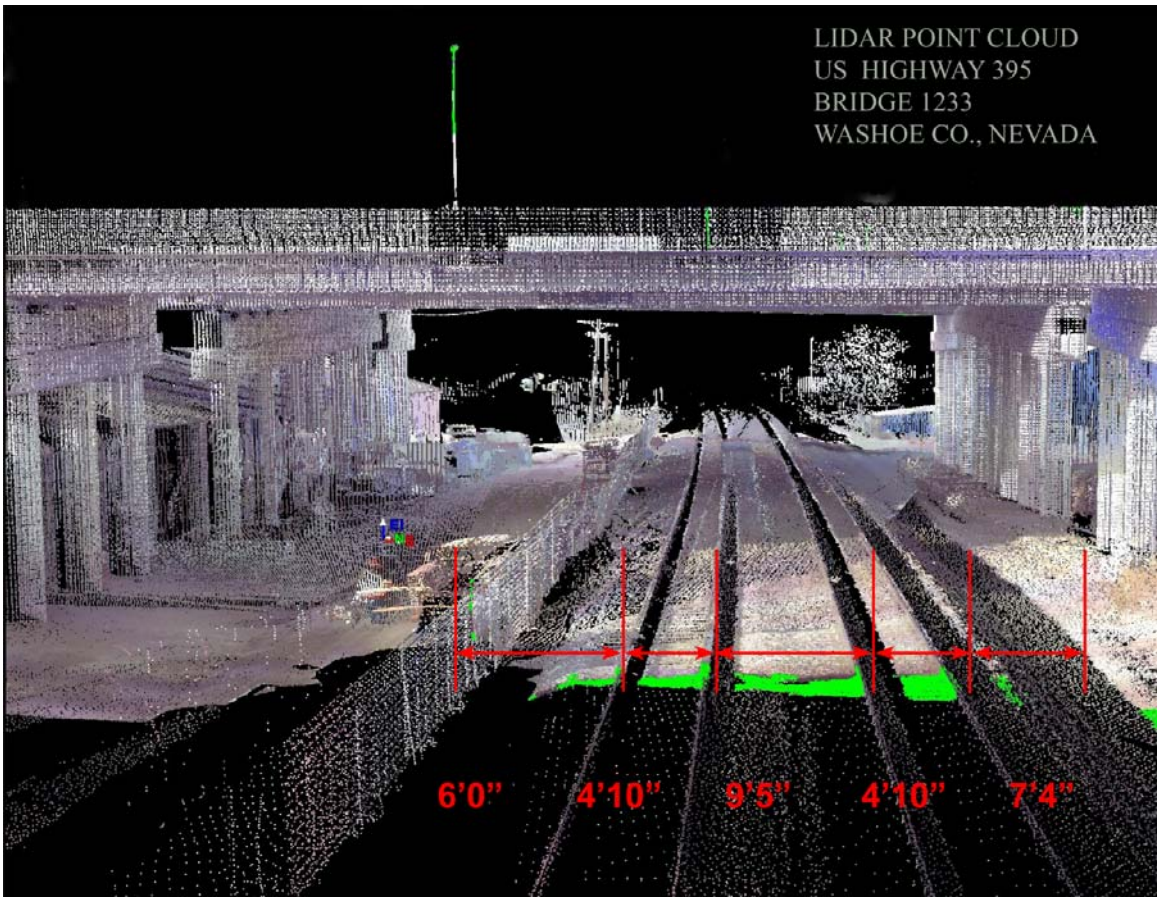
NEVADA DEPARTMENT OF TRANSPORTATION

"On Call Program"

SPECIAL INSTRUCTIONS for SURVEY, MAPPING or GIS Consultants



LOCATION DIVISION

February, 2007

CONSULTANTS' MANUAL

Jim Gibbons
Governor
Susan Martinovich, P.E.
Director

Nevada Department of Transportation
1263 S. Stewart St.
Carson City, Nevada 89712
(775) 888-7000

Published By: Location Division
(775) 888-7250

February 2007

FOREWORD

Another year has come and gone and as usual changes in our profession continue to occur. We update this manual on a regular basis in an attempt to keep current with modern industry standards, document changes that have occurred internally at NDOT and to keep you the practitioner notified as well. This most current Consultant Special Instructions manual has been edited to provide a ready reference to established uniform policies, procedures, and minimum standards concerning mapping and land surveying at the Nevada Department of Transportation. The manual is to provide guidance for consultants developing enterprise topographic mapping and survey information for the Department, while also reflecting current standards used by Location Division. With many NDOT divisions using survey and mapping consultants, we present this material for the benefit of all.

As always seems to happen with a new printing, standards of technical instruction have become larger in physical size, more complex in detail and in some ways more difficult to work with. We have strived to alleviate this situation, failing in some cases and succeeding in others but always willing to accept constructive criticism. Take the time to comment on this product, as those comments will only make the results of our work more accurate which leads to increased efficiency. This is the goal of every professional.

This year we highlight some extra critical components:

- Map Accuracy Standards
- Inclusion of monument perpetuation instructions
- Mandatory testing of photogrammetric products using the NSSDA standards
- Temporary work encroachment permits may be required per each NDOT district

Remember that while completing your work, our personnel are the most important of all our assets, so our work must be done in a safe manner. The safety of all concerned is a top priority here at NDOT and we expect it to be one of your top priorities as well. Error on the side of safety and we will have a Survey Safety Manual available by this years end.

Prior to starting a mapping or survey project, please check with the Location Division, Cartography Section at (775) 888-7449 for any addendum or updated versions of this manual. Technical Survey questions should be directed to the Geodesy Section at (775) 888-7256. GIS questions should be referred to the GIS Coordinator at (775) 888-7265. Those with Imagery questions should call (775) 888-7162.

We hope this manual serves your needs and again we welcome any comments.

Benton J. Grissom, P.E., PLS
Location Engineer

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CONTRACT STANDARDS

GENERAL “ON CALL” PROGRAM

To acquire information about “ON CALL” program placement, please contact the following persons:

For Current DBE Information:
Contact:

Roc A. Stacey
Contract Compliance
(775) 888-7497
rstacey@dot.state.nv.us

“On Call” Pre-qualifications:
Contact:

Dana A. Olivera
Administration
(775) 888-7070
dolivera@dot.state.nv.us

NDOT Location Division Consultant Coordinator
Contact:

David R. Hamlin, PLS
Chief Geodesist
(775) 888-7256
dhamlin@dot.state.nv.us

After pre-qualifications the following will occur:

Review of consultant qualifications
List developed
Ranking
Signing of “ON CALL” Agreement between consultant and NDOT
Issuing a task order

GENERAL "TASK ORDER" PROGRAM

The purpose of the "ON CALL" program is to use consultants when:

A. There is inadequate manpower in-house.
B. Inadequate expertise in-house in the given field of study.

The fourteen-step process shown below briefly describes the "task order" process. This by no means replaces the formal provisions of the current standard consultant selection process as defined by NDOT in the "**Consultant Agreement Procedures**" manual. Task orders will be released to those firms already selected as "ON CALL" consultants.

1. Assign project to "ON CALL"
2. Initial telephone contact with consultant
3. Letter detailing scope of work
4. Acquire in-house cost estimate
5. Receive cost estimate from consultant
6. Assign and develop task order
7. Documents signed, work begins
8. Submit initial work to appropriate section within Location Division for adherence to standards.
9. Submitted for payment
10. Audit review
11. Final billing when work is finished
12. Post audit and review for final payment
13. Consultant evaluation and response
14. Agreement closeout

VENDOR RESPONSIBILITIES

A. It is the vendor's responsibility to be familiar with all specifications and guidelines provided by NDOT and to follow them in performing work for NDOT.

B. It is the vendor's responsibility to consult with NDOT to resolve all discrepancies and ambiguities between these specifications and the task order **prior** to proceeding with work on the project.

C. Where these specifications, task order, and the mapping limits diagram describe portions of work in general terms, but not in complete detail, it is to be understood that only the best professional practice is to prevail. Satisfactory materials and equipment are to be used as necessary to complete the work in accordance with accuracy and content requirements specified therein.

D. It is the vendor's responsibility to use materials, software, and equipment and other incidentals necessary to perform the work that are of uniformly high quality and will be compatible with the quality and accuracy standards specified for the project.

E. It is the vendor's responsibility to provide safe storage of any point marked diapositives and control photos provided by NDOT while they are in the vendor's possession and to ensure their safe return to NDOT at the completion of the project.

F. At the completion of a mapping or GIS project, the vendor shall return to NDOT all materials including original negatives, diapositives, contact prints, and scanned digital image files on CD-ROM or DVD. In addition for GIS projects, source code, required documentation and data as appropriate will be provided to NDOT.

G. A Nevada Professional Land Surveyor will be responsible for Mapping or Survey projects. A PLS stamped report will be required of the consultant to indicate that the minimum requirements of surveying and mapping have been met.

H. Safety is a first priority at NDOT. Field personnel will at all times wear vests, and hats. They will also have proper signage set at the work site.

CONSULTANT PROPOSAL

Sept.1, 2002
REVISED

Mr. Ben Grissom
Nevada Department of Transportation
1263 S. Stewart Street
Carson City, Nevada 89712
FAX (775) 888-7203

SUBJECT: S.R. 28 - SPOONER JUNCTION TO TWO MILES NORTH OF SPOONER JUNCTION

Dear Ben,

Per your request, we have prepared this proposal to survey and map the right-of-way of a two-mile portion of S.R. 28 at Lake Tahoe. As discussed, this will be performed on the State Route beginning at Spooner Junction on the south and continue north approximately two miles to the northerly terminus of our mapping project, NDOT Agreement No. P000-00-000.

Proposed tasks for this project are:

RESEARCH: All record documents and right-of-way mapping information defining the existing right-of-way and adjacent property ownership lines will be obtained to aid in the recovery of boundary corners and the establishment of property lines.

RECONNAISSANCE: Recover and locate all existing NDOT construction control monuments, base control, right-of-way, and boundary corners necessary to control and define existing alignment and adjacent property ownership lines.

FIELDWORK: Tie existing property corners, section corners, and highway monuments from the existing control monuments set by NDOT.

CENTERLINE ALIGNMENT CALCULATIONS: Calculate best-fit centerline using record maps and found prima facie evidence.

GEODESY ALIGNMENT DRAFTING: Draft calculated alignment and submit individual sheets on disk along with all required deliverables per the "Consultant Handbook."

MEETINGS: Three meetings are anticipated with NDOT personnel.

The cost estimate has been itemized on the attached spreadsheet and amounts to a total of $14,273.25 for this service contract.

If you should have any questions or require further information regarding our scope of services or this proposal, please contact

Respectfully submitted,
SodHouse Surveying, LTD.

_____

James Merritt, President

Sept. 1, 2002
S.R. 28
Page Two

TYPICAL "ON CALL" TASK ORDER

The consultant shall provide for the survey and mapping as follows:

I Overview

A. The required scope of work is to supply photogrammetric mapping covering a width of (********) meters along route (********) as shown on the attached sketch map.

B. Accuracy and scale requirements necessary to assure digital photogrammetric mapping for this project as defined by NDOT's "Special Instructions for Survey and Mapping Consultants" manual, will be met. The quality of compiled maps will be periodically verified by NDOT with methods described in the FHA "Survey and Mapping Manual."

C. Included in this scope is the necessary survey work consisting of aerial control, construction control, and cadastral surveying. The accuracy requirements for these surveys have been delivered to you in the "Special Instructions for Survey and Mapping Consultants" manual or will be delivered to you upon request.

II Reconnaissance

A. Your firm will be expected to perform an initial reconnaissance that will reveal approximately where:

1. All existing highway reference or right-of-way monuments are located.
2. Any existing state plane coordinate data may be extended from.
3. The location of photo control panels will be set.
4. Construction control monuments will be set.
5. Locate PLSS monuments found in oil.

III Horizontal and Vertical Control

A. The basic control survey shall provide for all other project surveys and consist of a traverse or a series of connected traverses. These points shall be monumented, stamped, have a witness post set 1m south of the monument wherever feasible, and have a written description sufficient for monument retrieval. GPS points are acceptable if they meet specifications and are visible with other GPS points.

B. The Construction Control Survey shall provide monumented and stamped control approximately every 450m and at offsets from each PC and PT along the project limits.

C. The Aerial Control Survey shall provide monumented and stamped control as needed for the placement of aerial panels.

D. The Cadastral Survey shall provide geodetic positions on all found highway reference monuments and R/W posts. In addition, section corners and property corners as identified and requested by the R/W division of NDOT shall be tied.

E. All Surveys shall occur under the direct supervision of a Nevada Professional Land Surveyor.

IV Computations

A. The coordinates of each point shall be reported in the geodetic coordinate system authorized for the project by the Geodesy Section of NDOT and will reflect the mean ground to grid factor.

B. A best-fit alignment retracement shall be generated showing the centerline of the right-of-way and equations showing the newly generated alignment and the existing alignment documented and correlated to show the relationships between the two alignments.

C. All computation work shall occur under the direct supervision of a Nevada Professional Land Surveyor.

V Mapping

A. Your firm shall provide mapping that will be used in both the preliminary and design phases of engineering projects and as such you will compile both topographic and planimetric data. The generated MTCs may be used to calculate engineering volumes and all data must meet NDOT minimum standard specifications.

B. Mapping shall be completed using authorized NDOT cell libraries and will observe NDOT color/layer/line type conventions.

VI Deliverables

A. Deliverables shall include the following:

1. Survey:
   - a. Reconnaissance report
   - b. Traverse and survey closures with network diagram
   - c. ASCII final coordinate listing
   - d. ASCII coordinate/alignment offset report
   - e. ASCII descriptions for all monuments

2. Mapping:
   - a. Aerotriangulation results
   - b. MicroStation 3D planimetric files
   - c. MicroStation 3D topographic files
   - d. InRoads DTM file

3. Imagery:
    a. One set of contact prints of the project
    b. Digital images of the project
    e. All negatives related to the project

VII Special Concerns

A. Points set in the field must be uniquely name stamped.

B. All applicable required permits shall be acquired before fieldwork begins, i.e. (Right of Entry).

C. All proper safety procedures concerning visibility and signs will be observed in surveying and mapping data collection.

D. If a specific duty has not been identified within the task order, but is required for the project, the consultant is expected to complete them in their normal course of work.

GIS OUTLINE FOR PROJECT PROPOSALS

Initial proposals should be submitted electronically in the current NDOT word processing software package to allow for commentary or editing. Final proposals should be submitted in PDF format. The suggested outline includes minimum information.

Purpose
- Project purpose

Project Narrative
- Description of problem and major issues to be resolved

Project Approach
- Methodology for resolution of issues in narrative

Tasks and Deliverables
- Project Initiation
- Requirements and Design
- Development and Testing
- Delivery

Management Approach
- Covers status reporting/communications
- Forms
- Work plans
- Information requests
- QA/QC
- Deliverable Acceptance

Location of Work
- Specific locations where work will be done and what phases will be performed at these locations.

Deliverables
- A listing of all deliverables

Assumptions
- Limiting factors and hardware, software issues

Resources (Staff)
- Includes contact information and function

Project Schedule
- Includes a graphic of staff assigned, title, and hours
- Includes plan of actions and milestones.

