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Memo

To Dale Harrison

tom Linda Potter, P,E, CFM — Project AZER Gila River Bridge Crossing

cc Terry Hsu, Rot) Turton

Date May 17, 2007 (Revised June 29, 2007} — **Job No 55774**

RE: AZER Safford Proposed Rail Alignment - Hydrology and Hydraulics Memorandum

Executive Summary

This memorandum summarizes the worK performed under the hydrology and hydraulics task for the AZER Safford proposed rail alignment (preliminary design). The proposed rail alignment crosses two FEMA-designated floodplains at the Gila River and San Simon Creek, These floodplains are designated by FEMA as Zone A (approximate study) on the Gila River and Zone At (base flood elevations determined) on the San Simon Creek,

The preliminary design of the proposed alignment and bridge design limits the rise in water surface elevation in the Gila River to less than one foot during the 100-year event. No rise in water surface elevation is anticipated to occur on the San Simon Creek due to the placement of the rail facility. The final design of the facility will ensure that these design criteria conditions are maintained and verified.

Introduction

The scope of work for this task develops the parameters necessary for final design of the bridge over the Gila River. Two proposed alignments for the crossing were supplied by Mountain States and are shown graphically on Figure 1, attached.

Existing Conditions

The Gila River is one of the main watercourses in Arizona, and traverses the width of the state. The River stretches from western New Mexico's Gila Mountains to the Colorado River. The portion of the watershed that encompasses the project site is part of the Upper Gila Watershed, which drains an area of approximately 12,300 square miles at the proposed crossing.

Additionally, the San Simon Creek enters the proposed project alignment from the south.- This creek-has- a drainage area of over 2,000 square miles in Arizona, with additional area in the state of New Mexico During most of the year, the runoff from the San Simon is conveyed to the Gila River via a low flow channel, constructed to allow agricultural use to occur in the floodplain during non-flooding events Initial observations of the low flow channel are deceiving, as the potential for the large amount of runoff from the creek is not readily apparent. Although the low flow channel parallels the proposed alignment to the north, during flooding events the channel flows in a northwest orientation.

The area has been the subject of numerous studies over the years, The following is a brief description of the information obtained (see References):

- NEMO Watershed Based Plan Upper Gila River Watershed: contains information on the physical characteristics of the watershed,
- Upper Gifa River Fluvial Geomorphology Study Final Report, contains recommendations for river crossings and restrictions.

* Upper Gils River Fluvial Geomorphology Study Stable Channel Analysis: contains hydraulic modeling and sediment transport analyses
* Southeast Arizona Flood History, contains a summary of flood events, damages and flows from the late 1800's to 2005.

Existing Floodplains

Research was performed of the Federal Emergency Management Agency (FEMA), State of Arizona, and Graham County records. The site has been mapped as being within Zone A and Zone A1 special flood hazard areas. Zone A is defined by FEMA as "areas of 100-year flood, base flood elevations and flood hazards not determined." Zone A1 is defined as "areas of 100-year flood, based fiood elevations and flood hazard factors determined." Figure 1 contains a graphical representation of the various flood zones and locations in relation to the proposed alignments. The original hydraulic studies used to develop these flood zones were not available.

The FEMA zone designations do not define a floodway for the river reach. In general, encroachments are not allowed into the floodway. Encroachments are occasionally allowed into a floodplain, provided the water surface elevation is not raised a maximum amount above the existing floodplain elevation, generally 1 -fool or less Coordination with the appropriate floodplain administrator is recommended in order to verify the allowable encroachment. However, adjacent structures across the Gila River have allowed narrower bridge openings than the width of the floodplain, with the most recent bridge in the valley being approximately 1,500 feet in opening length.

River Flow Estimations

Since the flows used to develop the FEMA mapping were not available, recurrence interval flows for the Gila River and the San Simon River were calculated using Army Corps of Engineers software HEC-SSP Version 1.0 (Hydrologic Engineering Center - Statistical Software Package).

The HEC-SSP program calculates flows based on mean annual data taken from the USGS website. It uses a USGS Bulletin 178 approach, the industry standard for gaged sites, to statistically determine recurrence interval flows. Gages were located near Solomon very close to the proposed rail crossing vicinity at the above rivers.

Gila River:
Based on a data record of 93 peak annual events utilizing HEC-SSP

100-year	144,000 cfs
10-year	40,200 cfs
5-year	24,100 cfs
2-year	9,400 cfs

San Simon River:
Based on a data record of 53 peak annual events utilizing HEC-SSP

100-year	20,600 cfs
10-year	10,000 cfs
5-year	7,890 cfs
2-year	4,690 cfs

The San Simon flow estimate is generated from actual flow events. However, the watershed has been heavily modified with levees, dams and other man-made influences. Although a restoration plan may occur sometime in the future, the existing condition is utilized for design.

Hydraulic Modeling

Existing Conditions Modeling

A hydraulic model was prepared for the proposed crossing location of the Gila River using USAGE'S HEC-RAS River Analysis Software program. The model prepared in the Upper Giia River Fluvial Geomorphology study was used as a base, and modified to reflect current conditions and flow regimes. The 100-year event was used for analysis due to the river's location in a FEMA floodplam. A copy of the cross sections from the base mode! is contained below.

Hydraulic Cross Sections - Base Hydraulic Model (obtained from Bureau of Reclamation)

Numerous dirt channels and roadways on embankments exist in the area. During high flow events, these unreinforced features are not anticipated to remain. This is supported by the assumptions in the existing model obtained from the Bureau of Reclamation and historical records from the National Weather Service that document destruction of these features.

The lateral extents of the water in the project reach is anywhere between Vfe mile and one mile wide The proposed rail alignment is located in a natural constriction in channel width, where the top width narrows to approximately one-half mile wide. Table 1, below, contains specific hydraulic information on the existing or pre-project condition.

Table 1: Existing Conditions Hydraulic Data

Reach	River Sta	Profile	Q Total (•*)	Mm Ch El (1)	WS Bev (lt)	CritWS (ll)	EG Elev (ft)	EQ Slops (MO	v« Chnl CW)	FtowArea Jsqft)	Top Widlti (ft)	Fiouch
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Reach	3533432	100 year	143977 90	2925 26	294473	294295	294633	0002811	10,97	20736,38	3730 97	059

Proposed Conditions Modeling

Two proposed alignments were supplied for analysis. The proposed rail alignment and vertical grade were placed in the model to simulate post-construction conditions. A maximum rise of approximately one foot in the water surface elevation was used to develop a recommended length for the bridge structure

The western-most of the two alignments included a 900-foot bridge length with horizontal curves The water surface elevation rise upstream of the structure was a maximum of approximately 3-feet over Vfc a

mile with this geometry, Due to the horizontal curve, a longer geometry was not considered with this alignment.

The eastern-most alignment included numerous bridge lengths in order to determine a geometry that results in the 1 -foot maximum water surface elevation rise. The minimum recommended length developed with this analysis for the new structure is 1,500 feet, which results in approximately 1 foot of rise However, the maximum allowed rise in water surface elevation will need to be reviewed and accepted by the appropnate regulatory agencies prior to final design. Therefore, this recommended length is subject to change.

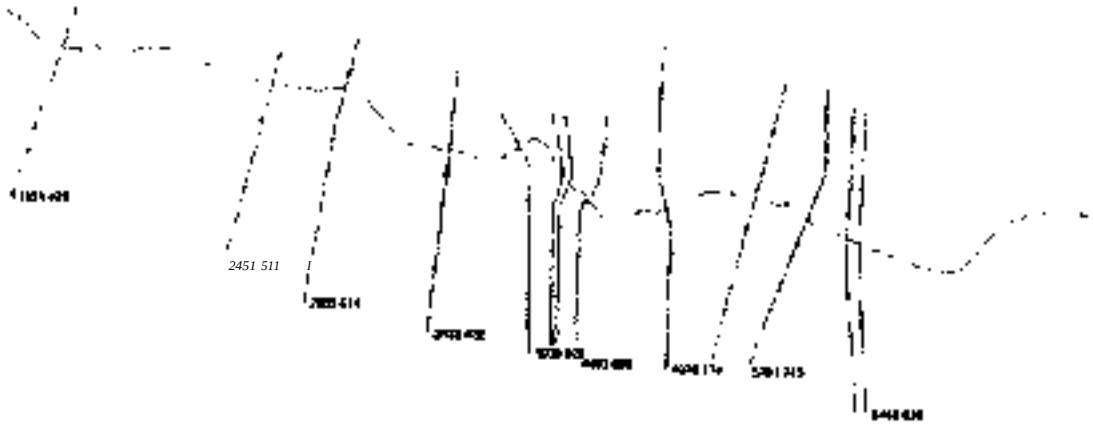

Figure f: HEC-RAS Plan View with approximate rail crossing location

Table 2: Proposed Conditions Hydraulic Data

Reach	FHver Sta	Profile	0 Total (Cfs)	Wn Ch E3 {ll}	W'S Elev ft))	Cm W S (tl}	E Q &ev mi	£ Q Sop* {Hrtij	Vel Cbni (ftfs)	BowArua	TopWWtti	Froude*Chl
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Sediment Transport

Detailed sediment transport analyses were nor performed. The Upper Gifa River Fluvia! Geomorphology study indicates that, at the time of the report, the channel is relatively stable through the project reach in vertical grade. However, significant lateral movement has occurred along the reach due to river response to both natural and man-made processes Therefore, although long term scour is not anticipated to be a factor during final design, a factor of safety is prudent to apply during design to account for future unknowns of channel response,

A preliminary local pier scour depth was calculated using the U.S. Army Corps of Engineer's HEC-18 methodology. Pier scour is anticipated to be around 30 feet. A final local pier scour depth will be calculated prior to final design once the bridge, abutment, and fill geometry is finalized

San Simon River Crossing

The current rail alignment does not include a crossing for the flows generated from the San Simon during a 100-year runoff event. The capacity of the existing San Simon low flow channel is approximately 2,600

cubic feet per second (cfs) This was determined using Manning's Equation with the channel cross section and associated longitudinal slope at the restriction, caused by the crossing of the Montezuma Canal The capacity of the channel is anticipated to be exceeded during relatively frequent events (less than the 2-year event). Once the channel capacity is exceeded, flooding will begin to occur in the adjacent fields until either the overtopping elevation of the canal or the constructed overtopping elevation of the track is reached. The topographic map was examined; however, the 5-foot contour interval mapping was not sufficient in determining the exact geometry and elevation of the canal banks. For the purposes of this evaluation, the overtopping elevation of the canal and the track is considered approximately equal, at elevation 2965.

A potential for overtopping to occur along the tracks exists between Stations 11 +00 and 64+00, or from the departure of the track from the mainline to SR 70. Since the track is level in this reach, it is assumed that flow will be spread evenly along the 5,300 feet of track. However, minor fluctuations in track grade will likely exist after construction and may influence the overtopping location. The following are the depths of water possible on the tracks during the associated events:

100-year	1.0 feet
10-year	0.6 feet
5-year	0.4 feet
2-year	0 2 feet*

*Note: The peak discharge and therefore depth over the tracks may be less due to the effect of storrnwater storage in the adjacent fields. The reduction effect that any storrnwater storage may have on the peak discharge was not evaluated.

These depths assume that the flow is distributed evenly across the entire 5,300 feet of track, and the track and embankment remain during the event. However, it is possible that local portions of the track embankment may fail during an overtopping event. Protection of the embankment is recommended in all areas that are subject to San Simon flows.

Recommendations

At this time, the eastern-most alignment with minimum bridge length of 1,500 feet is recommended for the Gila River crossing However, final geometry is subject to review and approval by the appropriate junsdiclional agencies and is subject to change. Should this recommendation be chosen, coordination with regulators should begin as soon as possible to avoid possible project delays

Additionally, should the owner find the overtopping of the tracks unacceptable, a conveyance feature is necessary for the San Simon River flows. In lieu of overtopping, a bridge structure capable of passing 20,600 cfs is recommended, and should be placed so that no impacts occur to upstream and downstream properties. Coordination between the rail alignment, the existing low-flow channel for the River, and the existing floodplain mapping is necessary. It was beyond the scope of this memorandum to develop recommended geometry for this structure,

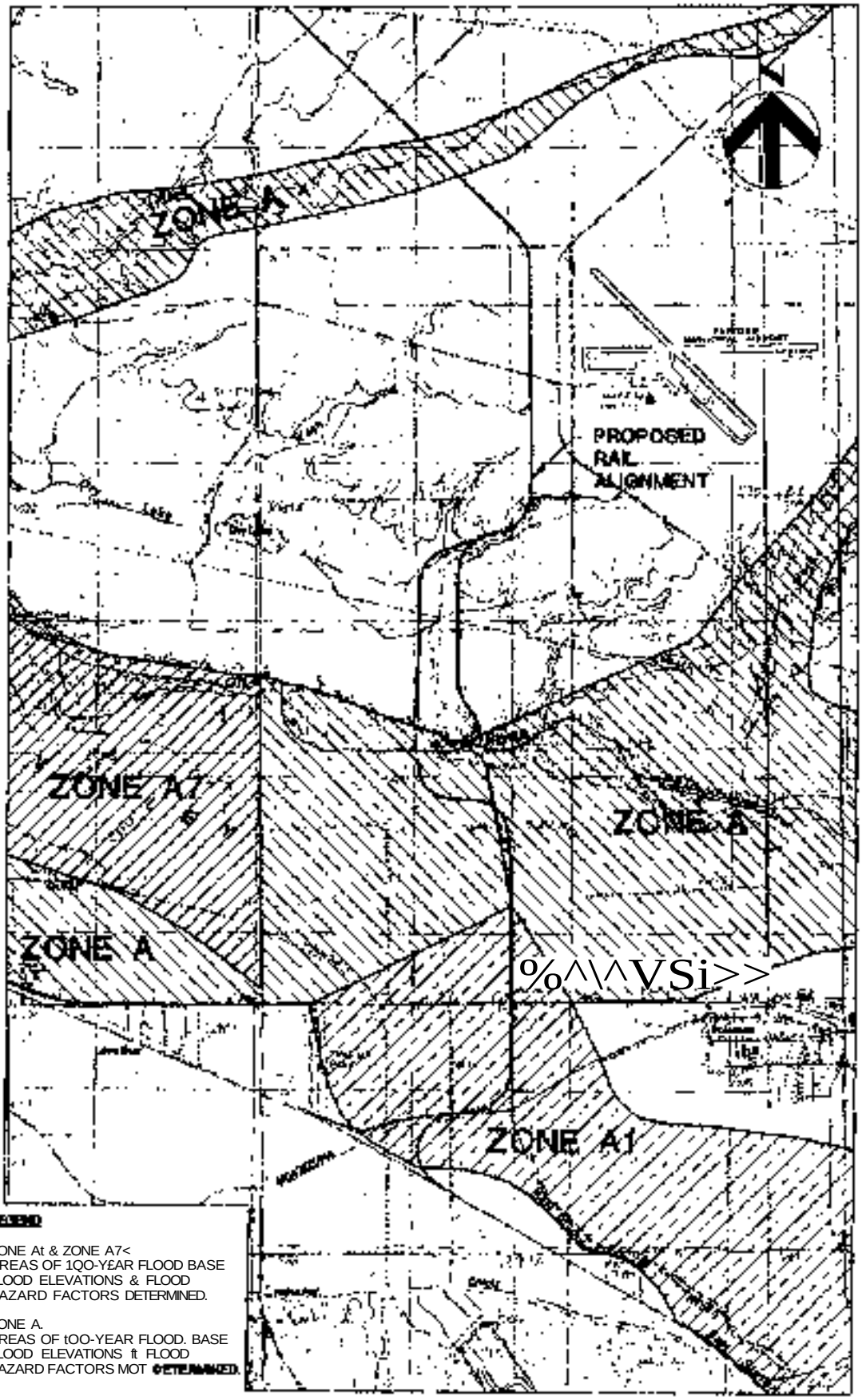
References

Ajami, H et.al 2005, NEMO Watershed Based Plan Upper Gila Watershed, University of Arizona, Tucson,Arizona

National Weather Service, Southeast Arizona Flood History, www.wrh noaa gov

Wittier, R.J,, Delcau, M.R., Klawon, J E, 2001 (Revised 2002). Upper Gila River Fluvial Geomorphology Study Stable Channel Analysis. Technical Service Center, U S. Department of the Interior, U.S. Bureau of Reclamation, Denver, Colorado.

Wittier, R.J. et.al. 2004. Upper Gila River Fluvia! Geomorphology Final Report, Technical Service Center, U.S. Department of the Interior, U.S. Bureau of Reclamation, Denver, Colorado.



LEGEND

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PROJECT

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EXISTING FLOOD PLAIN MAPPING

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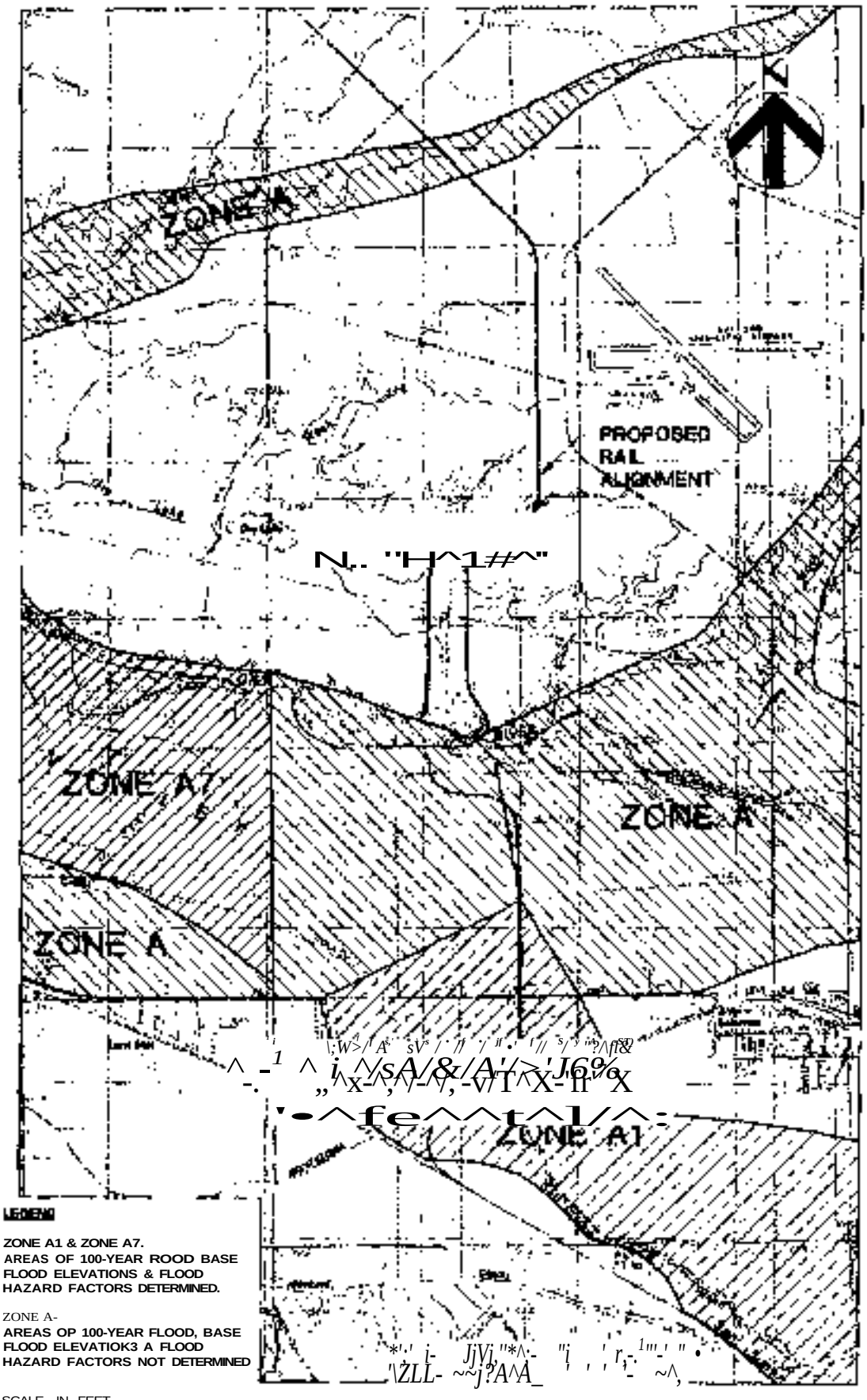
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