

***INDOT Long-Range Research Focus  
Group Project***

**Barry Partridge  
Chief  
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**DRAFT FINAL REPORT**  
**LONG-RANGE RESEARCH PLAN**  
**FOCUS GROUP INITIATIVE**  
**FOR THE**  
**INDIANA DEPARTMENT OF TRANSPORTATION**

**Prepared by**

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**Purdue University**  
**West Lafayette, Indiana**

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## **HISTORY OF THE INITIATIVE**

The Indiana Department of Transportation (INDOT) Long-Range Research Focus Group Initiative was an outgrowth of the Research Program Peer Exchange for State Departments of Transportation. Although this is a required review for continuation of federal funding for research activities, the peer exchange process is not a critique, but rather is an opportunity for state transportation research programs to exchange solutions to mutual problems. This process took place for INDOT on August 16-19, 1998 in Indianapolis and West Lafayette. Representatives from several other research programs around the country conducted interviews and discussions for two days with individuals from INDOT, the Federal Highway Administration (FHWA), and Purdue University, all of whom are involved in the conduct and implementation of INDOT's research. Many strengths were noted in the 63-year old Joint Transportation Research Program (JTRP), foremost of which was the identification of current research needs on the basis of an annual solicitation of INDOT staff and potential researchers. However, in light of INDOT's recent establishment of a strategic planning cycle and and new increased federal funding for state DOTs, the peer group members, in conjunction with JTRP, highly recommended implementing focus groups aligned with the strategic planning cycle to establish long-range research priorities to meet INDOT's research needs. This initiative recommendation was presented to the JTRP Advisory Board in May 1999 and was subsequently unanimously supported for immediate implementation.

The Long-Range Research Plan Focus Group Initiative was thus established and a Study Advisory Committee (SAC) was appointed, consisting of Don Johnson, FHWA; Firooz Zandi and Barry Partridge, INDOT; and Kumares Sinha, Purdue University. Dr. Sinha served as the initiative's coordinator. The SAC was given the responsibility for preparing the guidelines for the focus groups and monitoring their on-going activities, as well as reviewing each focus group's recommendations. Their ultimate goal would be the preparation of a proposed consolidated long-range research plan for the JTRP Advisory Board's consideration and approval in conjunction with the annual research need solicitation schedule.

## **ORGANIZATION OF THE INITIATIVE**

After due consideration of INDOT's strategic plan and the experience of others involved in similar focus group processes, it was decided that the best approach would be to develop teams of professionals in the civil engineering disciplines common to TRB's topic areas and INDOT's organization. Therefore, during the summer of 1999 the following seven focus groups were established, and the noted individuals agreed to contribute their particular expertise in the subject area and to organize and facilitate the subsequent discussions and investigations. Purdue University facilitators were designated as lead facilitators in each group, responsible for the daily management of their group's activities and submission of required reports.

- |   |   |
|---|---|
| 1. <u>Construction/Surveying</u>        | Jim Bethel, Purdue<br>Dan Halpin, Purdue<br>Rick Yunker, INDOT<br>Rick Drumm, FHWA  |
| 2. <u>Environmental</u>                 | Jim Alleman, Purdue<br>Janice Osadczuk, INDOT<br>Joyce Newland, FHWA  |
| 3. <u>Geotechnical</u>                  | Al Altschaeffl, Purdue<br>Athar Khan, INDOT<br>Tom Saad, FHWA   |
| 4. <u>Intermodal/Planning/Financing</u> | Jon Fricker, Purdue<br>Larry Goode, INDOT<br>Rick Whitney, INDOT<br>John Weaver, INDOT<br>Larry Heil, FHWA  |
| 5. <u>Pavement/Materials</u>            | Jan Olek, Purdue<br>Adam Hand, Purdue<br>Kumar Dave, INDOT<br>Tony Zander, INDOT<br>Lee Gallivan, FHWA  |
| 6. <u>Structures/Hydraulics</u>         | Mark Bowman, Purdue<br>Julio Ramirez, Purdue<br>A. R. Rao, Purdue<br>Hasmukh Patel, INDOT<br>Phelps Klika, INDOT<br>Merril Dougherty, INDOT<br>Tom Saad, FHWA |
| 7. <u>Traffic/ITS/Safety</u>            | Darcy Bullock, Purdue<br>Dan Shamo, INDOT<br>Jim Poturalski, INDOT<br>Wendall Meyer, FHWA   |