Project Costs
- Hourly rates
- Cost per phase
- Travel
- Sub-contractor work subtotal (if applicable)
- Cost total

Appendices
- Timeline
- Design or Functional Requirements documents

CONSULTANT TIME/COST EXAMPLE INVOICE

SR28 – FROM SPOONER JUNCTION NORTH 2 MILES

09/01/02

DIRECT COST **VOID – SEE REVISED BELOW**

Task 1: Research			
Professional Land Surveyor	8 hr. @	$28.61/hr.	$228.88
Technician	16 hr. @	$15.75/hr.	$252.00
Task 2: Reconnaissance			
Professional Land Surveyor	16 hr. @	$25.50/hr.	$408.00
Party Chief	24 hr. @	$17.75/hr.	$426.00
Instrument Man	24 hr. @	$14.00/hr.	$336.00
Clerical	4 hr. @	$15.05/hr.	$60.20
Task 3: Horizontal and Vertical Control			
Professional Land Surveyor	16 hr. @	$25.50/hr.	$408.00
Party Chief	40 hr. @	$17.75/hr.	$710.00
Instrument Man	40 hr. @	$14.00/hr.	$560.00
Technician	8 hr. @	$15.75/hr.	$126.00
Clerical	10 hr. @	$15.05/hr.	$150.50
Task 4: Calculations and Right-Of-Way Resolution			
Professional Land Surveyor	40 hr. @	$28.61/hr.	$1,144.40
Technician	40 hr. @	$15.75/hr.	$630.00
Party Chief	10 hr. @	$17.75/hr.	$177.00
Instrument Man	10 hr. @	$14.00/hr.	$140.00
Clerical	4 hr. @	$15.05/hr.	$60.20
Task 5: Right-Of-Way Mapping			
Professional Land Surveyor	40 hr. @	$23.56/hr.	$942.40
Technician	60 hr. @	$15.75/hr.	$945.00
Task 6: Meetings			
Principal Professional Land Surveyor	4 hr. @	$51.92/hr.	$207.68
Professional Land Surveyor	8 hr. @	$28.61/hr.	$228.88

Subtotal		8,141.64
Overhead	$8,141.64 x 1.49	$12,131.04
Subtotal		$20,272.68
Fixed fee	9% (profit)	$1,824.54
Subtotal		**$22,097.23**

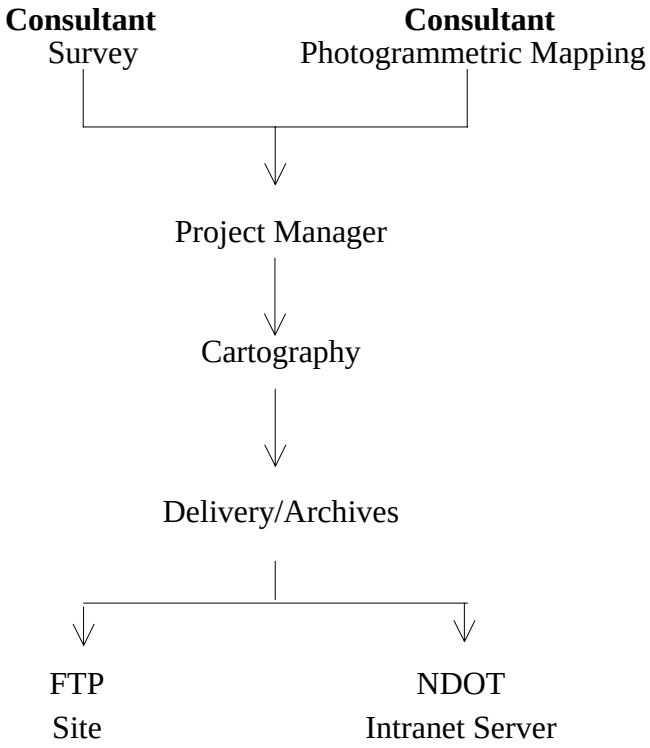
INDIRECT NON-SALARY COST

GPS Receivers	40 hr. @	$25.00/receiver-hr.	$1,000.00
Mileage	1660 mi @	$0.45/mi	$747.00
Total Station	32 hr. @	$8.25/hr.	$264.00
Material		$450.00	$450.00
Subtotal			**$2,461.00**

Direct Labor, Overhead, and Fee	$22,097.23
Indirect Costs	$2,461.00
Total	**$24,558.23**

NOTES: Wages listed are averaged per category and are current through March 1998.

FLOWCHART OF CONSULTANT MAPPING



BILLING STANDARDS

INVOICES / AUDITS

The billing process is fully described in the Master Agreement or the "On Call" agreement that was signed by your firm. To reiterate and further clarify, please note the following:

I Pre-negotiation Audit

A. Prior to the negotiation of the first task order issued against an "On Call" agreement, NDOT will perform, or have performed, an on-site audit of the consultant's accounting system to assure that it can handle the segregation of costs necessary for the agreement and that the consultant understands Federal cost eligibility regulations contained in 48 CFR, chapter 1, part 31. In addition, the consultant's overhead costs and fixed profit percentages will be determined for inclusion into agreement negotiations.

II Monthly Billings

A. Location Division requires the use of a standard monthly billing invoice (example page 19). In addition the standard monthly progress report will be required (see page 20). Send these to the "On Call" coordinator. NDOT will pay 90% of the amount of an agreement with the last 10% being retained until the work is accepted and the closeout audit performed. Monthly billings will be reviewed for reasonability, conformity, and accuracy by the project manager; he then approves an invoice of payment certifying that there are sufficient funds left in the agreement for payment.

B. For projects less than 90 days in duration a "lump sum" payment upon completion of project approach may be used.

C. For GIS projects, billing at 30%, 60%, and 90% is acceptable. The final 10% payment will not be made until all deliverables are received.

III Final Billings

A. The final billing will be a typical monthly billing with the statement of **"final billing"** clearly marked on the billing invoice.

IV Close-Out Audits

A. Upon completion of a task order, NDOT will schedule a closeout audit. They will verify the supporting documentation for your invoices, as described in the "On Call" agreement. Further questions relating to either of the audits may be addressed to:

Chief Internal Auditor
Phone (775) 888-7007

LOCATION DIVISION CERTIFIED INVOICE

To
Attn: Chief Geodesist
Nevada Department of Transportation
1263 S. Stewart St
Carson City, NV 89712

Remit to
Attn: Ray Bolger
Sierra Engineering
1616 Molly Dr
Yerington, NV 89447

Re:
Carson City By-Pass Mapping
Final Billing

Date:
September 1, 2001

Period:
4-1-01 through 8-31-01

DIRECT LABOR COSTS:

Employee	Rate	Hours	Amount
Woods, Jack T.	51.25	30	1537.50
McQueen, Ray, S.	27.41	23	630.42
Eastwood, Frank, W.	30.29	4.0	109.35
Duvall, Bert, L.	20.15	8.0	260.45
Dunne, Judy, D.	19.50	9.0	110.90
Cusack, Billy, B.	15.37	5.5	289.90
Hamilton, T. R.	10.02	6.0	54.56
Cushing, Charles	5.09	8.0	49.50

Direct Labor: 3042.58

Overhead at 168% of Total Direct Labor 5135.87

Total Direct Labor Subtotal: 8178.45

NON – DIRECT LABOR COSTS:
(see attached billing)

J & S Contractors		100.00
Carson Trucking		250.50
Total Non-Direct Costs	Subtotal:	350.50

Fixed Fee at 12% of Total Direct Labor Subtotal: 981.40

Adjustment to costs:
(see attached) Subtotal: 0.00

Total Amount Due this Invoice Total: $8,859.31

Authorized Signatures

Name	Date	Signature
_____	_____	_____
_____	_____	_____
_____	_____	_____

INVOICE NO. _____

NEVADA DEPARTMENT OF TRANSPORTATION
CONSULTANT SERVICES
CONSULTANT MONTHLY INVOICE AND PROGRESS REPORT

BILLING PERIOD: FROM _____, 20___ TO _____, 20

CONTRACT NO. _____
PROJECT ID NO. _____
PROJECT NO. _____
PROJECT NAME _____
FIRM NAME _____
REMIT TO ADDRESS _____
_____
_____
_____
PHONE NO. _____
FAX NO. _____
CONTACT PERSON _____
DBE GOAL _____
% DBE TO DATE _____

PROJECT TERMINATION DATE
AGREEMENT NO.
AMOUNT OF AGREEMENT $
AMOUNT OF SUBCONTRACTS $
SUBCONTRACTS PAID TO DATE TOTAL $
TASK ORDER NO.(S)
AMOUNT OF TASK ORDER $
TOTAL AMOUNT INVOICED THIS PERIOD $
BALANCE REMAINING $
$ INVOICED TO DATE
% OF PROJECT COMPLETED TO DATE
LIQUIDATED DAMAGES START DATE
FINAL INVOICE: YES_____ NO

***COST PLUS FIXED FEE AGREEMENTS**

COMPLETE PROJECT BREAKDOWN - REVERSE SIDE OF SHEET

TARGET MILESTONE DATES

30% SUBMITTAL _____ 60% SUBMITTAL
90% SUBMITTAL _____ 100% SUBMITTAL
OTHER:

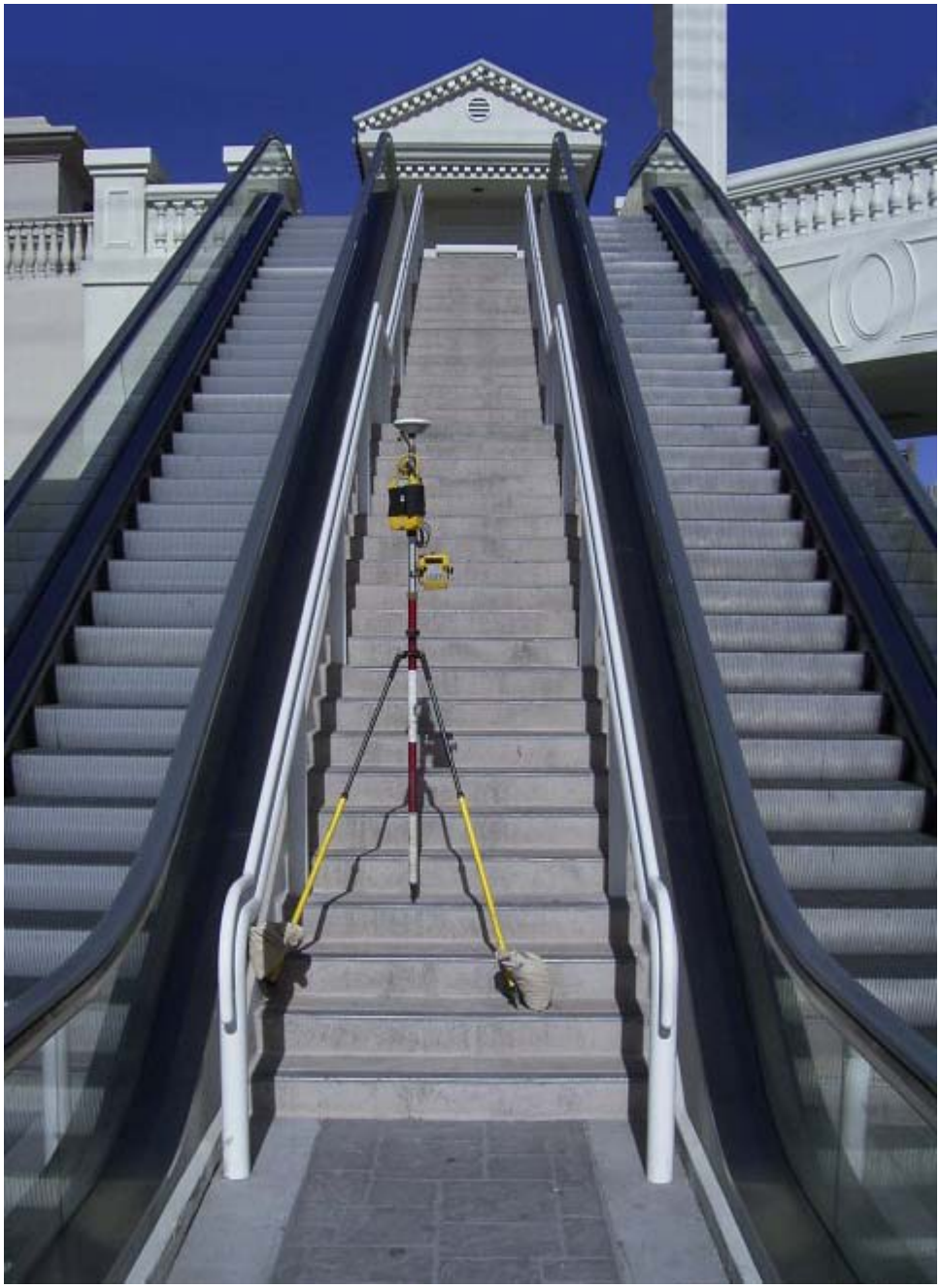
SUMMARY OF WORK PERFORMED THIS INVOICE
(Attach additional sheets if necessary)

SUBMITTED BY:
Signature of Consultant Date

APPROVED:
NDOT Project Manager Date

NDOT CODING:

Org: _____ Appro.: _____ Activity: _____ Object: _____ Job/Project:



SURVEY STANDARDS

TYPES OF SURVEYS

The Nevada Department of Transportation Location Division has identified the following as typical **types of surveys** that may be released to an "On Call" consultant. Please note the use of hierarchical survey methods used at NDOT. This method of surveying prevents the buildup of systematic errors over large regions by imposing restraints and allows the surveyor to determine the maximum computed uncertainty of a position, with respect to controlling Monumentation, and in terms of local relative positional accuracy. Because the published High Accuracy Reference Network (HARN*) has negligible systematic errors, it serves as the current reference frame considered to be absolutely accurate at NDOT. The survey type or types required in a given task order shall be referred to and have a meaning as described below:

Control Surveys

BASIC CONTROL SURVEY: The basic control survey or control densification, based directly upon fixed HARN control, provides control for all other project surveys and is a connected series of independent vectors, properly weighted, constrained, and adjusted least squares network.

CONSTRUCTION CONTROL SURVEY: This survey, based directly upon previously adjusted and fixed **Basic** control, includes reference monuments placed every 1450 feet (+/-) along the project length, and being inter-visible between adjacent monuments, at or near right-of-way limits in secure locations.

AERIAL CONTROL SURVEY: This survey, based directly upon, as a minimum, previously adjusted and fixed higher order **Construction** control, provides for the placement of aerial panels.

Cadastral Boundary Surveys

CADASTRAL BOUNDARY SURVEY: This survey, based directly upon and as a minimum, previously adjusted and fixed **Construction** control, providing for positions of Highway Reference monuments, R/W monuments, property monuments, and section corners that would typically, in addition to construction control, be used to identify properties and boundary locations.

Engineering Surveys

TOPOGRAPHIC SURVEY: This survey, based directly upon and as a minimum, previously adjusted and fixed **Construction** control, provides for the location of topographic features, including utilities, surfaces, and other detail that may be found within or along NDOT right-of-way.

CONSTRUCTION SURVEYS: This survey, based directly upon and as a minimum, previously adjusted and fixed **Construction** control, marks the horizontal location (line) as well as the vertical location, or elevation (grade) for proposed fixed works.

* HARN: refers to the NAD83/94 adjusted NAD83 datum.

MINIMUM ENGINEERING SURVEY STANDARDS

Topographic Surveys

NDOT has determined that dependent upon various needs, topographic surveys will be collected with a precision defined by these levels:

Level 1 Details that can be precisely defined, usually consisting of points.
Example: sewer/culverts inverts, white pavement, and bridge beams.
Positional accuracy:
Horizontal class = **IV** vertical class = **II**

Level 2 Details that require a location at moderate precision, consisting of points or polylines.
Example: manhole cover, edges of oil, walkway.
Positional accuracy:
Horizontal class = **VII** vertical class = **VII**

Level 3 Natural features not precisely defined, consisting of polylines.
Example: stream banks, rock outcrops, edges of gravel road.
Positional accuracy:
Horizontal class = **VIII** vertical class = **VIII**

Plotting of topographic features requires a positional accuracy dependent upon the final map scale and a plotting accuracy assumed to be 0.002ft.

Contract Stakeout Survey

Positional Tolerances

	Horizontal (+/-)		Vertical (+/-)	
Rough Grade Stakes	0.15m	0.50ft	0.05m	0.16ft
Sub grade Red Head Stakes	0.05	0.16	0.01	0.03
Finish Grade Blue Top Stakes	0.05	0.16	0.01	0.03
Building Offset Stakes	0.005	0.03	0.01	0.03
Sewer Offset Stakes	0.05	0.16	0.01	0.03
Waterline Offset stakes	0.05	0.16	0.02	0.07
Hydrant Offset stakes	0.05	0.16	0.01	0.03
Street Lights	0.05	0.16	0.03	0.10
Curb Offsets	0.01	0.03	0.01	0.03
Structural Concrete	0.01	0.03	0.01	0.03

MINIMUM CONTROL AND LAND SURVEY STANDARDS

The Nevada Department of Transportation Location Division has determined that the following minimum standards must be met by all "On Call" consultants. These standards are given in terms of relative position accuracies and exceed those minimums as required by NAC 625.780, NAC 625.790, and NAC 625.860. Further, we have correlated these tables to match NDOT classifications, thus assuring that everyone understands the minimum accuracies required at 95% probability. These standards are independent of measurement equipment and technology but do reflect the objectives required by NDOT. While the classification chart used by NDOT is the FGCS accuracy classification chart, products prepared for NDOT must only meet NDOT specifications. NDOT does not intend to "Blue Book" tied monuments, therefore specifications, but not accuracy standards, are significantly different.

NDOT Minimum Positional Accuracies

	Basic Control	Construction Control	Cadastral Control	Aerial Control
Horizontal	**IV**	**V**	**VI**	**VI**
Vertical	**VI**	**III**	**VI**	**VI**
NAC 625	State	County	High Urban	Photogrammetric

Note:

- Positional tolerances required use the next highest, or greater, classification of control for their relative frame of reference.
- Basic control points set in concrete and having a greater likely permanence, are commonly referred to as "X" points or HARN densification points. These typically include establishing basic control points on existing NGS benchmarks.
- Control Extension only occurs from monuments with semi-permanent character.

NDOT Classification Chart at 95%

Classes	Range	Typical uses
I	< 0.001 m (. 003ft.)	Precise measurement studies
II	< 0.002 m (. 007ft.)	Precise measurement studies
III	< 0.005 m (. 020ft.)	Precise measurement studies
IV	< 0.010 m (. 030ft.)	Basic control or HARN densification
V	< 0.020 m (. 070ft.)	Construction control
VI	< 0.040 m (. 152ft.)	Aerial control, cadastral corner
VII	< 0.100 m (. 330ft.)	Utilities location
VIII	< 0.500 m (1.64ft.)	Features mapping
IX	< 2.000 m (6.65ft.)	Resource mapping
X	< 5.000 m (16.40ft.)	Resource mapping
XI	< 10.00 m (32.81ft.)	Resource mapping
XII	> 10.00 m (32.81ft.)	Resource mapping

MINIMUM GPS ACQUISITION SPECIFICATIONS

NDOT has established these rules as to how the minimum positional tolerances (standards) can best be met. As new technology becomes available, it is expected these specifications may require modification or additions.

GPS Specifications by Survey Type

Specifications	Basic	Construction	Cadastral	Aerial	Topographic
Minimum number of connections to higher order fixed known horizontal/vertical control per network	3	3	2	2	2
Minimum number of independent vectors to individual control points	2	2 vectors 1 scalar	2	2	1
Max number of network traverse legs without 3 independent vectors	2	4	4	4	N/A
Dual frequency	Y	N	N	N	N
Minimum satellite mask angle above horizon	13	13	13	13	13
Minimum number of satellites tracking/GDOP	5/7	5/6	5/6	5/6	5/6
Epoch recording Rate Seconds	15	15/5	15/5/1	15/5/1	15/5/1
Field data log required	Y	Y	Y	Y	N
Point description with unique name required	Y	Y	Y	Y	N
Recommended min/max station spacing (miles)	6/31 max	.3/.35	0/6	0/.3	0/.3
Survey Method:					
Static					
Fast Static					
Stop & Go					
RTK(post processing)					
RTK(calibration)					
Conventional					

NDOT Minimum GPS Occupation Times

Dual Frequency

	< 5 Km	**≥ 5km to <15Km**	**≥ 15 to <50Km**
Static	20 minutes	20 to 50(2x60 Basic)	50-130*(2x120 Basic)
Fast Static	8 to 10 minutes*	10 to 20 minutes *	N.A.
Stop & Go	10 epoch's minimum		N.A.
RTK (post processing)	Reoccupation > than 45 minutes apart		N.A.

Single Frequency

	< 5 Km	**≥ 5 to <10Km**	**≥ 10 to <15km**
Static	20 minutes	20 to 50 minutes *	50 to 75 minutes*
Fast Static	15 minutes	15 to 20 minutes	N.A.
Stop & Go	10 epochs		

Observation times and accuracy are functions of GDOP, number of satellites, ionospheric disturbances but mainly distance. It is highly recommended that baselines be kept to a minimum while also recognizing the NDOT has minimum monument distances assuring a relative line accuracy (RLA). RLA is the allowed positional tolerance / distance between station.

* Indicates a range of time proportional to the vector distance.

Observation times are determined avoiding both the worst "observing window" and optimum "observing window" while traditionally assuring a fixed ambiguity integer solution.

Below are some industry standard occupation times that are not reflective of NDOT standards, but that are acceptable.

Static (95%)
- Double Frequency: 20 min + 2min per km
- Single Frequency (15km max): 30 min + 2 min per km

Fast Static (95%)
- Single Frequency: 10 min + 2min per km
- Double Frequency: 5 min + 1 min per km

NDOT Minimum GPS Network Adjustment Procedures

1. Vector Processing

- Basic control will use Precise ephemeris & others Broadcast
- Process using best independent baselines
- Ratio >2, variance <2, fixed solutions with dual frequency
- Ratio >4, variance <4, fixed solution with single frequency
- Check loop closures

2. Free - Network Adjustment

- Fix one coordinate for adjustment
- Tribrach error = .002m and HI error = .003m
- Evaluate all vectors eliminating those failing
- Process monuments in hierarchical method.

3. Constrained Network Adjustment

- Constrain all control
- Use geoid 03, or latest, for orthometric elevations
- Compare constrained adjustments to free adjustment
- Calculate ground coordinates

CONVENTIONAL SURVEYS

While we expect to use conventional surveys only in unusual circumstances, they will be with us for a number of years. Traditional survey equipment may be used to collect all types of surveys, except "Basic Control Surveys." If used, traverses and networks must be adjusted using least squares and positional tolerances evaluated verifying they meet NDOT standards. Further, they may be included into GPS data sets and thus must be properly weighted. Below are standard NDOT weights used in adjustments.

Angle Weighting (95%)

	Instrument/Distance Shot					
	1 sec <100m	1sec >100m	6 sec <100m	6 sec >100m	20 sec <100m	20 sec >100m
1 set	5.1	3.1	5.9	4.1	7.7	6.5
2 set	4.6	2.3	5.1	3.0	6.2	4.7
4 set	4.4	1.8	4.7	2.3	5.3	3.4
8 set	4.3	1.5	4.5	1.8	4.8	6.2

Distance Weighting Using Manufacturer's Specifications

	Constant	PPM
Trimble 5600	2mm	2
Geodimeter 112	9mm	1
Engineer chain	0mm	200

Centering Errors

Horizontal Centering =	0.003 m
Vertical Centering =	0.006 m

Precise Elevations

Procedure Used

2nd order class 1	$6mm \times \sqrt{km}$
2nd order class 2	$8mm \times \sqrt{km}$
3rd order class 1	$12mm \times \sqrt{km}$

FINAL SURVEY REPORTS

At the end of a project a final survey report will be delivered to the Geodesy Section at NDOT, where they will be archived. The final reports, paper and digital, may include:

- Network diagram
- Raw data files
- Minimally constrained report (grid or geographic)
- Constrained report (grid or geographic)
- Point ellipse diagram
- Project combination factor
- Final coordinate list (gnd)
- Point descriptions
- ASCII utilities file
- Supplemental roadway profiles
- Contract control list
- “Best Fit” alignment report
- Drafted project plat showing best-fit alignment, necessary jurats, monument offsets, PLSS offsets, and a coordinate table. Created PLSS corner perpetuation document.

A general report or narrative shall be written describing the project in general thus documenting any found concerns or problems with the survey or problems that the survey brought to light. When this report is stamped and delivered with the surveyor’s seal, the final product can be considered delivered.

INSTRUCTIONS FOR SETTING AND STAMPING OF CONTROL MONUMENTS

Monuments Character

Monuments may include both horizontal station markers and benchmarks. All points shall be placed before the point is occupied by an instrument, signal, or rod. NDOT requires a specific type of monument to be used on all projects dependent upon the type of control. Stamping will reflect the monument and name.

	Basic	**Construction**	**Cadastral***	**Aerial**
Wooden Hub				**x**
Washer Disc				**x**
Rebar Marker			**x**	
Feno Monument		**x**	**x**	
Concrete Marker	**x**			

*Cadastral monuments will be set in accordance with state and local laws and stamped by the PLS in responsible charge. Corner records will be filed if needed using NAC 625.810 as a guide.

NDOT Naming Convention

After a preliminary project review (reconnaissance) has been completed by the consultant and reviewed by NDOT, caps shall be provided to the consultant by NDOT. The station name shall be assigned using a unique number as assigned by NDOT, and the consulting surveyor shall complete field setting and stamping.

EX: LPN1012, first station point number, section corner
Designation = **1012001L**

- Letters 1, 2, 3&4 designate the Location Project Number (LPN) assigned by NDOT
- Letters 5,6, &7 designate the sequential station number assigned and stamped by consultant
- Letter 8 indicates the point type assigned and stamped by consultant

Point types

A = Traverse point
X = Permanent basic control point
M = Construction control point
K = Construction control point / no spirit level elevations
L = Section corner (PLSS)
H = Highway reference monument
S = Local street monument
P = Property corner
Z= Fixed NGS control (X, Y, & Z)
B= Boundary Control Point
R= Railroad or Reset

CONSTRUCTION CONTROL MONUMENTATION

Construction control monuments shall be used as reference monuments on all projects. Construction monuments (reference monuments) shall be constructed and surveyed prior to project design on all projects requiring preliminary surveying.

1. Monuments will be stamped Nevada Dept. of Transportation Control Monument and designated by the present Location Division's point naming convention. A minimum of three (3) Construction Monuments will be inter-visible and placed in NDOT's right-of-way in areas most likely not to be disturbed using conventional survey methods.
2. All monuments will be of a semi-permanent character.
3. Construction Monuments will be established and surveyed to construction control standards set forth in this manual. For monument character and NDOT naming conventions, see page 30.
4. Spacing between the Construction Monuments will not be greater than 1650 feet nor less than 1300 feet and will be inter-visible.
5. The distance error between inter-visible "Location" construction control monuments must exceed a ground relative line accuracy of **RLA** = 1:20,000 horizontally and .008m times the square root of the distance in kilometers vertically, or a positional tolerance at the 95% confidence level of <0.070 feet horizontally and <0.020 feet vertically.
6. All Construction Monuments will have horizontal and vertical positions constrained to NAD83/94 HARN adjusted coordinates and NAVD88 or NGVD29 vertical control or the most recent datum set forth by Nevada Revised Statutes. Horizontal grid positions should be corrected to ground using page 33 as a guide, or contact Geodesy Section directly.

The Consultant will generate a Control Schedule for inclusion into each design contract.

1. The Control Schedule will have a listing of Reference Monuments used in establishing the best fit alignment, its relationship to Public Land Survey Corners, Property Corners or Property Controlling Corner Monuments, property corners adjacent to the right-of-way corridor, construction control monuments, and any previously existing alignment reference monumentation. Examples will be provided upon request, through the Geodesy Section
2. The Stamped Control Schedule shall be sent to the Location Division for review and will be included in the contract plans.

MONUMENT DESCRIPTIONS

As experienced surveyors know, there is no perfect measurement. Therefore coordinate values used to pinpoint a monuments true location is a close approximation at best. The uncertainty of this position at some known confidence level (95%) is why two boundary surveys never precisely agree with one another. Monument descriptions, on the other hand, can precisely agree, and so while both coordinates and actual monument descriptions are both evidence of true location, the monuments actual position is best identified by a good description, a found monument, and a precise coordinate value.

NDOT has developed these description instructions to facilitate description writing and to further perpetuate a description with its automatic insertion into the Location Information System (LoIS) database.
Several rules must be adhered to:

Limit the total monument description length to 600 characters including spaces.
Use any word processor (text editor) to export out an ASCII text file (.TXT).
Pipe symbols (|) must separate the fields.

An NDOT description consists of six fields: point name| point type| northing| easting| ortho elevation| and description body. These six fields are divided by the pipe symbol (|) with a carat symbol (^) at the end.

Description Example

Field #1	**Point name:** “205204”
Field #2	**Point type:** “H”
Filed #3	**Northing:** “123456.78”
Field #4	**Easting:** “987654.32”
Field #5	**Elevation:** “1234.56”
Field #6	**Monument description at monument:** “Station is a found standard NHD brass disc in concrete, stamped "205204," 2.46’ below ground with a witness post set 3’ south.”
	To Reach: “To reach station proceed from the intersection of Pyramid Way and Emerson Road proceed NE’ly along Pyramid Way 0.60 of a mile and station is 34.45’ left of C/L”
	Special Information: “Station is 34.45’ lt of “E” 10+00.00PC, and is the NE S4 T15N R30E. See county recorder File #125-263 BK125.”

Final LoIS Import File with Description Example

205204|H|123456.78|987654.32|1234.56|Station is a found standard NHD brass disc in concrete 2.46’ below ground with a witness post set 3’ south. To reach station proceed from the intersection of Pyramid Way and Emerson Road proceed NE’ly along Pyramid Way 0.60 of a mile and station is 34.45’ left of the C/L. Station is 34.45’ lt of “E” 10+00.00PC and is the NE S4 T15N R30E. See county recorder file #125-263 BK125.

RESOLVING GROUND AND GRID DISTANCES

NDOT survey projects, while on the NAD83/94 state plane datum, must reflect contract distances and R/W descriptions as though horizontally measured on the ground. The effects of ignoring differences between distances on the ground and distances on the grid can lead to one thinking incorrectly that the initial survey work was poorly done, or they may fully recognize the cause but do nothing to resolve it. NDOT resolves ground to grid discrepancies by applying these rules:

1. All NDOT projects shall have as a Basis of Bearings the Nevada Coordinate System (NAD83-1994) with the control monuments used to establish the basis clearly indicated. Further, survey adjustments shall be accomplished and these adjustment data sets are given an appropriate positional tolerance rating based upon this grid and fixed higher order control monuments used.

2. All plan and R/W ground distance corrections, shall place an adjusted datum parallel with the initial state plane datum, by using a single combination grid factor and at a near enough ground level for any inherent distance differences to be lost in normal (acceptable) methods of surveying. A ground coordinate system is generated by dividing state plane coordinates by the project combination ground-to-grid factor. The normal error between true ground distances and grid distances has been determined to not exceed 50 ppm (1:20,000) over the length of a project. If this error is exceeded, then the project shall use multiple combination grid factors with coordinate equations.

3. R/W plans and contract plans shall reflect a mean combination ground-to-grid factor, be printed upon any calculation sheets any time ground (modified) state plane coordinates are used, and be noted in the bearing source statement.

4. R/W calculations, “best-fit” alignment retracements, and areas may be adjusted and calculated on the project ground (modified) coordinate system.

Combination Grid Factors Already Chosen for Specific Geographic Areas

AREA	NAD 83/94	NAD 27
Battle Mountain	0.99969109545	0.9996910955
Boulder City	0.99984402433	0.9998290292
Carson City	0.99980003999	0.9997992943
Elko	0.99964312740	0.9996427280
Ely	0.99963813100	0.9996390000
Lake Tahoe Basin	0.99973706915	0.9997107400
Las Vegas	0.99982303132	0.9998236040
Lovelock/Fallon	0.99973062500	0.9997101703
Minden/Gardnerville	0.99980003999	0.9997992943
Reno	0.99981103571	0.9998140346
Sparks	0.99981103571	0.9998140346
Winnemucca	0.99975605952	0.9997440655
Wendover	0.99988001440	0.9998800144

DATUM STATEMENT SPECIFICATIONS

A bearing source at NDOT is a horizontal angle turned from grid north (a known azimuth) and being within one of three zones on the Nevada Coordinate System. All projects will thus be referenced to a common known meridian as defined under NAC327. It is necessary to document both the horizontal and vertical datum as every survey performed is considered a corporate resource and each must connect to another survey, the totality of which NDOT is responsible. The location and design of long transportation corridors leads the surveyor into encountering unique problems that can usually be solved with a professional application of the principles of the Nevada State Plane Coordinate System, knowledgeable expectations, and documentation of all datums relied upon. Required example datum statements are shown below and will be shown on drafted projects and at the top of all calculation sheets:

Example: Vertical*

Elevations are based upon NGVD1929, using published control points:
J837 = 6259.554'
T4 = 6293.846'
and reflect a positional tolerance: +/- 0.015'.

Example: Horizontal*

Bearings of this map were derived from Nevada State Plane Coordinates, NAD 27 Datum, West Zone, with a mean convergence of 0°-51'-19". Local network control points used for Basis of Bearings are Castle Rock, Folsum Peak, EDO 001, EDO 021, and 162201. Further data is archived at NDOT under LPN298.

Example: Distance Adjustment Factor*

Coordinates and distances reflect a combination adjustment factor of 0.9997700529. State plane grid coordinates will reflect a relative positional tolerance as defined by NRS625.780 not exceeding 0.05m.

Example: Combination*

Coordinates of this map were derived from Nevada State Plane Coordinates (NAD83) East Zone, using a datum adjustment ground-to-grid factor of 0.9998140349, and whose State Plane Coordinates reflect a relative positional tolerance not exceeding +/- .05m. Elevations are based upon NVGD1929. Further data is archived at NDOT under LPN298.

- All three of these statement blocks must be used, usually on plats. Combination statements contain all three elements and typically are on calculation sheets.

PERPETUATION OF SURVEY MONUMENTS

Monuments found during survey and mapping phases of Nevada Department of Transportation (NDOT) projects are to be perpetuated in accordance with NDOT Policy 3-1-3 and Nevada Revised Statutes (N.R.S.) 329 titled "Perpetuation of Corners", and applicable Nevada Administrative Code (N.A.C.) 329. This policy, Nevada Revised Statute (N.R.S.) and Nevada Administrative Code (N.A.C.) state in a general sense the following.

- Found Public Land Survey System (PLSS) monuments must be perpetuated in place at the original position. This can be accomplished by setting a minimum of four reference marks outside of the construction area, surveyed from the PLSS corner with angles and distances taken to the reference marks. Alternately ties to a minimum of two NDOT Location Division, construction monuments, if the Location Division, Survey Section, has established them, with adjusted NAD83/94 coordinates will suffice. Copies of the monument control data sheets may be obtained through the State of Nevada Department of Transportation (NDOT), Location Division, Geodesy Section, at 1263 South Stewart Street, Room #206, Carson City, NV 89712 or by calling (775) 888-7256. A filed perpetuation record shall be made per N.R.S. 329.140, with a copy of the filed perpetuation record sent to the attention of the Chief Land Surveyor, NDOT, 1263 South Stewart Street, Room #206, Carson City, NV 89712.
- Stamped monuments set by a Nevada Professional Land Surveyor may be perpetuated outside of the travel area, if found in the oil. A minimum of two reference marks shall be placed outside of the construction area, with angles and distances taken to the reference marks. Alternately, ties to a minimum of two NDOT Location Division, construction monuments, if the Location Division, Survey Section, has established them, with adjusted NAD83/94 coordinates will suffice. Copies of the monument control data sheets may be obtained through the State of Nevada Department of Transportation (NDOT), Location Division, Geodesy Section, 1263 South Stewart Street, Room 206, Carson City, NV 89712 or by calling (775) 888-7256. A filed perpetuation record shall be made per N.R.S. 329.140; with copy of the filed perpetuation record shall be sent to the attention of the Chief Land Surveyor, NDOT, 1263 South Stewart Street, Room #206, Carson City, NV 89712.
- A corner perpetuation record must be filed at the County level per the requirements of NDOT policy #3-1-3 and Nevada Revised Statutes (N.R.S.) 329 "Perpetuation of Corners." A perpetuation record must be filed within 90 days of the date of the completed survey per N.R.S. 329.140, with a copy of the filed perpetuation record sent to the attention of the Chief Land Surveyor, State of Nevada Department of Transportation (NDOT), 1263 South Stewart Street, Location Division, Room #206, Carson City, NV 89712.

NDOT TRANSPORTATION POLICY (TP 3-1-3)

Perpetuation of Survey Monuments

I PURPOSE:

To establish standards and procedures for the perpetuation of survey monuments, ensuring compliance with Nevada Revised Statues (NRS) 329, 408 and 625.

II POLICY:

Monuments found during survey, mapping, construction, or maintenance phases of Nevada Department of Transportation (NDOT) projects are to be perpetuated under the direction of the Chief Land Surveyor.

III SCOPE:

This policy applies to all monuments placed in NDOT rights-of-way and construction zones.

IV RESPONSIBILITY:

A. The Location Division is responsible for:

(1) Initiation and revision of this TP.

(2) Administration of the perpetuation of monuments found in NDOT right-of-way.

B. All Divisions/Districts are responsible for:

(1) Following the procedures in this TP.

V DEFINITIONS:

A. Corner: A geographic point on the surface of the earth which is on and a part of a line and which controls the location of such line.

B. Monument: A physical structure that occupies the exact position of a corner.

C. NDOT Reference Monument: A special monument placed by NDOT which does not occupy the same geographical position as a corner, whose spatial relationship to a corner, line, or centerline is recorded at NDOT and which serves to witness the alignment of the roadway center lines, rights-of-way corridor boundaries, and the location of found monuments.

D. Property Corner or Property Controlling Corner Monument: A stamped or tagged monument set by a professional land surveyor used to control the location of the property.

E. Tie Monument: A special monument placed outside the construction zone of the roadway but within one hundred feet of a found Public Land Survey Corner or Property Corner or Property Controlling Corner with a measured distance to the found monument established and stamped on the surface with the letters "TM" and PLS and the license number of the land surveyor that established the tie monument.

F. Public Land Survey Corner: Any corner established and monumented in an original survey or resurvey used as a basis of legal description for issuing a patent for the land to a private person from the United States Government.

G. Corner Record: A written record of the spatial relationship of a found monument to reference monuments or the reconstruction of a Public Land Survey Corner or Property Corner or Property Controlling Corner as described in NRS 329.

H. Construction Zone: Any area within established rights-of-way or easements that may be disturbed during any construction or major maintenance activity, not including emergency projects.

VI PROCEDURE:

All visible stamped or tagged survey monuments and Public Land Corners found in NDOT rights-of-way that may be destroyed by construction or maintenance activities must be perpetuated under the supervision of a licensed Nevada professional land surveyor. This will be achieved for each found monument by the following:

A. Prior to the development of all construction or major maintenance contracts

(1) The Design Division shall request the Location Division to verify the presence of any Public Land Survey Corners within the construction zone.

(2) The Location Division will conduct an in-house record search to determine if there are any Public Land Survey Corners within the right-of-way. If so, they will be verified in the field.

(3) All found Public Land Corners will be listed in the contract by the Design Division for perpetuation.

a. They must be perpetuated according to Nevada Revised Statutes Chapter 329 by a Nevada licensed professional land surveyor then tied to two (2) existing NDOT reference monuments utilizing NDOT's "*Special Instructions for Survey or Mapping Consultants"* which is distributed by the Location Division. Public Land Survey Corners in the construction zone are to be set in a survey well and referenced by four (4) tie monuments set outside the construction zone. A copy of the recorded Corner Record for each monument with a written report identifying the character, location, description, and ties of the new monument and NDOT Reference Monuments shall be sent by the land surveyor to the Chief Land Surveyor, Headquarters Building, Carson City, Nevada 89712 (see page 35).

(4) At the discretion of the Chief Land Surveyor, any Public Land Survey Corner found in the roadway will be tied to two (2) NDOT Reference Monuments set by the Location Division. A Corner Record will be sent by the Chief Land Surveyor to the appropriate county to be recorded.

(5) Copies of the construction plans will be maintained in NDOT headquarters as well as the District Offices including Ely, Winnemucca, and Tonopah. The Chief Land Surveyor will maintain a record of all perpetuated Public Land Corners in the Geodesy Section.

B. Prior to staking a construction project

(1) The Resident Engineer, under the direction of the Chief Land Surveyor, will follow the provisions in the Construction Manual (Sec.2-102.8) and field verify the presence of all visible monuments.

(2) Any Public Land Survey Corners found and which are not listed in the contract plans for perpetuation will be added to the contract for perpetuation as defined in Procedure (3)(a).

(3) All visible stamped or tagged Property Corner or Property Controlling Corner Monuments that may be disturbed will be tied by the Resident Engineer. The ties will be to two (2) existing inter-visible NDOT Reference Monuments or two (2) set inter-visible NDOT Reference Monuments which will not be disturbed during construction activities. Instruction on procedures used to tie a Property Corner or Property Controlling Corner Monument or to construct a Reference Monument will Found Monuments will be noted in the as-built construction plans and a written report identifying the character, location, description, and ties of the monument and NDOT Reference Monuments will be sent to the Chief Land Surveyor, Location Division, Carson City.

(4) After review and acceptance of the written report, monuments used to reference a Public Land Survey Corner or Property Corner or Property Controlling Corner shall be approved to be stamped with the Chief Land Surveyor’s registration number by memo from the Chief Land Surveyor to the Resident Engineer.

(5) The Chief Land Surveyor will maintain a record of all tied Property Corners or Property Controlling Corner monuments in the Geodesy Section. Additionally, a Corner Record will be sent by the Chief Land Surveyor to the appropriate County to be recorded.

C. Prior to District maintenance activities that will cover or destroy monuments

(1) The District Engineer, under the direction of the Chief Land Surveyor, will follow the provisions in the Construction Manual (Sec.2-102.8) and field verify the presence of any monuments.

(2) Any Public Land Survey Corners found will be reported to the Location Division with a request that the monument be perpetuated prior to maintenance activities.

(3) All visible stamped or tagged Property Corner or Property Controlling Corner Monuments that may be disturbed will be tied by the District Engineer. The ties will be two (2) existing inter-visible NDOT Reference Monuments or two (2) set inter-visible NDOT Reference Monuments which will not be disturbed during maintenance activities. Instruction on procedures used to tie a Property Corner or Property Controlling Corner or to construct a NDOT Reference Monument will be available from the Chief Land Surveyor.

(4) Found and tied monuments will be noted in the latest as-built construction plans and a written report identifying the character, location, description, and ties of the monument and NDOT reference monuments will be sent to the Chief Land Surveyor, Location Division, Carson City.

(5) After review and acceptance of the written report, monuments used to reference a Public Land Survey Corner or property Controlling Corner shall be approved to be stamped with the Chief Land Surveyor's registration number by memo from the Chief Land Surveyor to the Resident Engineer.

(6) The Chief Land Surveyor will maintain a record of all tied Property Corners or Property Controlling Corner monuments in the Geodesy Section. Additionally, a Corner Record will be sent by the Chief Land Surveyor to the appropriate County to be recorded.

IMAGERY STANDARDS

AERIAL PHOTOGRAPHY STANDARDS

Aerial Camera

This section refers to aerial survey cameras of nominal focal length of 153 mm with format dimensions of 230 x 230 mm only. A metric quality survey camera shall be used, fitted with a lens that is designed to give an absolute radial distortion not exceeding 15 micrometers within 100 mm of the principal point. The film shall be held in the intended image plane during exposure to maintain sharp focus and hold image distortion to less than that, which will produce 12 microns of y-parallax after relative orientation anywhere in the model. The camera shall be mounted vertically in the aircraft in a mount designed to isolate the camera from vibration of the aircraft. Angular vibration of the camera shall be reduced to such a level so as to have no significant detrimental effect on resolution.

Camera Calibration

The camera lens unit shall have been calibrated, tested, and certified by the camera manufacturer or by a calibration center, recognized internationally or approved by the camera manufacturer. The certificate shall show that the camera has been calibrated within three years of completion of the photography and the calibration report must accompany the project mapping files.

Aerial Film Header Strip Information

The header information will have the following information in this order:

First Line Flight Number *, NDOT, Date, Time (24 Hour Clock set at Local Time), Lat/Lon,

Second Line Shutter Speed, F-Stop, Photo Scale, Mapping, Consultants' Name.

When multiple rolls of film are used on the same project the frame counter must **NOT** be reset for each roll; all frame numbering must run consecutively as single roll.

* **Prior to aerial photo flight call Imagery Services, Paul Cote at (775) 888-7162 or Sean McDaniels at (775) 888-7136 for a Flight Number to be assigned to the aerial photo project.**

Flying Conditions and Photographic Coverage

Aerial photography shall be secured based on the intended use of the photographs as stated in the specification. In general. Photography shall not be secured when the ground is obscured by haze, snow, smoke, dust, floodwaters, or environmental factors that may obscure ground detail. Clouds and/or shadows of clouds shall not appear in the project area. The solar altitude shall be defined by the application but in general it should not be less than 30 degrees when aerial negatives are exposed.

Photographic Mission

Forward overlap in the line of flight shall average not less than 57% or more than 62% at the mean elevation of the terrain, unless otherwise specified. Individual forward overlaps shall not be less than 55% or more than 68% excepting the situation where in a forward overlap in areas of low elevation must exceed 68% to attain the minimum 55% forward overlap in adjacent areas of higher elevation. Wherever there is a change in direction between two flight lines (other than between adjacent parallel flight lines) junction areas between the adjoining flight lines shall be covered stereoscopically by both lines. Side Overlap between adjacent parallel flight lines shall be 30% +/- 10% at the mean elevation of the terrain. In addition, any point on the flight line as flown shall not deviate from the flight plan location by a distance greater than 10% of the width of coverage of the photograph. Departures from flight heights required to produce the desired photo scale shall not exceed -2% or +5% unless changed by Air Route Traffic Control Centers. Changes in the course of the aircraft between successive overlapping photographs within a flight line shall not exceed 3 degrees. While exposing aerial photography, the camera shall be compensated for crab of the aircraft, with a resultant error not exceeding 3 degrees. The tilt within a single frame shall not exceed 4 degrees nor shall the difference in tilt between two consecutive overlapping frames within a flight line exceed 4 degrees. The average tilt for all negatives of the same nominal scale shall not exceed 1 degree. The combined effect of aircraft course corrections, crab and tilt shall result in an apparent crab not greater than 5 degrees on successive photographs. Apparent crab is defined as the angle between a line joining fiducial marks in the direction of flight and the line between the indicated principal point and the conjugate image of the indicated principal point of the adjacent photograph within the same line of flight.

AERIAL FILM AND IMAGE QUALITY

Aerial Film

The type of film to be used shall be unexpired and have a dimensional stable polyester base.
Color and panchromatic emulsions shall be sensitive to the entire visible spectrum with an extended red sensitivity. Color infrared and black and white infrared emulsions shall be sensitive to the visible and near infrared spectrum from 400 to 900 nanometers. Extreme care shall be exercised to insure proper exposure to minimize vignetting due to differential exposure. This differential shall not exceed that which would result from a basic 1/3 stop difference in exposure.

The conditions of the film stock to be used shall be such that when the unexposed film is processed:

- It shall be free of stains, discoloration, or brittleness that can be attributed to aging or improper storage: and
- The base-plus-fog density for all negative films and the minimum-density for all color reversal films shall conform to the manufacturers predicted density levels.

Suggested Aerial Films

Kodak	2407	Black and White Film or Afga	Pan 80	Black and White Film
Kodak	2427	Color Positive Film or Afga	Chrome 200	Color Positive Film
Kodak	1443	Color Infrared Film		

DELIVERABLE PRODUCTS

Aerial Film

The exposed/processed aerial film should be delivered in accordance with the stipulations of delivery schedule and delivery address. All flight maps used for the acquisition should accompany the aerial film, as an aid for the quality control inspection. Each processed roll or partial roll of aerial film shall be kept in roll form, on the spool, and in the plastic container supplied by the film manufacturer. Rejected exposures shall not be removed from any roll. The aerial film shall be delivered to the owner in accordance with the contractual stipulations of delivery schedule and delivery address.

Contact prints

Two sets of contact prints shall be made on an automatic dodging printer using medium weight resin-coated paper for which ink and pencil can be used on both sides. The contact prints shall be delivered to the owner in accordance with the contractual stipulations of delivery schedule and delivery address. The photographic emulsion shall be of fine grain and have a suitable light sensitivity range and contrast for the making of prints from the aerial film exposed under this contract. Outdated materials shall not be used. Processing, including exposure, development, fixation, washing, and drying of all photographic materials, shall result in finished photographic prints having a fine grain quality, a normal, uniform density, and such tone and contrast that all photographic details shall show clearly within the dark and light tone areas as well as in areas with intermediate tones. Adequate grades of contact paper and proper laboratory procedures shall be used to achieve the best prints possible. Excessive variance in tone or contrast between adjoining prints shall be cause for rejection. Photographic prints shall be trimmed as specified by the user. When trimmed always leave the camera fiducial marks, GPS and other data recorded in the border of each image. Prints showing fiducial marks of inadequate clarity and definition, or prints omitting fiducial marks, shall be rejected. All prints shall be clear and free from chemical stains, blemishes, uneven spots, air bells, newton rings, halo affects, light streaks or fog, and other defects, which would, in the opinion of the owner, interfere with their intended purpose. Hard copy prints shall be delivered to the owner in a smooth, flat and usable condition.

Digital Image Files

The selected project images shell be scanned at 15 microns or less, uncompressed .tif files, used in the Photogrammetry mapping process. The images shall be delivered to the owner imaged on CD-R or DVD-R diskette.

English

NDOT Map Type	Large	Intermediate	Small	Small
Film Scale	1”=300’	1”=600’	1”=1000’	1”=1200’
Flying Height	1800’	3600’	6000’	7200’
Scan Resolution	<15 micron	<15 micron	<20 micron	<20 micron
Scanned Ground Pixel Resolution	.18'	.33'	.79'	.94'
Ground Pixel Resolution Of Orthophoto	.25’	.50’	1’	1’
Mapping Photo File Size Scanned at 12.5 micron	350 MB B/W 1.05 GB Color	350 MB B/W 1.05 GB Color	350 MB B/W 1.05 GB Color	350 MB B/W 1.05 GB Color

Metric

NDOT Map Type	Large	Intermediate	Small	Small
Film Scale	1: 3600	1: 7200	1: 12,000	1: 14,400
Flying Height	550m	1100m	1830m	2200m
Scan Resolution	<15 micron	<15 micron	<20 micron	<20 micron
Scanned Ground Pixel Resolution	.05m	.11m	.24m	.29m
Ground Pixel Resolution Of Orthophoto	.08m	.15m	.33m	.33m

Micron to D.P.I.

25,400/Microns=D.P.I.

Example: 25,400/15 micron = 1693 D.P.I.

Ground Pixel Size

Photo Scale Ratio /D.P.I./12 = Ground Pixel in Feet

Example: 3600 Photo Scale/1693 D.P.I./12 = .18 feet

IMAGE SCANNING STANDARDS

Scanning Instrumentation

A photogrammetric grade-scanning device will be used to create uncompressed TIFF standard images. It should be located and operated in a thermostatically controlled, dust free environment with a stable power source.

Acceptable Aerial Films

When the aerial film is scanned the scanner must not physically come in contact with the film while the film is in motion. The introduction of scratches to the aerial film by the scanner will be unacceptable and cause for the rejection of the scans as well as possible penalties at the discretion of the Nevada Department of Transportation (NDOT). Unless otherwise specified, all digital aerial imagery will be produced from negative or color transparency film rolls and **not film diapositives**.

Scanning shall be carried out only from first generation transparent originals or aerial film.

Scanner Calibration

Any scanner to be used for the scanning of aerial imagery must be calibrated at least annually and provide a calibration report signed by the manufacturer's technician. The report must show that the scanner maintains a geometric accuracy of not more than five (5) microns RMSE at the scanner's plate scale, and be capable of resolving 256 levels of gray or of each color band. A minimum of 20 well distributed points shall be read on a calibrated glass grid plate of accuracy of one micron or better during the geometric accuracy test. It is not acceptable to post process the scan data to achieve this requirement. The calibration report shall show the manufacturer's name, model number, serial number, date of the calibration, individual readings of grid points, rectangularity, and calculated RMSE value for the instrument. A copy of the technician’s service report showing the scanner’s camera calibration must be sent if requested by NDOT.

Scanning Requirements

In order to maintain consistently high quality image scans certain procedures shall be carried out during the scanning process. The following instructions are based on normal scenes and do not apply directly to scenes with skewed tonal representations (i.e. Images with predominant snow, sand, water, or shadow areas). The minimum and maximum densities of the images shall be captured without clipping and without leaving unused bins on the ends of the histogram. The output pixel values shall be proportional to the Density of the media being scanned.

Image compression will not be applied during the scan process.

Scan Resolutions

Image scans produced to support digital orthoimagery must be scanned at a finer resolution than the intended orthoimage resolution. Resampling original image scans to a finer resolution is not permitted.

Unless otherwise specified, the scan resolution – or ground sample distance (GSD) used in the production of digital aerial imagery will conform to the standard identified in the following table.

Photo Scale	Scan Resolution	GSD
1: 3,600	12.5 µm or less	0.045 m = .18’
1: 7,200	12.5 µm or less	0.090 m = .36’
1:12,000	12.5 µm or less	0.150 m = .79’

Radiometric Accuracies

The scanner must be capable of scanning from the original negative or color transparency. The conversion from the original image to digital pixels shall be carried out proportionally to the density of the original. Representation of the tones proportionally to the transmissivity of the original will not be accepted. When a standard photographic step wedge is scanned, the resulting tones shall be within 10 pixel units from their calculated position based on the steps density. NDOT reserves the right to request sample scans of a calibrated step wedge in order to verify compliance. The calculated pixel value will be calculated as follows.

$$\frac{(Density - D\min)}{(D\max - D\min)} * 255 = \ Pixel\ \ Value \pm 10\ \ pixel\ units$$

For example if a step wedge is scanned with a range of 0.15 to 1.30 density values representing logE (exposure), the following pixel values will result (± 10 pixel intensity units)

Density	Pixel Value
0.15	255 (bright)
0.30	233
0.45	200
0.60	166
0.75	133
0.90	100
1.05	66
1.20	33
1.30	0 (dark)

Images of "normal" scenes will typically display a Gaussian distribution of pixel values with the mean centered on pixel value 127. There should be no unusual spikes of data, or gaps in individual pixel bins

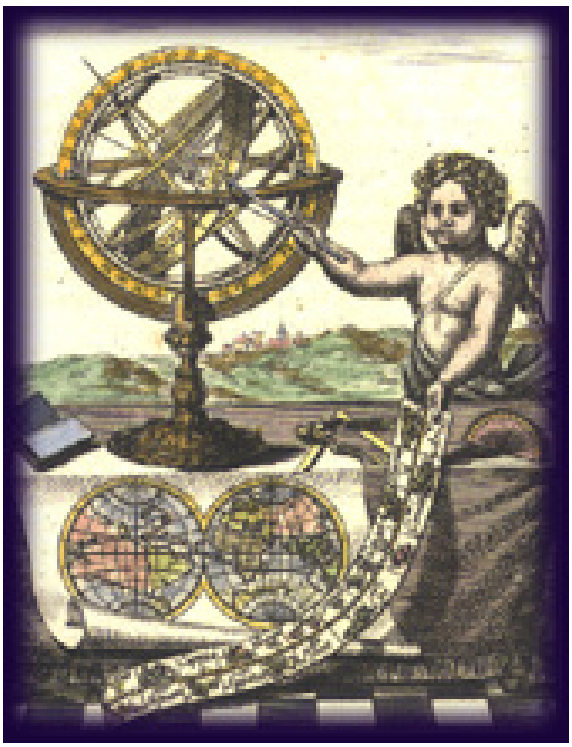
Density Ranges

Scanners must be capable of scanning original imagery with a density range (Dmax - Dmin) of at least 1.3 without resulting in missing pixel bins or gaps. Post processing to merge bins is not acceptable unless resolution is reduced by a factor of at least 40% at the same time (ie. Scan at 11 microns and resample to 15 microns). If originals are provided with a density range greater than 1.3 or greater than the instrument's effective density capability (if greater than 1.3), NDOT shall be informed and a proposal offered for the solution of the problem. A final solution shall be reached in consultation with NDOT.

Image File Naming Convention

Image scans will be named with NDOT flight number, under bar, frame #’s, as shown in the examples below:

2785_0103.tif
2785_0104.tif
2785_0105.tif



PHOTOGRAMMETRIC MAPPING STANDARDS

GENERAL SPECIFICATIONS

I Introduction

A. The specifications set forth are standards to be met and the general procedures to be followed in the production of digital photogrammetric map compilation for the Nevada Department of Transportation (NDOT). As used in this document, compilation refers to the preparation of large scale, photogrammetrically prepared engineering maps to be used on NDOT's CADD system for highway and structure design.

B. The Task Order provides specific details for each project and should be used in conjunction with this document. Specifications in the Task Order have precedence when a difference or a conflict occurs with this document.

II Aerotriangulation

A. Aerotriangulation must be performed with a minimum of six image pass points per model to adequately compute a simultaneous block adjustment with a final RMSE not to exceed bridging specifications for required mapping.

B. Resulting aerotriangulation report shall be delivered to NDOT within 2 days of completion for review.

C. Vendor shall provide a current USGS camera calibration report if NDOT camera is not used.

D. If minimum standards are not met, a conference call shall be arranged with NDOT personnel to resolve conflicts before proceeding.

E. Softcopy aerotriangulation methods will be acceptable and will be held to the same specifications.

III Production Methods

A. Digital planimetric features (.mfc) need to be delivered on CD-ROM or DVD in design file format. For specific details see the "File Requirements" section IV. If the vendor does not have MicroStation in-house, then the vendor may arrange for proper translation into MicroStation to provide NDOT with the specified file format. Enclosed in this manual is NDOT's Location Division "Tools" CD. For details about "Tools" CD please refer to page 57. The "sample mapping" incorporated on the "Tools" CD has several files to help clarify many of the situations which will occur during the collection phase.

B. Compilation of adjacent data files shall edge match exactly.

C. Stereo compilation of large-scale engineering mapping shall show all required planimetric features that are visible, identifiable, or interpretable from the aerial photography. Features to be portrayed and their respective levels, colors, linestyles or cells are defined in the Map Feature Codes.

D. Shared cells are cells whose definitions are stored only once in the design file, regardless of how often the cell is placed. Any change made to one shared cell is reflected in all instances of that shared cell. Shared cells are unacceptable; only cells from the NDOT standard cell library included with the Tools CD are acceptable.

E. Surface files shall not be generated from contour data.

F. Surface files (.mtc) should only have line string and points collected. Arcs, cells, curve string, text or any other data in the raw surface data files are unacceptable.

G. Features not specified in the Map Feature Codes need to fit the strategy of the level, color and linestyle. If a situation arises that needs clarification please contact the consultant coordinator identified on the "Task Order".

H. Orthophotos of the area mapped shall be delivered as untiled Geotiff version 6.0 with their accompanying world files (.tfw). Orthophotos shall not exceed 250MB in size. Please refer to "Task Order" for any special requirements.

IV. File Requirements

A. A diagram and/or description of required file limits for each stereo model pair or project will be provided to the vendor.

B. All stereo model pairs will be in MicroStation 3D Design file format utilizing NDOT's seed file. The correct Global Origin is derived from the physical location of the project relative to the Nevada State Plane Zones provided by NDOT (page 66.)

The working units for the design files shall be:

English	Metric
Master Units .....= '	Master Units..... = m
Sub Units..... = tn	Sub Units..... = mm
Sub Units per Master..... = 10	Sub Units per Master..... = 1000
Positional Units per Sub = 100	Positional Units per Sub. = 10

Coordinate values for all features are based on the grid system indicated by the survey control data.

C. Files shall be named using a unique number/letter designation with the appropriate extension. E.g.: .dgn .mfc .mTc .txt. Please refer to the "Task Order" for a Location Project number.

Example: 4381101.mfc
438… represents job number
11…. represents strip number
01…. represents model number

D. Each grid file (grd.dgn) will encompass the entire project area. The grid file must be in a MicroStation 3D design file format. Coordinate grids for 1:500 design mapping shall be shown as:

English	**Metric**
Grid Ticks.... = ¼"	Grid Ticks.... = 1cm
Grid Spacing = 250'	Grid Spacing = 100m

E. Each contour (cnt.dgn) file will encompass the entire project area. The contour file for 1:500 or 1:1000 must be a MicroStation 3D design file format.

English	**Metric**
Intermediate = 2'	Intermediate =. 5 m
Index ..... =10'	Index..... =3 m

Dashed lines will be used to portray the hidden intermediate and index contours when the ground is obscured by vegetation or cultural features to the degree that standard accuracies are not obtainable.

F. Colors, levels, linestyles, and cells shall be submitted in accordance with the appropriate guidelines provided in the Map Feature Codes (pages 67-69). In addition, model borders and exterior borders must be submitted as closed shapes.

G. It is the vendor's responsibility to archive data sets for a minimum of ninety days following NDOT's final acceptance of project.

V. MFC Files

A. Each planimetric .mfc file shall be clean, edited and contain one stereo model. Mapping design file collection of features that are visible, identifiable, or interpretable from the aerial photography at NDOT have been provided to help answer "how to" questions on the "Tools" CD under the "sample map folder". Also refer to the Map Feature Codes (pages 67-69).

B. All .mfc files shall be named in the standard naming convention. Please refer to section IV File Requirements part C.

C. NDOT will only allow feature collection as noted in the Map Feature Codes. Collection of elements such as arcs, curve string, patterns or shared cells are unacceptable. Please refer section III production methods parts E & F. (Page 51.)

D. Cell placement shall be at the proper scale and direction of the feature being collected. Also, take note of special instructions given on the Map Feature Codes (pages 67-69).

E. Area of special attention: Single post signs are collected with the "Sign" cell. Large signs with two or more posts, billboards and extreme signs such as hotel signs are collected without posts and with the custom linestyle of "BBD". Note that lights associated with these signs must be collected. Also, any street names or names of water bodies must be identified and labeled.

F. All text shall be oriented parallel with the flight line or feature being labeled. Additionally, the text shall be placed on the same level, color and vertical placement as the feature. Text (font 10) should have a weight of zero. Text height standards are as follows: English tx = 5 or metric tx = 1. The view rotation for all stereo models in the same strip shall be set to the same flight line angle as the first model in the strip. Text shall be placed as close as possible to the feature being labeled and in accordance with the guidelines provided in the Map Feature Codes (pages 67-69).

G. Survey control essential to mapping the project area will be included in deliverables. This includes not only cadastral and construction control but also pipe surveys, utility surveys and any other surveys that pertain to mapping projects.

VI MTC Files

A. Each surface .mTc file shall be clean, edited and contain one stereo model. Surface file (.mTc) limits must exceed the planimetric (.mfc) file border by 10 feet.

B. Surface files (.mTc) are separate from .mfc files and consist of 3D data measured along surface specific features in the form of lines along terrain changes and discreet points. The .mTc will contain elements that delineate both terrain and culture features. All 3D digital data shall be compiled directly using a softcopy or an approved analytical stereoplotter.

C. Surface files (.mfc) shall be named in the appropriate naming convention. Please refer to section IV file requirements part C.

D. NDOT will only accept collected features that adhere to the Map Feature Codes. Collection of elements such as arcs, curvestring, patterns or shared cells are unacceptable. Please refer to section III production methods parts E & F.

VII Triangulated Surface file

A. Each .dtm file will encompass the entire project area. The .dtm file will be provided in a "INROADS" format. The .dtm files are a topological triangle network file that contains all the input terrain data and the resultant network generated by the software. The data includes information about each triangle and its neighboring triangles, the vertical scale, Z base, multiplier and other information.

VIII Cursory Model Review

A. NDOT cartography section requires a cursory model review to make sure that vendors correctly set up their projects with NDOT standards at the beginning. The first stereo model completed shall be delivered to NDOT cartography section within 7 days for review. Mapping diapositives or scanned photo frames, contact prints, aerotriangulation report, georeferenced orthophotos and line work files (.mfc, .mTc) shall be included in the delivery.

B. Review of the initial .mfc, and .mTc files will include:

- Data is clean and conforms to NDOT standards.
- Proper feature representation using corresponding levels, colors, weight and linestyles (Map Feature Code).
- Required view rotation angle (flight lines), global origin and working units.
- A comparison of the field survey profile data and photogrammetrically collected EO's and centerlines.
- Adequate density of data (English = 250 ft., metric = 76m).

C. Vendor is notified of problems and corrections discussed.

D. Significant problems will be communicated and vendor shall deliver revised files within seven calendar days. NDOT will review the revised files and notify vendor to proceed if required corrections were properly accomplished. If significant problems still remain, the vendor will be notified of the problems, the project will be withdrawn, the contract cancelled, and no payment made. The vendor will return all project materials originally supplied by NDOT.

IX Project Deliverable Review

A. Mapping shall be delivered as flight line strips are completed (and not at the end of the project.) They shall be delivered as individual models and adhere to the "Production Methods" and "File Requirements."

B. Orthophotos, when specified, will be delivered in strips (not to exceed a 250MB file size) at the same time as the associated .mfc and .mTc files.

C. Point marked diapositives and annotated contact prints are to be packaged and delivered flat. When softcopy plotters are used, all stereomodel softcopy orientation files shall be delivered to NDOT at the completion of the job. File format of orientation files shall be PAT-B.ori. If SocetSet softcopy software is used, files required will be: *.sup, *.prj, and all files from the project data directory.

D. A copy of the Positional Accuracy Report including point identification.

SURVEY AND MAPPING DELIVERABLES

Check List

Detailed list is itemized in the Task Order.

- Wet stamped attesting that the mapping or survey requirements have been met
- Survey raw data
- Construction control
- Cadastral survey
- Aerial control survey
- Topographic survey
- Reconnaissance report
- Traverse and survey report
- ASCII final coordinate report
- ASCII coordinate/alignment offset reports
- ASCII description for all monumentation
- Digital photograph (.jpeg) of monuments tied in the field
- Aerial negatives
- Aerial prints
- Aerial Diapositives
- Digital images of scanned frames (CD & DVD)
- Aerotriangulation reports (per project)
- MicroStation 3-D mfc files (stereo pair model data)
- MicroStation 3-D mTc files (stereo pair model data)
- MicroStation 3-D cnt files (per project)
- MicroStation 3-D grd.dgn files (per project)
- Field collected profiles ASCII file and MicroStation 3-D .dgn
- InRoads DTM files (per project)
- Orthophoto georeferenced in a tiff format, version 6.0 (file size not to exceed 250MB.)

CONTENTS OF THE "TOOLS" CD

Consultant 2007.pdf

Digital copy of "SPECIAL INSTRUCTIONS for SURVEY, MAPPING OR GIS Consultants" in .pdf format.

MicroStation Seed Files

27ft_C.dgn, 27ft_E.dgn 27ft_W.dgn,	Blank MicroStation design files that are pre-set with NDOT standard working units, header information, etc. These files are for projects produced in an NAD27 datum. Project location determines which seed file to use; please refer to Work Zones map on page 66.
Ft_C1.dgn, Ft_C2.dgn, Ft_E1.dgn, Ft_E2.dgn, Ft_W1_W2.dgn	Blank MicroStation design files that are pre-set with NDOT standard English working units, header information, etc. These files are for projects produced with English working units and in an NAD83/94 datum. Project location determines which seed file to use; please refer to Work Zones map on page 66.
NV_C1.dgn, NV_C2.dgn, NV_E1.dgn, NV_E2.dgn, NV_W1.dgn, NV_W2.dgn	Blank MicroStation design files that are pre-set with NDOT standard metric working units, header information, etc. These files are for projects produced with metric working units and in an NAD83/94 datum. Project location determines which seed file to use; please refer to Work Zones map on page 66.
NVutm.dgn	A blank MicroStation design file that is pre-set with NDOT standard working units, header information, etc. This file is for projects produced in UTM projection, NAD83/94 datum, zone 11.

Other MicroStation Resources

ndot_font.rsc	NDOT standard font selections.
ndotcolor.tbl	NDOT standard color table.
NDOTeng.cel	NDOT standard cells in English working units.
NDOTEURO.cel	NDOT standard cells in metric working units.
NDOTSTYL.res	NDOT standard line style selections.

Sample Mapping

976.alg	InRoads alignment geometry files.
976.dtm	Digital Terrain Model generated with InRoads. It is a topological triangle network file of terrain coordinates.
976101.mfc - 976402.mfc	Map Feature Code file that shows the location of natural and man made objects within the model area.
976pat.xls	Spreadsheet file of Y, X, Z random points selected throughout the project area.
976meta.doc	NDOT-standardized metadata of the project.
9764SHT.dgn	Contract survey control sheet.
976cnt.dgn	Contour file: linear graphics that depict the terrain at points of equal elevation.
976ctl.txt	Text file of Y, X, Z survey control points for project.
976grd.dgn	Graphics file displaying "State Plane Ground Grid" of project area.
976mpck.dgn	Graphic display of random set of points collected within project to assist with the statistical check.
976pat.dgn	Graphic display of 976PAT.TXT file of random points collected throughout the project area.
976pipes.dgn	Labeled survey drainage point data associated with project.
976plss.dgn	Public Land Survey System (land section network grid projected to ground per project.)
976101.mTc - 976402.mTc	Surface terrain coordinates collected by photogrammetry and/or survey demonstrated with only break lines and points.
ALG976P2.TXT	Text file of alignments within the project.
CTL976.TXT	Text file listing coordinates of the location survey.
976pat.txt	Random points selected throughout project area for the statistical check.
OFF976P2.TXT	Text file of offsets to stationing.
PIP976.txt	Text file of surveyed drainage associated with project.
TAC976.TXT	Temporary Aerial Control panels with a surveyed location.
976_SHEET1.tfw - 976_SHEET4.tfw	Tif World File (orients .tif files into their geo-referenced world).
976_SHEET1.tif - 976_SHEET4.tif	Orthophoto saved as Tagged Image File format.

Files that are not demonstrated in sample mapping

***STK.TXT	Survey stakeout report.
XSEC**.TXT	Text file of Y, X, Z cross sections collected by survey.
UTL***.TXT	Text file that lists coordinates of all utilities within the project area.
SOE***.TXT	Text file of topography; organized by station, offset and elevation.
RR****.TXT	Text file of railroad topographic Y, X, Z points.
LDR***.TXT	Text file of Y, X, Z points of LIDAR target locations.
PRO***.TXT	Text file of Y, X, Z points collected along edges of oil and centerline.
PRO***.dgn	Graphic display of the PRO***.TXT points collected along edges of oil and centerline.
E***.TXT	Text file of events associated with flight position to imagery.
TOP***.TXT	Text file of Y, X, Z points of requested topological features.

Blank File Resources

NDOTDTMSeed.dtm
InRoads surface seed file pre-set with NDOT standards used in Design Division.

Positional Accuracy.xls
Microsoft Excel spreadsheet used to calculate positional accuracies of mapping projects.

Project Metadata.doc
NDOT Location Division standard metadata related to the project.

QA.xlt
Microsoft Excel spreadsheet with embedded Macro used to find duplicates and crossing breaklines in surface files.

ACCURACY REQUIREMENTS

NDOT produces two types of maps: survey grade (large scale) and resource grade (small scale.) A survey grade topographic map produced using photogrammetric methods is performed under the direct supervision of Land Surveyors while resource grade mapping (i.e. 30' Atlas) is not. The distinction is made clearer by recognizing that surveyor maps are made from raw data that is collected, verified and is a primary data collection or database system. Resource grade digital data and resulting general use maps are secondary data collections or database systems that are compiled from existing photography, plans or maps. Absolute accuracy is not the highest priority for resource grade mapping.

The primary map testing technique used at NDOT for both types of maps is the NSSDA (National Standard for Spatial Data Accuracy) method. Previously used map accuracy standards such as NMAS (National Map Accuracy Standards) and ASPRS (American Society of Photogrammetry and Remote Sensing) fail because they apply only to paper maps compiled at a specific scale. Digital data may be collected at one scale and used (or misused) at various scales. The NSSDA method for reporting accuracy of digital geospatial data is not constrained by scale and was developed to replace those older standards. Primary documents used to establish NDOT standards are:

- FGDC "Geospatial Positioning Accuracy Standards" part 3.
- "Positional Accuracy Handbook" published by Minnesota Land Management Information Center

Generally we:

- Use a methodology that compares sample mapped points with independent measurements of their location to derive a statistical assessment that is valid for 95% of the points.
- Decide whether to test for horizontal or vertical accuracy or both.
- Independently collect a minimum of 20 representative, well-defined, random and identifiable ground survey points through our survey crew (map checks) and compare them with our mapped features or terrain model.
- Record the measurement values into the positional accuracy spread sheet.
- Calculate the sum of all error radius measurements, then calculate the average, and then take the square root to yield the root mean square (RMS) error.
- Multiply the RMS error by 1.7308 for horizontal error and 1.96 for vertical error.
- Prepare a accuracy statement assuring the data or map user to expect locational errors no worse than "XX feet" 95% of the time, regardless of the scale at which the map is displayed.

This well defined statistic and testing methodology tests only the positional accuracy of spatial data. There are other components of data quality such as attribute accuracy, logical consistency, completeness and lineage, which may be of more critical importance. The NSSDA testing standard does not define a "pass-fail" accuracy value but has allowed this agency to define its own minimum standards. NDOT accuracy standards were developed using traditional technical methods and then correlated to NSSDA. Please note that different features may require different minimum accuracies. This is easily accomplished in a digital dataset while a traditional map may be rated at no better than its worst map layers accuracy

ACCURACY TESTING

A. Map checks are not restricted to specific models. The mathematical surface must be completed before any analysis of a photogrammetric .mTc can begin. Analysis of mapping terrain model data is the relationship between the final .dtm surface and survey points collected by a qualified surveyor in the field.

B. Following NDOT written procedures, the vendor shall prepare a checkpoint file using NDOT Location Division's standardized spreadsheet (PositionlAcrcy.XLS, included on the "Tools CD".) We require a minimum of 20 points for statistical comparison of elevation values taken from the compiled surface and checkpoint file. For mapping projects, please refer to pages 63 through 65 for designated accuracies at a given map scale.

C. Vertical accuracy standards vary depending on mapping scale requirements. Please refer to the complete chart on page 70, "NDOT Map Checks". For example in large scale (1:500) mapping, Vertical NMAS Feet 95% SPOTS accuracies may not exceed elevations higher or lower than .30 feet on transportation surfaces. If vertical surface results exceed this limitation, we will require a recompilation of the check file. Another analysis must be performed and the same criteria are applied. If the results are high or low again, the subject model will be checked by field methods to determine the cause of the problem. If the results show differences between the surfaces occurring only along the road, then the entire roadway (EO, centerline, shoulders) must be recompiled, including but not limited to the areas where bad points are detected. The same procedure must be followed if problems are occurring off the road surface. The quality of the entire project will be questioned if check errors exceed our standard.

MAPPING CRITERIA

The primary intent of this manual is to provide NDOT consultants with a definitive guideline in performing or acquiring design mapping that will meet or exceed NDOT standards. A secondary intent of this manual is to provide guidance in determining an optimal map scale required by those who request mapping or survey products. During the planning phase of a project, consideration should be given to the "highest and best" use to which a map will be put. Designers who determine the optimal map scale required for their project need to know that accuracy requirements have a great impact on cost. NDOT consultants will be notified which classification of mapping is required and are expected to meet or exceed the control factors in producing their product.

For those requesting mapping the following suggestions may be used for assistance.

Three questions are used to determine which map to request:

- What is the required target mapping scale? NDOT uses 1:500, 1:600, 1:1000, 1:1200, 1:1700 and 1:2000 specific scale mapping for their design projects.
- What is the vertical relief accuracy required? Expected accuracies are in the chart following under the heading "Elevation".
- What is the horizontal or planimetric accuracy required? Expected accuracies are in the chart following under the heading "Features".

Map Scale	Elevation	Features	Typical Applications
1:500 (Large Scale)	.58 ft topo .30 ft hard surface	1.0 ft	Determination of pay quantities, site development, roadbed modifications.
1:600 (Large Scale)	.70 ft topo .34 ft hard surface	1.2 ft	(Same as 1:500.)
1:1000 (Intermediate Scale)	1.16 ft topo .58 ft hard surface	2.0 ft	Overlays, easements, grading, excavation, drainage.
1:1200 (Intermediate Scale)	1.40 ft topo .70 ft hard surface	2.5 ft	(Same as 1:1000.)
1:1700 (Small Scale)	2.0 ft (.6m) topo 1.0 ft (.3m) hard surface	3.5 ft (1.0m)	Planning, natural resources, R/W condemnation.
1:2000 (Small Scale)	2.0 ft (.6m) topo 1.0 ft (.3m) hard surface	3.5 ft (1.0m)	(Same as 1:1700.)

Survey or mapping projects invariably involve problems peculiar only to that project, and the solution to those problems may not necessarily conform to the procedures outlined in this manual. If you find this to be the case, please contact us for specific recommendations.

ACCURACY STANDARDS

For Common NDOT
Large Scale Digital Photogrammetry

English Control Factors 1:600 or 1"= 50ft.

Note: The maximum flying height for all NDOT Large Scale mapping shall not exceed 1800 ft. AGL.

Max Flying Height	Camera	Minimum Contour Interval	Minimum Photo Scale
1800ft.	***6”***	***.90ft.***	***1”= 300’***

Aerotriangulation (RMSE)	**Grid/Survey Control**	**Elevations (95%)**	**Features (95%)**
Horizontal =.20 ft. max = .43 ft.	All at true Value	Spots/dtm = .34 ft.	Horizontal =1.2 ft.
Vertical =.20 ft. max = .43 ft.		Topo = .70 ft.	

The maximum image point residual for any point shall not exceed 25 microns.

Contours
Display Interval = 2ft.

Note: If surface elevations are derived from solid line contours, 95% will be within 2/3 of the maximum contour display interval.

Final Orthophoto Ground Pixel Resolution = 0.25 ft.

Metric Control Factors 1:500

Max Flying Height	Camera	Minimum Contour Interval	Minimum Photo Scale
550m	***153mm***	***.27m***	***1:3600***

Aerotriangulation (RMSE)	**Grid/Survey Control**	**Elevations (95%)**	**Features (95%)**
Horizontal=.06m max = .13m	All at True Value	Spots/dtm=.09m	Horizontal=.31m
Vertical =.06m max = .13m		Topo =.18m	

The maximum image point residual for any point shall not exceed 25 microns.

Contours
Display Interval = .5m

Note: If surface elevations are derived from solid line contours 95% will be within 2/3 of the maximum contour display interval.

Final Orthophoto Ground Pixel Resolution = 0.07m

Survey checkpoints are a requirement for consultants performing work for NDOT. We require a large enough data set (>20) to assure compliance of the Elevation and Feature standards listed above. Check Points should be restricted to well-defined points (spots & features) distributed through out the project. If the finished map elevation surface is to be checked without using well-defined points, the Elevation Topo standard is held. A spreadsheet program is available to evaluate checkpoints. Calculations are based on an analytical plotter with a “C” factor of 1980 and capable of 7X enlargement.

ACCURACY STANDARDS

For Common NDOT
Intermediate Scale Digital Photogrammetry

English Control Factors 1:1200 or 1"=100ft.

Max Flying Height	Camera	Minimum Contour Interval	Minimum Photo Scale
3600ft.	***6"***	***1.77 ft.***	***1"=600 ft.***

Aerotriangulation (RMSE)	**Grid/Survey Control**	**Elevations (95%)**	**Features (95%)**
Horizontal =.36ft. max = .87 ft.	All at true Value	Spots/dtm = .70 ft.	Horizontal =2.5 ft.
Vertical =.4ft. max = .87 ft.		Topo = 1.40 ft.	

The maximum image point residual for any point shall not exceed 25 microns.

Contours
Display Interval =2 ft.

Note: If surface elevations are derived from solid line contours, 95% will be within 2/3 of the maximum contour display interval.

Final Orthophoto Ground Pixel Resolution = .5 ft.

Metric Control Factors 1:1000

Max Flying Height	Camera	Minimum Contour Interval	Minimum Photo Scale
1100m	***153mm***	***.56m***	***1:7200***

Aerotriangulation (RMSE)	**Grid/Survey Control**	**Elevations (95%)**	**Features (95%)**
Horizontal =.11m max = .26m	All at true Value	Spots/dtm = .18m	Horizontal =.62m
Vertical =.12m max = .26m		Topo = .36m	

The maximum image point residual for any point shall not exceed 25 microns.

Contours
Display Interval =1m

Note: If surface elevations are derived from solid line contours, 95% will be within 2/3 of the maximum contour display interval.

Final Orthophoto Ground Pixel Resolution = 0.15m

Survey checkpoints are a requirement for consultants performing work for NDOT. We require a large enough data set (>20) to assure compliance of the Elevation and Feature standards listed above. Check Points should be restricted to well-defined points (spots & features) distributed through out the project. If the finished map elevation surface is to be checked without using well-defined points, the Elevation Topo standard is held. A spreadsheet program is available to evaluate checkpoints. Calculations are based on an analytical plotter with a "C" factor of 1980 and capable of 7X enlargement.

ACCURACY STANDARDS

For Common NDOT
Small Scale Digital Photogrammetry

English Control Factors 1:1700 or 1"=142ft**.**

Max Flying Height	Camera	Minimum Contour Interval	Minimum Photo Scale
6000 ft.	***6"***	***3.0 ft.***	***1"=1000 ft.***

Aerotriangulation (RMSE)	**Grid/Survey Control**	**Elevations (95%)**	**Features (95%)**
Horizontal =.6ft. max = 1.8 ft.	All at true Value	Spots/dtm = 1.0 ft.	Horizontal = 3.5 ft.
Vertical = .67ft. max = 2.0 ft.		Topo = 2.0 ft.	

The maximum image point residual for any point shall not exceed 25 microns.

Contours
Display Interval =5ft.

Note: If surface elevations are derived from solid line contours, 95% will be within 2/3 of the maximum contour display interval.

Final Orthophoto Ground Pixel Resolution = 1.0ft.

Metric Control Factors 1:1700

Max Flying Height	Camera	Minimum Contour Interval	Minimum Photo Scale
1830m	***153mm***	***.92 m***	***1:12000***

Aerotriangulation (RMSE)	**Grid/Survey Control**	**Elevations (95%)**	**Features (95%)**
Horizontal =.18m max = .55m	All at true Value	Spots/dtm = 0.3m	Horizontal =1.0m
Vertical =.20m max = .60m		Topo =0.6m	

The maximum image point residual for any point shall not exceed 25 microns.

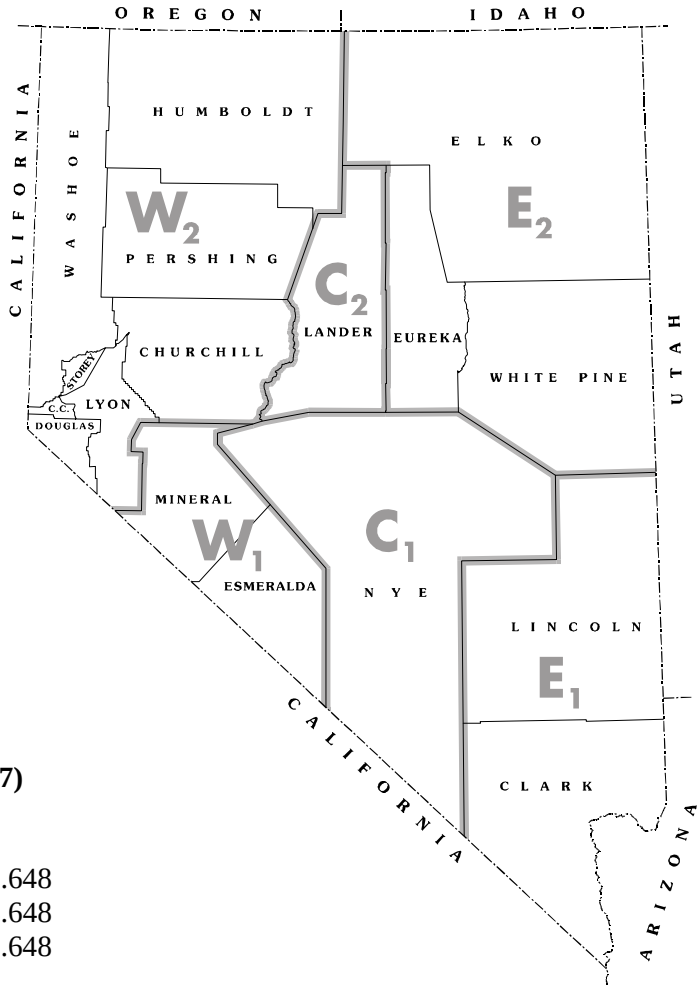
Contours
Display Interval =2m

Note: If surface elevations are derived from solid line contours, 95% will be within 2/3 of the maximum contour display interval.

Final Orthophoto Ground Pixel Resolution = 0.30m

Survey checkpoints are a requirement for consultants performing work for NDOT. We require a large enough data set (>20) to assure compliance of the Elevation and Feature standards listed above. Check Points should be restricted to well-defined points (spots & features) distributed throughout the project. If the finished map elevation surface is to be checked without using well-defined points, the Elevation Topo standard is held. A spreadsheet program is available to evaluate checkpoints. Calculations are based on an analytical plotter with a "C" factor of 1980 and capable of 7X enlargement.

NDOT MICROSTATION WORK ZONES



Global Origins (NAD27)

	X	Y	Z
E	0	0	-2,147,483.648
C	0	0	-2,147,483.648
W	0	0	-2,147,483.648

English State Plane

Global Origins (NAD83/94)

	X	Y	Z
E1	0	26,000,000	-2,147,483.648
E2	0	27,000,000	-2,147,483.648
C1	0	19,000,000	-2,147,483.648
C2	0	21,000,000	-2,147,483.648
W1, W2	0	14,000,000	-2,147,483.648

NV UTM (Zone 11)

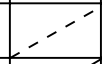
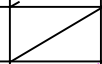
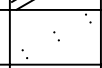
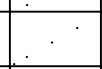
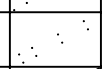
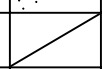
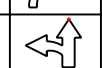
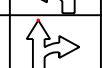
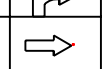
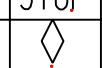
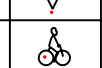
X	Y	Z
1650000.0000	-2120000.0000	2147483.648

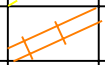
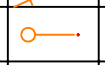
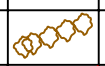
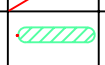
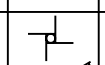
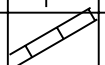
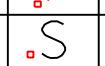
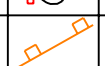
Metric State Plane

Global Origins (NAD83/94)

	X	Y	Z
E1	0	8,000,000	-214,748.365
E2	0	8,400,000	-214,748.365
C1	300000	6,000,000	-214,748.365
C2	300000	6,400,000	-214,748.365
W1	600000	4,000,000	-214,748.365
W2	600000	4,400,000	-214,748.365

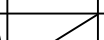
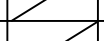
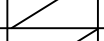
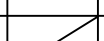
Note: Type in values located here to achieve the global origin needed to map in each specified zone. Notice that these values are multiplied by a (-1) in MicroStation.

LV	SYMB	DESCRIPTION	CO	LC	WT	AC	CLASS
1		CONTROL POINT W/NAME	6		0	CP	SYMBOL
2		BRIDGE DECK SEAM	4	5	1		LINESTRING
2		EDGE OF PAVEMENT	4	0	1		LINESTRING
5		BUILDING	5	0	2		SHAPE SQUARED
5		FOOT BRIDGE NON CONC STAIRS	126	0	2		SHAPE SQUARED
5		DECKS - CANOPY CARPORT	5	5	2		LINESTRING
5		FOUNDATION - RUINS	7	3	2		LINESTRING
5		MOBILEHOME - BLEACHER	168	0	2		SHAPE SQUARED
6		DOUBLE STRIPING	0	DBLINE	1		CUSTOM LS
6		BUTTONS TWO WIDE	0	2BUTS	1		CUSTOM LS
6		BUTTONS SET OF FOUR	0	4BUTS	1		CUSTOM LS
6		BUTTONS DOUBLE SET OF FOUR	0	2x4	1		CUSTOM LS
6		STRIPING	0	0	1		LINESTRING
6		LEFT TURN ARROW	0		1	ALT	SYM ROTATED
6		RIGHT TURN ARROW	0		1	ART	SYM ROTATED
6		LEFT TURN / STRAIGHT ARROW	0		1	ALS	SYM ROTATED
6		RIGHT TURN / STRAIGHT ARROW	0		1	ARS	SYM ROTATED
6		STRAIGHT ARROW	0		1	AS	SYM ROTATED
6		SINGLE BUTTON	0		3	PB	SYMBOL
6		EXIT	0		1	PE	SYM ROTATED
6		ONLY	0		1	PO	SYM ROTATED
6		STOP	0		1	PS	SYM ROTATED
6		DESIGNATED BIKE LANE	0		1	BL	SYM ROTATE SCALE
6		DESIGNATED BIKE LANE	0		1	BIKE	SYM ROTATE SCALE
7		EARTHWORK- PITS-BERM	4	4	2		LINESTRING
7		DIKES	4	DIKE	2		CUSTOM LS

LV	SYMB	DESCRIPTION	CO	LC	WT	AC	CLASS
7		DIRT ROADS - TRAILS	4	5	2		LINESTRING
8		RAILROAD	6	RR	0		CUSTOM LS
8		RAILROAD GATE ARM	6		0	RRGT	SYM ROTATE SCALE
8		RAILROAD SWITCH	6		0	RRSW	SYM ROTATE SCALE
12		ROCK - BOULDERS	126		0	ROCK	SYM ROTATE SCALE
12		MINING ACTIVITY	126		0	DIG	SYM ROTATED
12		ROCK LINE - RIPRAP	126	RCKL	0		CUSTOM LS
13		CONCRETE	3	0	0		LINESTRING
17		CHEMICAL TANK	215		0	LAP	SYM ROTATE SCALE
19		STREET/STOP SIGN	4		0	STSGN	SYMBOL
19		SIGNS WITH 2+ POSTS	4	BBD	0		CUSTOM LS
19		POST	3		0	P	SYMBOL
19		SIGN	4		0	SIGN	SYMBOL
20		GUARD RAIL	6	GRL	0		CUSTOM LS
20		JERSEY BARRIER	3	JB	0		CUSTOM LS
21		CATTLE GUARD	3		0	CTX	SYM ROTATE SCALE
21		FENCE	5	FENCE	0		CUSTOM LS
21		GATE	5		0	G	SYM ROTATE SCALE
22		RETAINING WALL	5	RW	0		CUSTOM LS
22		FREE STANDING WALL	5	WALL	0		CUSTOM LS
24		WATER CHECK GATE	126		0	CG	SYM ROTATE SCALE
25		FLAG POLE	168		0	FL	SYM ROTATED
25		SATELLITE DISH	0		0	TV	SYM ROTATE SCALE
26		FIRE HYDRANTS	126		0	FH	SYM ROTATED
26		LIGHT	4		0	LITE	SYM ROTATED
26		LIGHT ON ARM	4		0	LITEX	SYM ROTATED

LV	SYMB	DESCRIPTION	CO	LC	WT	AC	CLASS
26		SINGLE POLE NO RAY	4		0	POR	SYM ROTATED
26		SINGLE RAY POLE	4		0	P1R	SYM ROTATED
26		DOUBLE RAY POLE	4		0	P2R	SYM ROTATED
26		FOUR RAY POLE	4		0	P4R	SYM ROTATED
26		GUY WIRE	4		0	PGUY	SYM ROTATE SCALE
26		RAY ONLY	4		0	PRAY	SYM ROTATED
26		MULTI FOOTING POLE LINE	0		0	TRANS	SYM ROTATE SCALE
27		TRAFFIC SIGNAL	4		0	SL	SYM ROTATED
27		TRAFFIC SIGNAL ON ARM	4		0	SGNL	SYM ROTATED
28		ELECTRIC BOX	0		0	EB	SYMBOL
28		ELECTRIC PULL BOX	0		1	EPB	SYMBOL
28		ELECTRIC VAULT	0		1	EVLT	SYMBOL
28		GAS METER	231		0	GM	SYMBOL
28		GAS VALVE	231		0	GV	SYMBOL
28		MANHOLE CONC APRON	152		0	MH	SYM SCALED
28		MANHOLE	152		0	MHP	SYM SCALED
28		SEWER MANHOLE	152		0	MS	SYM SCALED
28		STORM DRAIN MANHOLE	152		0	MSD	SYM SCALED
28		COMM. MANHOLE	152		0	MT	SYM SCALED
28		COMM. PULL BOX	6		1	TPB	SYMBOL
28		COMM. VAULT	6		1	TVLT	SYMBOL
28		WATER METER	1		0	WM	SYMBOL
28		WATER VALVE	1		0	WV	SYMBOL
28		UTILITY UNKNOWN W/TEXT	0		0	UTL	SYM SCALED
29		WATER / STOCK TANKS	1		0	T	SYM SCALED
30		CATCH BASIN W/ELEV	95		0	CB	SYM ROTATE SCALE

LV	SYMB	DESCRIPTION	CO	LC	WT	AC	CLASS
30		DROP INLET W/ELEV	95		0	DI	SYM ROTATE SCALE
33		BRUSH - HEDGE LINE	2	HDG	0		CUSTOM LS
33		TREE CANOPY	2	TL	0		CUSTOM LS
33		TREE	2		0	TREE	SYMBOL
33		PINES - PALMS NON DECIDUOUS TREE	2		0	PINE	SYMBOL
41		INTERMITTENT FLOW	9	6	0		LINESTRING
41		CANALS - RIVERS	9	0	2		LINESTRING
41		LAKES - POOLS - PONDS	9	0	1		LINESTRING
41		MARSH - SWAMP	2		0	SWAMP	SYM ROTATE SCALE
47		REINFORCED CONC BOX	3	0	0		LINESTRING
47		CULVERT PIPE - CMP	6	0	0		LINESTRING
50		SPOT ELEVATION W/TEXT	1		0	SX	SYM ROTATED
58		OBSCURED AREA	6	3	1		LINESTRING
10		POINTS	3		3	POINT	SYMBOL
14		RIDGE LINE	6	0	0		LINESTRING
23		BREAK LINE	2	5	0		LINESTRING
41		FLOW LINE	9	6	0		LINESTRING
43		EXTERIOR BORDER	0	0	0		LINESTRING
1		GRID TICKS	168		0	GRDTK	SYMBOL
1		NORTH ARROW	0		0	N	SYM ROTATE SCALE
2		STATE ROUTE SHIELD	0		0	SNV	SYM ROTATE SCALE
2		160 STATE SHIELD	0		0	S160	SYM ROTATE SCALE
2		US ROUTE SHIELD	0		0	SUS	SYM ROTATE SCALE
2		395 US SHIELD	0		0	S395	SYM ROTATE SCALE
2		50 US SHIELD	0		0	S50	SYM ROTATE SCALE

LV	SYMB	DESCRIPTION	CO	LC	WT	AC	CLASS
2		95 US SHIELD	0		0	S95	SYM ROTATE SCALE
2		INTERSTATE SHIELD	0		0	SIS	SYM ROTATE SCALE
2		15 IR SHIELD	0		0	S15	SYM ROTATE SCALE
2		515 IR SHIELD	0		0	S515	SYM ROTATE SCALE
2		80 IR SHIELD	0		0	S80	SYM ROTATE SCALE
3		INDEX CONTOUR W/TEXT	165	0	3		LINESTRING
4		INTERMEDIATE CONTOUR	14	0	1		LINESTRING
3		OBSCURED INDEX W/TEXT	165	3	1		LINESTRING
4		OBSCURED INTERMEDIATE	14	3	0		LINESTRING
40		SECT LINES	5	0	1		LINESTRING
41		¼ SECT LINES	5	0	0		LINESTRING
42		T & R SECT LINES	5	0	3		LINESTRING
60		MODEL BORDER	0	0	2		LINESTRING
61		MODEL TEXT	6	0	0		LINESTRING

LEGEND:

AC	active cell	CO	color	LC	linecode
LS	linestyle	LV	level	ROT	rotate
WT	weight	SYM	symbol		

FILES:

NDOTCOLOR.TBL NDOTFONT.RSC NDOTENG.CEL
NDOTEURO.CEL NDOTSTYL.RSC ATLAS.RSC

SPOT ELEVATION REQUIREMENTS (2 DECIMAL PLACES):

Spot elevations should be placed,

* At flow line of culverts and pipes with in R/W
* At ℄ of roadway above culvert / pipe.
* At crown of paved roadway intersection.
* At drop inlets, catch basins and storm drain in R/W.
* At bridge deck ℄ seams and center of bridge deck.
* At ramp ℄ seams and every 150' along ramp ℄.

ADDITIONAL REQUIREMENTS:

Text should be placed at elevation of feature and on corresponding codes.

Example: * PAVED PARKING LV=2 CO=4 WT=0 FT=10
* CONC LV=13 CO=3 WT=0 FT=10

Points used in the block adjustment within the project boundaries should be placed in the .mfc file and reflected in the .mTc file as a point on level 10.

NOTE:

*All cell origins are at center unless noted with .
*Please refer to "sample mapping" for reference on the NDOT tools CD.
*Typical text scales are TX=5 for foot mapping and TX=1 for metric mapping.
*Text scale for section numbers are TX=5
*Public Land Survey System (PLSS), Text Font=10, WT 1

*NDOT does not accept shared cells.
*NDOT does not accept curve strings, arcs, circles etc.
*NDOT only accepts linestrings and individual cells.

NDOT MAP CHECKS

Planimetric Horizontal & Vertical Accuracies
Based upon
National Standard for Spatial Data Accuracy

Engineering Standards based on NSSDA

Final Map Scale	Engineering Map Scale	Minimum Contour Interval	Horizontal ASPRS Feet 68%	Vertical ASPRS Feet 68% SPOTS	Vertical ASPRS Feet 68% TOPO	Horizontal NMAS Feet	Vertical NMAS Feet	**Horizontal NSSDA Feet 95%**	**Vertical NSSDA Feet 95%SPOTS**	**Vertical NSSDA Feet 95% TOPO**
360	30.0	0.62	0.30	0.10	0.21	1.00	0.31	0.73	0.20	0.40
500	**41.7**	**0.89**	**0.42**	**0.15**	**0.30**	**1.39**	**0.45**	**1.02**	**0.29**	**0.58**
600	50.0	1.06	0.50	0.18	0.35	1.67	0.53	1.22	0.34	0.69
1000	**83.3**	**1.77**	**0.83**	**0.29**	**0.59**	**2.78**	**0.89**	**2.04**	**0.58**	**1.16**
1200	100.0	2.12	1.0	0.35	0.71	3.33	1.06	2.45	0.69	1.38
1700	**141.7**	**3.00**	**1.42**	**0.50**	**1.00**	**4.72**	**1.50**	**3.47**	**0.98**	**1.96**
2000	166.7	3.54	1.67	0.59	1.18	5.56	1.77	4.08	1.15	2.31
2400	200.0	4.24	2.0	0.70	1.41	6.67	2.12	4.90	1.38	2.77
3600	300.0	6.36	3.0	1.06	2.12	10.00	3.18	7.34	2.07	4.15
4000	333.3	7.07	3.33	1.17	2.35	11.11	3.54	8.16	2.30	4.61
4800	400.0	8.48	4.0	1.41	2.82	13.33	4.24	9.79	2.76	5.53
5000	416.7	8.84	4.17	1.47	2.94	13.89	4.42	10.20	2.88	5.77
6000	500.0	10.60	5.0	1.76	3.53	16.67	5.30	12.24	3.45	6.92
7200	600.0	12.72	6.0	2.11	4.24	20.00	6.36	14.69	4.14	8.30
10000	833.3	17.68	8.33	2.93	5.89	27.78	8.84	20.40	5.75	11.54
12000	**1000.0**	**21.22**	**10.0**	**3.52**	**7.07**	**33.33**	**10.61**	**24.48**	**6.90**	**13.85**
20000	1666.7	35.37	16.67	5.87	11.78	55.56	17.69	40.80	11.51	23.09

GIS Standards based on NMAS

24000	2000.0					**40.00**				
50000	4166.7					**83.33**				
63360	5280.0					**105.60**				
100000	8333.3					**166.67**				
250000	20833.3					**416.67**				
500000	41666.7					**833.33**				

Note:

- Maximum contour Interval is determined using a "C" factor = 1980, a maximum 7X enlargement ratio and a camera with a 6" lens.
- ASPRS classification is for a class 1 RMSE map. Class 2 and 3 are multiples of RMSE.
- NDOT standards are ASPRS-based, converted to NSSDA Standards and are in **bold.**
- 20 well defined points with a higher accurate position are the minimum number needed for testing as described by the Positional Accuracy Handbook at www.mnplan.state.mn.us/press/accurate.html
- NMAS (National Map Accuracy Standards) are shown for reference and include both large and small-scale specifications.

GIS STANDARDS

GEOGRAPHIC INFORMATION SYSTEM STANDARDS

GIS is a spatial information system used at NDOT for planning, analysis, and resource grade maps. GIS map products are not to be used for engineering purposes. Engineering data can be used in the department GIS, but the nature and standards for the GIS data are not as stringent as those in engineering. The GIS at NDOT is an enterprise system; flexibility and integration of the system are key components critical to ongoing operations.

GIS consist of two primary data areas: The geographic component or geometry graphics, and the information system or data attribute components. Each of these primary data areas can be further subdivided. The following discussion will outline the various components of the two primary data areas, and describe existing NDOT Geographic Information System standards. Basic GIS hardware and software standards will also be discussed. When using this document, it is useful to keep in mind that Information Systems today are dynamic. As such, user requirements and technology dictate that standards change. This is especially true in the world of Geographic Information Systems. The standards for Geographic Information Systems at NDOT will be under constant scrutiny and changes will be implemented as necessary. Therefore, consultants shall follow this document for any GIS project at NDOT, but should also check with the GIS section for any recent changes, and follow any additional written contract detail specifications. Consultants working on applications should also contact the Information Services Division for current specifications relating to web applications and compliance with Section 508 Disability Requirements.

Divisions within NDOT that have projects with a GIS component must comply with guidelines contained in this document per Transportation Policy 1-9-4. It should be remembered that the success of GIS at NDOT is a team effort and consists of the GIS section, the other divisional staff involved and the vendor if applicable. *The GIS section is here to help GIS related projects be successful.*

HARDWARE STANDARDS

NDOT has established the Intel-based computer as the Department standard. There are generally two categories of computers, the Business computer and the CAD computer or Workstation.

Business Computer Definition (Recommended Configuration)

1GB RAM
80GB Hard Drive
3.0+ GHz Pentium IV
DVD ROM/CD-R Drive
3.5" Floppy Drive
17" Monitor

CAD Computer Definition (Recommended Configuration)

2 GB RAM
80 GB Hard Drive 7200 RPM or greater
3.0+ GHz Pentium IV
DVD-ROM/CD-R Drive
3.5" Floppy Drive
19" Monitor (second monitors are recommended for high end users)

GIS Computer considerations (Recommendations)

1 GB RAM (more on machines doing actual analysis or modeling). Sufficient space for GIS data on the local machine should consist of 10 GB for a casual user or a minimum of 40 GB for modeling. Swap space commensurate with the RAM should also be available. Video is a major component of GIS. A minimum of 128 MB of video RAM are recommended for the casual user. Systems used for analysis should have at least a minimum of 256 MB of Video RAM. Processing power is important but primarily for modeling and analysis. 3.0 GHz or faster processors are recommended for such persons. A minimum of 2.0 GHZ is necessary for 'casual' users due to software requirements. Additionally, DVD drives are required for storing, retrieval, or archiving image data. Fast network connections 100MB or greater are necessary for accessing larger files on the servers or for data transfer.

Note: These hardware standards are current at the time of this writing but will change with technological innovations. Contact Information Systems for the most recent computer definitions. Each set of the machine specifications is adequate for most end user GIS applications. The CAD computer is adequate for most GIS development and maintenance applications. Specialized GIS applications (such as image processing) may require an enhanced performance computer.

