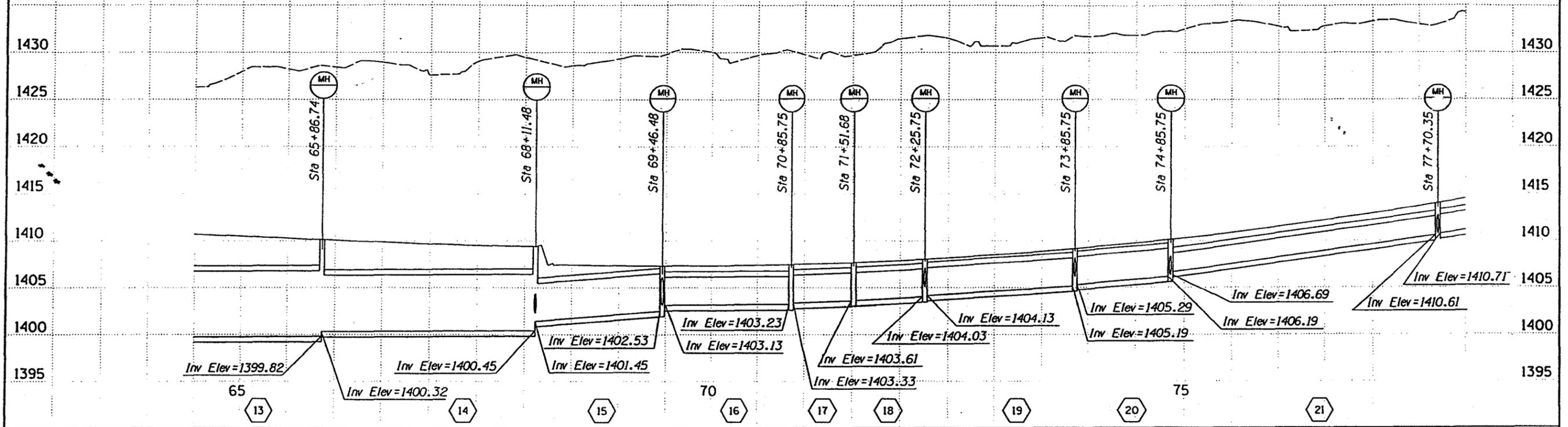
ROUTE SR 51 LOCATION THUNDERBIRD ROAD TO BELL ROAD

PRELIMINARY  
NOT FOR  
CONSTRUCTION  
OR  
RECORDING

SHEET 0-116 OF



FED. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	600-2-522			
OSI-MA-011					



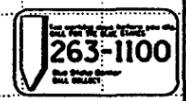
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16	36"x139.27' RCP	S=0.00072/fi
17	36"x65.93' RCP	S=0.00425/fi
18	36"x74.07' RCP	S=0.00567/fi
19	36"x160.00' RCP	S=0.00663/fi
20	36"x100.00' RCP	S=0.00900/fi
21	24"x284.60' RCP	S=0.01317/fi
22	24"x191.86' RCP	S=0.01402/fi
23	24"x53.80' RCP	S=0.02026/fi
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DATE: 24-Feb-96 14:26

**EXHIBIT III.8  
ON-SITE STORM DRAIN PROFILE**

60% SUBMITTAL

DESIGN	JJ	DATE		ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION	PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
DRAWN	WH				
CHECKED				SR 51 MAINLINE ONSITE DRAINAGE PROFILE SHEET Sta 64+50 to 78+00	SHEET D-LIT OF
ROUTE	SR 51	LOCATION	THUNDERBIRD ROAD TO BELL ROAD	TRACS NO. H 4047 OIC	600-2-522
					OF



\*\*\*\*\*SYSTRM\*\*\*\*\*  
VIEW NAME: