

BEST PRACTICES FOR PLANNING AND DESIGN OF FREEWAY FACILITIES

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1. PREAMBLE

1.1 Function of Freeways

For purposes of this paper, **freeways** are defined as high capacity, high speed, multi-lane roadways with full access control in both urban and rural settings.

Freeways are generally primary highway linkages having regional, provincial and continental connectivity and importance that serves long distance travel. **Freeways** may also serve as major urban highway linkages in corridors with heavy demand.

Freeways carry a mix of private and commercial vehicles, including inter and intra urban buses on express routes. Their primary function is to carry this mix of traffic at consistently high speeds, **safely** and efficiently. Freeways must perform this function in a controlled environment that minimizes turbulence, considering the full range of visibility, weather conditions, and traffic mix.

Freeways exclude bicycles, pedestrians, and slow-moving vehicles. Planning to accommodate these needs through supporting infrastructure should proceed in parallel with freeway planning.

1.2 Primary Design Features of Freeways

Full control of access is essential to freeway operation. Control of access implies exclusion of pedestrian, slow-moving vehicle and cycle traffic, and exclusion of random movement of any kind to and from the freeway main line. Access and egress for vehicular traffic occurs only at grade separated interchanges where provision can be made to minimize speed differentials between entering and exiting vehicles and main line traffic. Freeway rights-of-way are usually fenced.

High standard vertical and horizontal geometry are required to accommodate freeway speeds and **safe** operation of the full range of motor vehicles using the facility. Gentle horizontal and vertical curvature, long sight distances, medians, and shoulders for emergency stopping are all well-established standards of freeway design.

Speed transition zones outside of the main traffic lanes are provided for access and egress movements at interchanges.

Freeways connect only to other freeways, arterial streets, other primary highways or major roadways at interchanges. Freeways are not access roadways for adjacent land-uses of any kind.

Freeway operations require high standard / high visibility information and control signing, along with adequate roadway lighting in urban areas and at some heavy movement / interchange locations in rural areas.

2. ECONOMIC IMPORTANCE OF FREEWAYS

2.1 Competitive Environment

Freeways provide the basic infrastructure for the flexible and efficient movement of goods and people with random origins and destinations. Proper freeway design and operation facilitates this movement in a safe, fuel-efficient and consistent speed environment.

Canadians, and specifically Albertans, live, work and compete in an economic environment that is continental in scope. The United States has developed the world's leading economy, with infrastructure playing a major role in this leadership. The U.S. Interstate Highway System is one of the key components of American infrastructure. It is essential to note that the Interstate System is a true freeway system. The system features a consistent standard of design with full control of access throughout all of the rural and urban routes that make up a network that covers the entire country. Road users know what to expect from the system anywhere in the U.S.

Alberta's infrastructure needs to be planned and implemented so it is at least competitive. This translates into a requirement for a designated primary system in rural and urban Alberta that compares favorably to the U.S. Interstate system. Full access control and consistently high design standards will achieve this objective. It is to be noted that there is generally a positive correlation between a nation's GNP and the efficiency of its transportation networks.

2.2 Environmental Considerations

Freeways are more environmentally friendly than other types of roadways in a number of ways. In terms of space, a freeway lane is a much higher capacity traffic conduit than an equivalent lane on a lower standard roadway or two-lane highway, although freeway right-of-way requirements are generally greater than for other roadway standards. Full control of access and consistent speeds, without stop-and-go traffic, allows fuel efficient vehicle operation, with lower volumes of emissions per vehicle mile than other roadway standards.

Concentration of major traffic volumes into freeway corridors relieves other areas of high volumes of heavy vehicles and other road traffic, allowing more capacity and less congestion for local land access requirements. Controlled access with consistent and high standards of geometry allows safe vehicular operation on freeways, reducing accidents and their associated economic and social costs.

3. CRITICAL RELATIONSHIPS

Freeway planning and design involves several critical and complex relationships with surrounding uses and driver / operators.

3.1 Land-use / Land Access

Land-use immediately adjacent to freeways and the uses served by the freeway are critical factors in planning and design. Freeways are **not** land access roadways. Direct access to land-uses for traffic is made via the surface street system (arterial, collector and local roads in urban areas; local roads in rural areas). Access to and from freeways is made only via arterial streets or primary highways and other major roads at interchanges. Access to and from arterial streets and primary highways should be made at intersections that respect proper standards of spacing from interchange intersections. This access hierarchy is critical to the maintenance of freeway function and should not be compromised. Consistency in this principle is critical to maintaining driver confidence and rational decision making. It also protects the freeway infrastructure investment as land uses change and redevelop.

The only direct egress and access to and from freeways for specific land-use should be for rest areas and vehicle inspection station facilities associated with freeways. Drivers, who have an expectation of continuing on in their original direction after stopping, consider these uses part of the freeway facility.

The volumes of traffic that may use freeways are estimated through trip generation analyses for areas likely to develop, based on assumed land-uses and / or counts of existing traffic for developed areas. These estimates can and will vary as actual development or redevelopment occurs and transportation or other technology changes. Land-use changes to existing development in unforeseen directions can alter traffic demands. Changes in fuel and vehicle costs, transportation technology or policies can also impact traffic demands, making flexibility a key issue in planning.

Freeway facilities that are initially built to arterial or expressway standards as part of initial staging should avoid temporary access that will require removal at full freeway development. Such accesses are often difficult to remove from mature development areas as existing travel patterns are changed.

Protection of the infrastructure investment in freeways is optimized by planning and designing a system that limits freeway access and egress to properly spaced interchanges and maintains the land access function with lower standard roadways. The surface roadway system can be modified to serve land-use changes and other variations at much lower cost than modifying the freeway infrastructure. Complementary lower class roadway systems are required to carry the shorter trips rather than place them on the freeway system for short distances.

3.2 Driver / Roadway Interaction

Freeways are high speed, high capacity, multi-lane facilities that carry a mix of private and commercial vehicles. Drivers require the assurance of a consistent operating environment that will provide a minimum number of decisions with maximum time to make them in high volume situations. This is a critical objective in freeway design and an absolute requirement for optimizing **safety** and investment return.

Driver expectations are formed based on driver experience with local, regional and international systems, and consistency in standards for these systems is becoming increasingly important. (A major effort in motorway standards is underway throughout the European Union.)

The consistent operating environment is provided through consistency of all design features and roadway elements. Each driver knows what to expect from the roadway under any operating condition in a properly designed system. This expectation is critical to safety of operation and minimizes the number of decisions a driver needs to make, particularly if an unexpected incident occurs.

Consistent design throughout the system also allows logical and effective motorist information systems to be utilized. Application of Intelligent Transportation Systems (ITS) technology such as variable message signs for weather, accident and emergency routing, and GPS navigation systems, is simplified in systems with consistent design features.

3.3 Application of Standards

All jurisdictions with responsibility for freeway systems have well established minimum standards for design elements. These standards specify minimums below which design of specific elements is not considered adequate for the facility.

In the application of design standards, there is need for wider recognition that a combination of minimum standards for a number of interacting design elements does not usually produce an acceptable design. The technical basis for a minimum standard does not usually assume that all other interacting elements will also be

minimums. The application of higher than minimum standards in every area where it is physically and economically possible is good planning and design practice.

This philosophy in the application of standards is absolutely critical in the planning stage, where not all constraints are always known. It also allows for maximum flexibility in future expansion and operation, thereby maintaining the value of the investment.

A number of the critical relationships are illustrated in **Figure 1**.

4. SOME SPECIFIC “BEST PRACTICES”

4.1 Level of Service

At the planning stages, it is critical to size primary roadway systems at Level of Service C or better for the ultimate design of the freeway. In some urban areas, it is recognized that Level C may not always be achievable during peak hours.

Traffic demand can and will vary as systems are implemented, land-uses develop or change and technology changes. Variations that add demand will immediately degrade design levels of service, so maintaining planning standards at Level C or better will allow some flexibility in future use. Higher Occupancy Vehicle (HOV) lanes may be considered in some corridors to maintain a higher Level of Service.

4.2 Horizontal and Vertical Alignment

Application of the best attainable curvature design in both horizontal and vertical alignment is a well-accepted design practice. Incorporating the best possible alignment not only optimizes the operating environment; it also allows maximum flexibility in future expansion or modification. Consistency in application is also critical to how the system will be perceived and operated by individual drivers.

A specific example relates to bridges carrying freeway traffic on curves. In the Alberta climate, bridge decks are subject to icing that may not be present on the remainder of the roadway. Use of minimum curvature standards for alignment involving bridges can be hazardous under some weather conditions and reinforces the requirement to apply higher than minimum standards.

4.3 Cross-section Design

Provision of wide medians for separation of traffic is a key safety consideration as well as providing flexibility for future expansion. It also allows the use of independent profiles for the divided roadways.

Shoulders for emergency stopping are also critical safety elements. Side-slopes in medians and roadway edges are design features that impact safety, along with barriers that protect traffic from roadside obstacles. Good design practice should minimize barrier use, either in medians or at obstacles, since barriers themselves are safety hazards. Median barriers, for example, may cause undesirable snow drifting and drainage situations on multi-lane facilities that negatively impact safety.

4.4 Interchange Spacing

Maintaining interchange spacing that allows proper operation of the freeway mainline is a key factor in protecting the infrastructure investment. Mainline freeway operations and safety are generally enhanced by reducing the number of interchanges, thereby reducing the number of points of turbulence introduced by entrance and exit maneuvers. Desirable longer interchange spacing must be balanced against the traffic demand for freeway use, interchange capacity and the constraints on the connecting local and arterial systems.

In urban areas, preferred spacing between local interchanges is 2000 metres or more. Where a supplementary road system cannot be implemented, some exceptions may be required. Systems interchanges are preferably spaced 3000 metres or more from adjacent local interchanges. These spacing requirements relate to the need for adequate distances for weaving and directional signing. Systems interchanges generally involve longer ramps and higher volumes than local interchanges, thus increasing the minimum spacing requirement.

Where development demands and / or existing roadway systems complicate the application of these spacing requirements, frontage roads and collector / distributor roads should be considered to maintain the integrity of the basic spacing requirements.

In some cases, a grade separated connection, or “flyover”, may be considered to allow traffic and/or pedestrians to cross a freeway without access to the freeway. These connections reduce the amount of short trips on a specific section of freeway. These connections are typically costly and should only be used where there is an identified need and long term benefit. No interim at-grade intersections should be provided at these locations as the future grade separations will prohibit existing access to the freeway.

For rural areas the intensity of development and the local road system will determine spacing requirements for interchanges on freeways. A desirable spacing of 8000 metres ranging up to 16000 metres is a rough guideline.

4.5 Interchange Design

Interchanges, as points of access and egress and / or changes of direction in freeway systems are the significant points of turbulence and decision-making in freeway systems. Consistency of design features is absolutely critical to driver confidence in system usage. Right-hand, single exit design at all interchanges is a best practice that contributes to this confidence. This design feature allows entry and exit maneuvers to be made from the lower speed lane and all traffic interface with the freeway main line is on the driver's side of the vehicle for maximum visibility. Right-hand entrances are preferable for the same reasons. Right-hand, single exit design at all interchanges also provides consistency in directional signing.

Provision of all movements at each interchange is another feature that is critical to logical operation and driver confidence. If a vehicle leaves a freeway at an interchange there is a logical expectation that the driver may return to the freeway at the same location, either travelling on in the same direction, or returning in the opposite direction. Interchanges that provide only partial movements are often confusing to drivers and may cause maneuvers that are safety concerns. Drivers will search for return movements and this can cause wrong-way movements on ramps and freeway main lines, or median crossovers at prohibited locations, with serious accident potential.

Access to and from commercial land-uses, for example, should be achieved from the arterial or major roadway that has full local interchange with the freeway. Drivers' expectations are then consistently maintained. If individual access ramps to specific land uses are provided without logical return movements in all directions, confusion and unsafe driver decisions will result. Local access should not be provided directly off freeway ramps for the same reasons.

The only cases where driver expectations do not involve return movements in all directions are for freeway related facilities at rest areas and vehicle inspection / weigh stations. Drivers generally expect to carry on in their original direction after using these facilities.

Consistency of design in terms of logical turning directions at the stop sign or signal-controlled intersections in local interchanges is also recommended. For example, the use of both Parclo A and Parclo B interchanges causes drivers to turn in different directions at different interchanges to achieve access to or egress from the freeway. Not all drivers are familiar, and inconsistent design features can result in dangerous wrong-way movements. Spacing of intersections adjacent to interchange intersections is also critical to proper interchange operation. Arterial intersections should be a minimum of 400 meters from intersections at freeway interchanges.

Interchange exit and entrance areas are the critical speed change areas in freeway operations and require careful design. The combination of horizontal and vertical sight distances at these locations are critical to driver reaction and smooth transitional maneuvers at entrance and exit locations. Structures, sign supports, lighting and other roadway hardware can impact decision sight distances as well as the horizontal and vertical design at these critical locations, requiring a coordinated design of all elements.

4.6 Information Systems / Highway Services

Efficient use of freeway systems is dependent on reliable information transmitted in a consistent way to drivers. The provision of information through directional signing is enhanced by many of the individual design features listed above, particularly use of right-hand, single exit geometry only and provision of all return movements at interchanges.

Another best practice that should be considered for application is the numbering of interchanges (exits) in a logical manner. The U.S. Interstate System is a good example. Motorists can pre-select access and egress points by number, simplifying navigation. This feature also ties in well with the growing number of computer based information systems available to motorists on highway services and other key destinations.

Highway services development is logically accessed by freeway users when concentrated adjacent to local interchanges. This arrangement also facilitates provision of information on these services to drivers in a consistent location and manner. The U.S. Interstate System is an example. The specific access to each business requires careful design considering the operation of the interchange and arterial / major road as well as the access needs of the business.

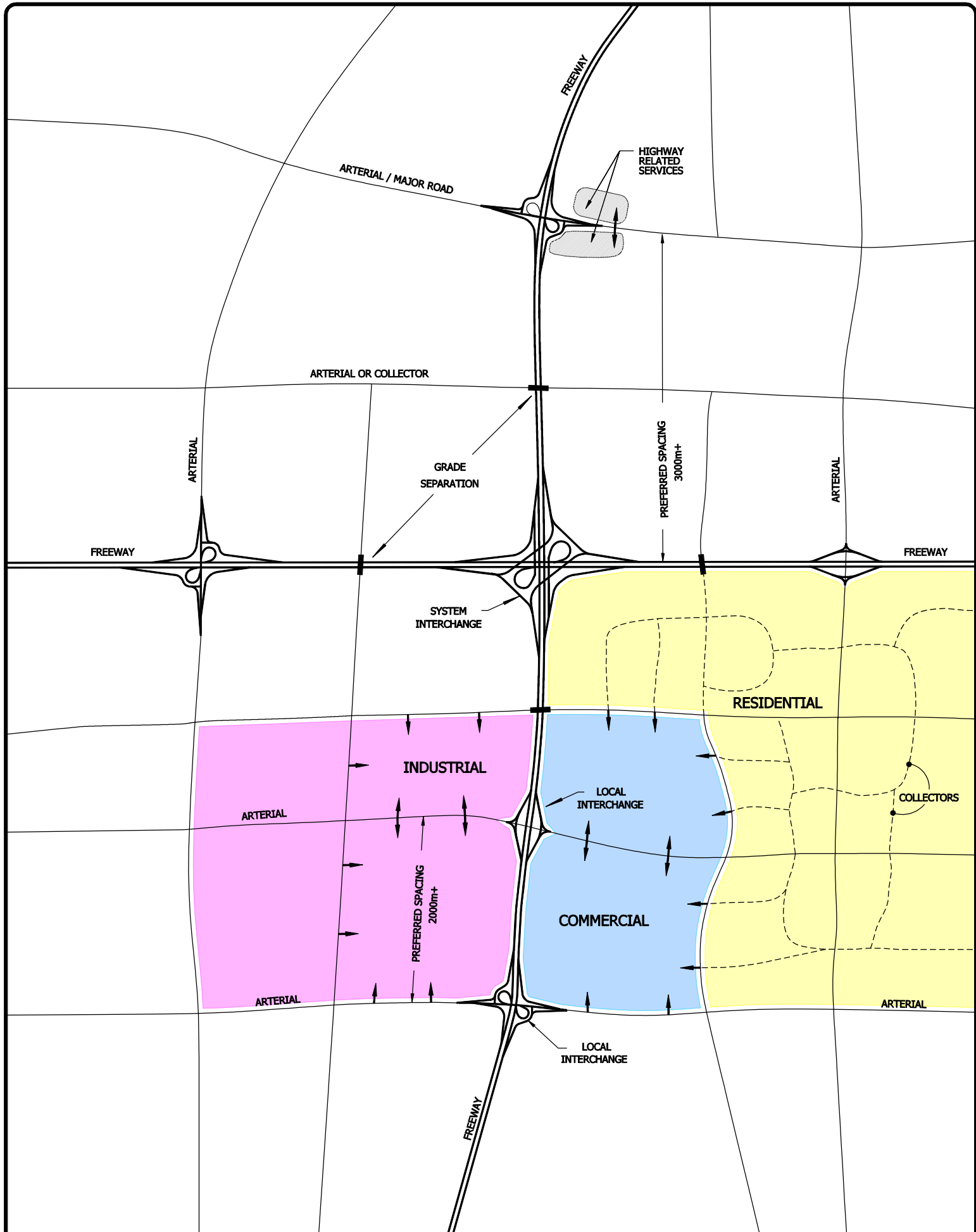
Rest areas are a safety feature that should be considered in freeway planning. Rest areas should be separated from the freeway mainline, provide parking for large vehicles as well as regular passenger vehicles, and have restroom facilities.

4.7 Planning Horizon / Staging

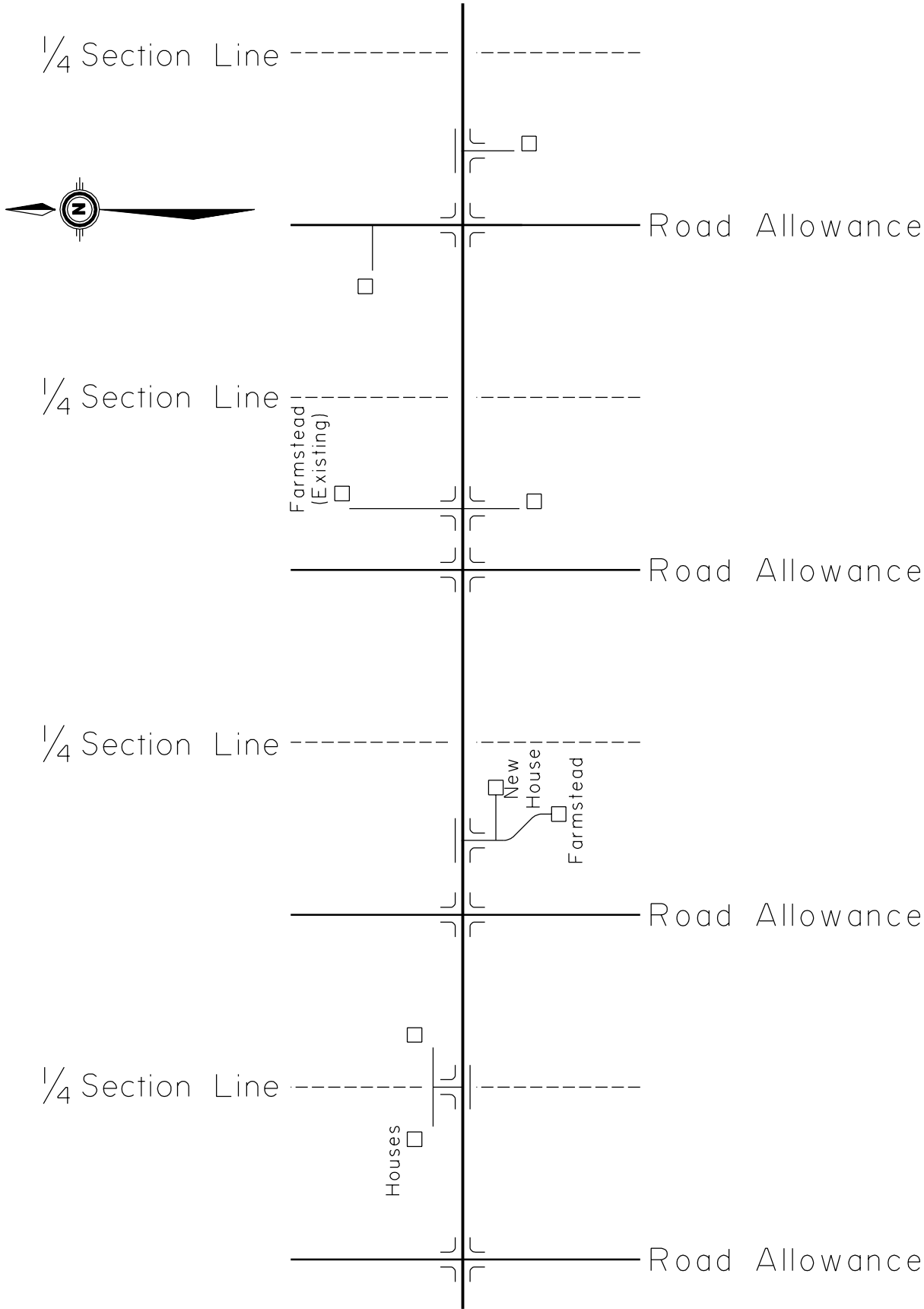
A long term planning horizon of 30+ years is critical in achieving a system that serves needs far into the future and justifies investment. In planning for an access-controlled roadway or system of roadways, it is recognized that initial stages of the roadway development may involve construction and operation of parts or all of the roadway at lower than full freeway standards. Economic considerations and initial traffic demands may not justify full freeway standards at the earlier stages. A typical staging scenario is illustrated in **Exhibits 2, 3 and 4**.

The critical element in the planning stages is to recognize and designate the specific roadway or system ultimate function in the planning stage and plan for the ultimate upgrading at the time first stage design is done. This may involve upgrading some elements that were not initially planned for ultimate freeway standard and these will be the more difficult and expensive areas. The earlier the ultimate system standards are known and applied in planning, the more economical the implementation of full access control will become, with the least disruption. Ultimate right-of-way acquisition, or at least protection, is a key factor in achieving objectives.