SOFTWARE STANDARDS

Operating System Software

NDOT currently uses Microsoft Windows 2000 Professional as the operating system platform for virtually all computers in the department. All application software, including GIS software, must run in this environment. NDOT uses Windows 2000 Professional for workstations and Windows 2000 & 2003 Server for servers.

Current Versions: Microsoft Windows 2000 5.0 – Check for latest Service Pack

Database Software

The State of Nevada has a licensing agreement with Oracle. NDOT has established Oracle as the Relational Database Management System (RDBMS) for the primary database standard with the other option being SQL-Server database. The GIS section of NDOT has a licensing agreement for the Spatial Data Cartridge from Oracle. Oracle (preferred) or SQL will be used for the Department-wide GIS data warehouse. Microsoft Access is also used for some GIS application development and end user applications. MS Access is used for those applications that require less sophistication and performance demands from the database management system. In all cases, applications **will be** compatible with the NDOT Linear Referencing System and Bentley LRSx product.

Current Versions:

Oracle Enterprise Oracle 9.2.0.7 Oracle Spatial Cartridge is also used.
SQL Server 2000 SP3
Microsoft Access 2000
LRSx 1.x

GIS Software

GIS software can be divided into two categories, the development/ maintenance products and end user desktop software. NDOT currently uses GeoMedia Professional as the primary enterprise GIS software tool for data editing and analysis. ArcExplorer or GeoMedia will be used as data viewers. It may also be used for data maintenance and development by the end user. Non-technical end user applications will be developed in GeoMedia WebMap Professional.

Current Versions:
Intergraph GeoMedia Pro 5.2 sp.72 or later or GeoMedia Pro 6.0 sp .94 or later
GeoMedia Transportation Manager or Analyst
GeoMedia Transaction Manager
Bentley/TransDecisions LRSx software 1.x
GeoMedia WebMap Pro 5.2 check for service pack. (Migration to 6.x may occur in 2007)
ArcExplorer 2.0

Applications

Applications ***should not be*** developed for the desktop software. Applications for end users should be developed in the web software environment. Application developers should keep in mind that some remote offices and public access users still only have limited internet connectivity. Additional requirements on Web, database, network security, and other IS related issues should be investigated with the IS division. The GIS section can furnish you with appropriate points of contact.

GIS DATA STANDARDS

Data Types

The Geographic Information System data standards must address two primary data types: the geographic data (geometry) and the informational (attribute) data or database. The data types are created & maintained by either the enterprise or local end user.

It is the responsibility of the GIS section, in coordination with the Cartographic Section, to establish and maintain standards for the digital base map data, both the geographic and the attribute data types (TP 1.9.4). The GIS and Cartographic sections jointly establish and maintain standards for the digital base map data. The GIS and Cartography sections will also coordinate Oracle or SQL database activities with the IS Division.

Generally, the creator of a particular set of data is responsible for developing and maintaining standards that meet his or her data needs within the greater enterprise-wide concept. The GIS standards pertaining to data formats, minimum attributes, coordinate system, accuracy assessment, and metadata must be adhered to. Attribute information and database fields are left to the discretion of the data collector and specific project needs, except those specified by the GIS section. It is strongly recommended for any groups (internal or external) developing data to consult with the GIS section early in the process.

Data Formats

Listed below are the data types, formats, attribute information, and minimum metadata information. All data presented to NDOT for inclusion in the GIS **will be** in NAD83 - HARN, GRS 1980, UTM (Zone 11, meters).

Accuracy Issues

The accuracy issue is always of concern when developing standards. However, accuracy can have many different meanings in the GIS. First there is the geographical or positional accuracy and equally important is the informational or attribute accuracy. Then there is the issue of how precise the specific data is. Unknowns in either case could potentially render unacceptable results in the GIS. This document is primarily concerned with the standards on accuracy relative to the NDOT digital base map data. Positional Accuracy assessment or validation of data is the responsibility of the Geodesy Section. There may also be other data that is used as a Department-wide resource that the standards in this manual will be applied to. However, in general, it is the responsibility of the source organization to provide the accuracy information as part of the metadata included with all GIS data. Map accuracy standards are in the section titled "Map Content Requirements." **Any data provided by vendors will have appropriate metadata reflecting accuracy.** Compilation of that value will follow the guidelines set forth in this document under the Geodesy standards accuracy requirements.

Geographic Data Standards

The geographic data, or map, is one of the two primary data components of a Geographic Information System. Geographic data can generally be subdivided into two categories, the base map geographic data and the mapping data for end user applications. The following discusses

the various data and the standards that apply. Geographic standards already exist at NDOT for graphic data, such as Survey and Cartography standards. It is not the intent of this document to replace these standards but to maintain those standards where appropriate. In fact, it is the goal at NDOT that all base map geographic data be verified using Survey standards or to be attributable to an appropriate authoritative source.

Base Map Standards

The following describes the standard that applies to the Digital Cartographic Reference Base Map (DCRB). Generally this standard parallels the Mapping standard that has been established by the Cartography Section at NDOT. However, there may be differences in the way the two standards are structured. It is important to note that the base map standard applies only to the digital base map data and not necessarily to other data (end user data) that may be displayed as part of a GIS map presentation. **End user data or application data standards will depend on the requirements of the users and the objectives of the application. These standards will be set in the Requirements Specification for a project.** However, as stated earlier, certain minimum standards will be adhered to. The Base Map standard is feature based. This means that each map feature may have its own defined standard that may be different than other map features. Each feature is also associated with a particular category. Currently, categories that are of concern for the digital base map standard consists of Transportation, Public Land Survey System (PLSS), hypsography/Digital Elevation Models (DEM), Hydrology, and Political Boundaries. Each category has a spreadsheet that contains a list of features for that category and information describing their standards. Associated with each spreadsheet is a description of the features and the attributes used to define the standard.

Vendors who collect data using GPS will also provide the information on hardware, metadata on the data collected, and post processing. (Use of WAS enabled or other real time correction method, GPS units is strongly encouraged). Features should be occupied when collected. Proper safety considerations should be taken into account when doing this. “Drive by” data is not acceptable unless collected in accordance with approved ‘road viewer’ technology. It is also recommended to capture a digital photograph of the feature at this time to ensure the proper feature was collected. The photo number should be included in the database for the feature. **A full understanding by the vendor of the customer needs and collection requirements should be obtained before data is collected.**

GIS BASE MAP FEATURES

Transportation Category

Feature Name	Feature Type	Horizontal Position	Vertical Position	Attribute Verification
Major Highway CL	Linear	2.394 m +/- @ 95%	2.394 m +/-@ 95%	NDOT Verified
Major Highway EO	Linear	2 m +/- @ 95%	2 m +/- @ 95%	NDOT Verified
Minor Roads CL	Linear	15 m +/- @90%	tbd	Application Verified
Mileposts	Point	15 m +/- @ 95%	tbd	NDOT Verified
Railroads	Linear	10 m +/- @ 90%	tbd	Application Verified
Engineering District	Area	tbd	n/a	NDOT Verified
Maintenance District	Area	tbd	n/a	NDOT Verified

tbd - to be determined
n/a - not applicable

Other point, or line information of a transportation nature should adhere to the positional standards for the examples listed above.

Feature Description

Major Highway CL	*Centerline for Interstate, US and Nevada State Highways*
Major Highway EO	*Edge of Oil for Interstate, US and Nevada State Highways*
Minor Roads CL	*Centerline for all other roads, e.g. County, rural and local roads*
Mileposts	*Mileposts for Interstate, US and Nevada State Highways*
Railroads	*Centerline for major rail lines*
Engineering District	*Nevada DOT Engineering District Boundary*
Maintenance District	*Nevada DOT Maintenance District Boundary*

Standards Attribute Description

Feature Name	*Name of feature in the GIS database*
Feature Type	*Type of graphical representation - point, line, area*
Horizontal Position	*Horizontal positional accuracy stated as distance and percentage*
Vertical Position	*Vertical positional accuracy stated as distance and percentage*
Attribute Verification	*Informational data confidence level based on verifying entity*
Datasource Origin	*of the information i.e. GPS, DOQ, DRG or other.*

Hydrology Category

Feature Name	Feature Type	Horizontal Position	Vertical Position	Attribute Verification
Water Area	Area	~20 meters @ 90%	tbd	Source Verified
Major Rivers	Linear	~10 meters @ 90%	tbd	Source Verified
Major Drainage	Linear	~10 meters @ 90%	tbd	Source Verified

tbd - to be determined
n/a - not applicable

Feature Description

Water Area	*Major bodies of water to include lakes, ponds, and reservoirs*
Major River	*Rivers considered to be navigable*
Major Drainage	*Drainage considered to be in place year-round*

Standards Attribute Description

Feature Name	*Name of feature in the GIS database*
Feature Type	*Type of graphical representation - point, line, area*
Horizontal Position	*Horizontal positional accuracy stated as distance and percentage*
Vertical Position	*Vertical positional accuracy stated as distance and percentage*
Attribute Verification	*Informational data confidence level based on verifying entity.*
Datasource Origin	*Origin of the information i.e. GPS, DOQ, DRG or other.*

Political Boundaries Category

Feature Name	Feature Type	Horizontal Position	Vertical Position	Attribute Verification
State Boundary	Area	PLSS	n/a	NDOT Verified
County Boundary	Area	PLSS	n/a	NDOT Verified
Military Reservation	Area	tbd	n/a	Source Verified
National Forest	Area	tbd	n/a	Source Verified
Wilderness Area	Area	tbd	n/a	Source Verified
Indian Reservation	Area	tbd	n/a	Source Verified
National Parks	Area	tbd	n/a	Source Verified

tbd - to be determined
n/a - not applicable

Feature Description

State Boundary	*Nevada State boundary*
County Boundary	*Boundaries for the counties of Nevada*
Military Reservation	*Any boundary defining a military facility*
National Forest	*Any boundary defining a National Forest area*
Wilderness Area	*Any boundary defining a Wilderness area*
Indian Reservation	*Any boundary defining an Indian land area*
National Park	*Any boundary defining a National Park*

Standards Attribute Description

Feature Name	*Name of feature in the GIS database*
Feature Type	*Type of graphical representation - point, line, area*
Horizontal Position	*Horizontal positional accuracy stated as distance and percentage*
Vertical Position	*Vertical positional accuracy stated as distance and percentage*
Attribute Verification	*Informational data confidence level based on verifying entity*
Datasource Origin	*Origin of the information ie. GPS, DOQ, DRG or other.*

GIS DATABASE STANDARDS

The database is the heart of an Information System. In a GIS, the database actually serves two purposes. It is the mechanism by which the vector graphics (map) takes on intelligence and it is the system that stores, manages, and retrieves all informational data. The database is the component that makes the GIS a system. It is also the component that requires the most time and effort both in design and implementation.

NOTE:

This section of the GIS Standards document is still under development.
There will be both additions and changes to the information presented here.

Oracle Database Tables:

RN.SDS_SOURCE_MONSTER Properties

LOC.MPMARKERS Properties

LOC.MPMARKERS_GREEN Properties

LRSx Requirements Fields

Oracle with spatial cartridge
LRSx – LRS – Metadata – user defined tables
LRSx – event metadata – user defined event tables
A schema for TD SYS TABLES- stores feature class metadata
LRS DATUM- underlying geometry, naming & measure
LRS DATUM-ID- feature ID
LRS DATUM-street code- LRS route identifier
LRS DATUM-measurement-begin & end segment values

For other fields used in points or lines see next page. Additional Requirements may exist in Information Services Division.

END USER DATA STANDARDS

End user data should meet two criteria for implementation into the NDOT GIS. The GIS data format standard and the minimum metadata standard are defined below.

GIS Data Format Standards

The following GIS data formats are currently acceptable at NDOT.

MGE data format	**.DGN *files and Oracle database***
GeoMedia data format	***Microsoft Access .MDB file format***
Arc Info data format	***arc coverage***
ArcView data format	***Shapefile format (.SHP/.SHX/.DBF/.PRJ files)***
MapInfo data format	**(.MAP/.DAT/.TAB/.ID/.IND files)**
GeoTiff image	**with world file (if not written in header)**
Mr. Sid image	**with .sdw worldfile**
Autocad	**DXF format**
Arc GIS	***Geo database format is not acceptable***

GIS Metadata Standards

The following is a list of the minimum required information that will accompany all GIS data. This information is required in electronic form and as a part of the deliverable to NDOT.

Geodetic Datum **Coordinate System** **Zone**
Vertical Datum **Coordinate Units** **Coordinate Value**
Horizontal Accuracy **Attribute Definition**
Vertical Accuracy

(Note: Has the data set been modified to reflect grid to ground inconsistencies?)
Data source origin of the information, i.e. GPS, DOQ, DRG or other.

Data Source *(Name / Address of agency or firm)*
Contact Name:
Position:
Phone:
Fax:
E-mail:
Collection Method *(GPS / survey / digitizing, etc.)*
Accuracy Information *(attribute and positional)*
Data Collection Data

If modified from an original source a description of the modifications and software used to perform the modifications including version and the original data source must be listed. List of attributes and data types. *Preferred content is Sections 1-7 of the FGDC standard.*

Data Transfer procedures

For files under 150MB compressed FTP is acceptable.
For files over 150MB CD-Rom, DVD-Rom, or Portable USB hard drive (NTFS format) as appropriate.

GIS DATABASE STANDARD FIELDS

Field Name	Field Type	Field Size	Notes	Status
Northing	Number	Double	UTM Coordinate	Point Features#
Easting	Number	Double	UTM Coordinate	Point Features#
GPSHeight_M *	Number	Double	Metric units	Point Features#
Latitude	Text	50	D:M:SSSS	Point Features&
Longitude	Text	50	D:M:SSSS	Point Features&
GPSHeight_FT *	Number	Double	English units	Optional
MileReferencePost	Number	Double	Mileage Number	Prefered
CountyCode	Text	3	Abbreviated county string	Optional
CountyString	Text	20	County full name	Prefered
FIPSCode	Text	10	County FIPS code	Required
DOTDistrict	Text	2	NDOT Maintenance District	Optional
Direction	Text	3	Cardinal travel direction	Prefered
Prefix	Text	3	E/W/N/S/NE/NW	Optional
System	Text	20	IR/US/SR/FR/Other	Prefered
Route	Text	20	Route number/Street name	Required
Suffix	Text	2	RD/AV/ST	Optional
Offset	Number	Long Interger	Distance from E.O.	Optional
SideOfRoad	Text	10	LT/RT/N/S/E/W	Optional
Name	Text	50	Data collected issue	Prefered
Type	Text	50	Data collected issue	Optional
Status	Text	20	Active/Inactive	Prefered
DataSource	Text	50	Source data collected from	Prefered
DataSourceMethod	Text	20	GPS/Digitized	Required
DataSourceDate	Date/Time	Date	Date data collected	Prefered
PhotoNumber	Text	20	Name or number of photo	Prefered

Sample	Prefix	System	Route	Suffix
		IR	80	
	S	Other	Virginia	St

** ellipsoid height # Required Field & Preferred*

GIS DELIVERABLES

The following are the minimum deliverables expected for GIS related projects. It is the responsibility of the consultant to ensure they understand the deliverables for the contract and to make this a part of the proposal. Given the potential complexity of scope and scale of a project the consultant should actively communicate with NDOT to ensure deliverables are properly understood and correctly delivered. Projects will not be considered complete for payment until all deliverables are received and approved.

Application documentation will be reviewed by the GIS and appropriate IS staff for completeness and readability in draft and final form. Reports will be reviewed by appropriate project related personnel including internal NDOT customers and GIS staff. Sufficient time (not less than 10 business days) for documentation review should be allowed for in the scope of work. Drafts should be delivered in a timely manner to facilitate review.

Reports

1. Preliminary draft documents will be presented in NDOT's word processing package format (Microsoft Word 2000 v9.0) editable for review, updates and changes by NDOT staff.
2. An electronic copy of the final deliverable document will be delivered in PDF file format.
3. A minimum of 4 hard copies of the printed report, in color if appropriate.

Applications

Two copies of Program files and data are to be delivered on CD-Rom(s)

Data files

Any data generated for the project will be returned in the proper coordinate system (NDOT Standards) and acceptable data format(s) with appropriate metadata. Time should be allotted for review and acceptance of both GIS data and metadata.

Documentation

Items will be clearly labeled in a single document(s) folder presented in NDOT's word processing package format (Microsoft Word 2000 v9.0) editable for review, updates, and changes by NDOT staff. This may include a programmers guide, a users guide, application specifications, or any other documentation as required or requested in the contract. All documentation will be reviewed prior to project acceptance. Metadata should be in FGDC or ISO compliant format and delivered in HTML format.

Application

Items will be in separate folders for maximum clarity.

1. All source code.
2. A final installation version of the installed application
3. Any other associated files for the program.

Databases or other data

Data will meet the contractually specified requirements listed in either the GIS or Cartographic Section for accuracies and type.

It is expected that all applications will be thoroughly tested prior to deployment. However experience indicates that minor fixes may be required after installation. NDOT expects the contractor to support these applications for a minimum of 30 days. Repairs necessitated by factors outside the original contract (such as operating systems changes and items of related nature with the exception of security patches) will not be reasons to request corrections.