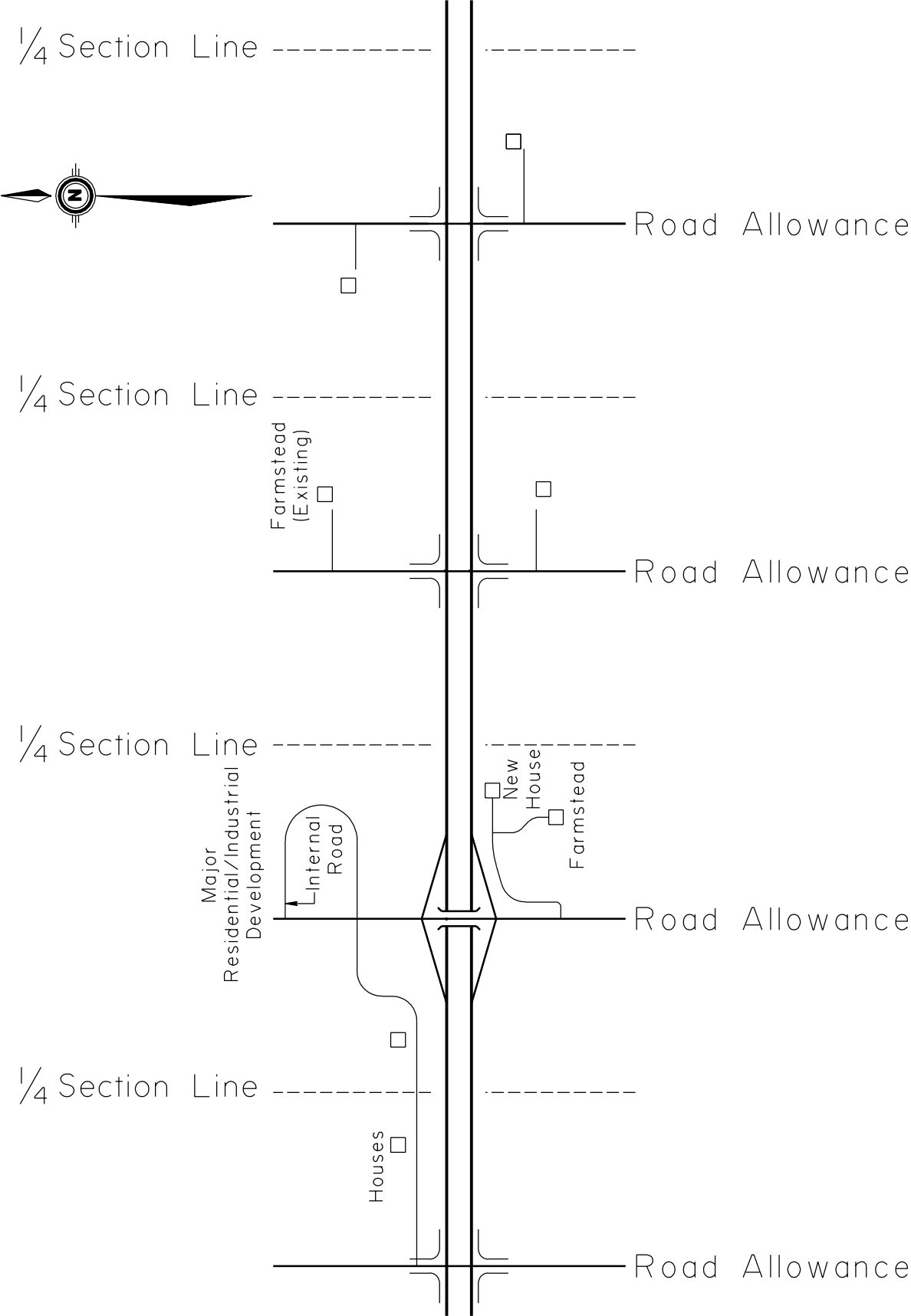
Staging freeway construction requires that commercial land-use/development be planned and located at permanent interchange sites with setbacks that will allow for the proper design of the future interchange and connecting roadways.



MAJOR TWO-LANE HIGHWAY



EXPRESSWAY



FREEWAY