## **INITIATIVE TIME LINE**

On August 30, 1999 the Long-Range Research Focus Group Initiative was launched with a meeting at Stewart Center on Purdue University's West Lafayette campus. The participants in this meeting were all of the above individuals as well as other interested staff and researchers from INDOT, FHWA, and Purdue University. A document outlining the initiatives goals and guidelines was distributed and discussed in detail at that meeting, and the focus groups were given the charge to investigate the changes that

are shaping Indiana's transportation needs as well as the technological, social, and environmental forces affecting the means by which transportation needs are being met. Each group was instructed to hold focused discussion sessions and conduct appropriate literature searches to identify state-of-the-art practices (including other DOTs) and research needs within the current INDOT strategic plan. The ultimate goal of each focus group was established as a report containing a prioritized list of research problem statements for three years, 2001-2003.

The completion of the focus group's tasks continued from September through December 1999 in the following sequence of milestones.

- A work plan overview and meeting schedule was submitted September 15, 1999 to the SAC for presentation at the JTRP Advisory Board meeting on September 23, 1999.
- Ideas were exchanged through a series of meetings, surveys, and other instruments within each group in the fall of 1999. Participants included researchers, INDOT staff including district personnel, industry representatives, local agencies, and other relevant organizations. Issues, problem areas, and research needs were identified. The ultimate goal of each group was the development of a maximum of 15 INDOT-specific problem statements for a maximum total of \$1.5 million per group for a period of three years. Highlights of these meetings and attendees are outlined in the individual focus group reports.
- A literature search, including information from other states, was conducted to determine the state-of-the-art of each specific area. All resources at Purdue University, including access to the TRIS database, were made available to the researchers, and each group also made its own specific relevant searches as outlined in the individual reports.
- Each focus group prepared a "mid-point" report that was presented by its Purdue facilitator to the JTRP Advisory Board on November 5, 1999. Attendees at this meeting included Commissioner Cristine Klika in addition to a large percentage of the focus group initiative participants. Valuable feedback was given to the focus groups at this meeting as they entered the decision-making and final reporting stage of the initiative.
- A consensus draft report was prepared by each focus group according to the following guidelines and submitted on December 31, 1999.

***Background Information:***

- Major research issues
- State-of-the-art practice (general)
- Literature search results (including other state practices)

***Problem Statements:***

- Research need (problem identification)
- State-of-the-art practice (specific)

- Scope of research
- Relevance to INDOT and transportation community in Indiana
- Is the research need of regional or nationwide interest?
- Are similar efforts underway elsewhere?
- Probability of this research being successful
- Costs of research/partnering
  - Cost of research and other resources required (for research phase).
  - Possible partnerships with local and other state agencies and private sector organizations and potential for matching funds
- Expected benefits in terms of specific products, procedures, specifications, change in work practices, etc.
- Estimated benefit-cost ratio
- When to expect benefits
- Customer impacts in terms of INDOT staff, its consultants, contractors, and vendors, and road users
- Who benefits, how, and how much
- Research Schedule
- Recommended start date/project tasks/completion date
- Project duration
- Potential research agency(ies)/staffing needs
- Urgency of research
  - Probability of implementation, its costs and other resources needed, and its expected time frame
  - Intermediate implementation possibilities
- Possible partnerships and potential for external matching funds
- Impact of implementation on INDOT (benefits and resource demands)

***Focus Group Contacts:***

- Individuals/agencies

***Prioritization of Needs/Timeline:***

- General ranking of research needs
- Which projects should be accomplished in which fiscal year (FY 2001-2003)
  - Are projects dependent on one another?

**RESEARCH PRIORITIES**

As meetings and information searches were conducted, the following research priority areas were identified by each focus group. A detailed discussion of the process and final priorities is provided in the individual focus group reports contained herein.

**CONSTRUCTION/SURVEYING**

This field is dominated by the impact of e-commerce and other data collection and data transfer protocol on the areas of construction and surveying. High technology as it impacts metrology and mensuration is also an important issue. Major research topics in this field relate to:

- Contracts and Project Delivery Systems
- Impact of Electronic Commerce and Information Transfer
- Risk Reduction and Allocation
- Safety
- Spatial Data Collection and Data Management
- GIS/GPS

## ENVIRONMENTAL

The 'environmental' context under which a long-range research plan would be formulated must correspondingly cover a considerable breadth of relevant issues. This range reflects the fact that our environmental concerns and sensitivities extend far beyond a core motivation to evaluate and maintain the physical quality of our air, water, and land assets. Indeed, the following listing of thirteen (13) major 'environmental' research topics (i.e., as were originally developed and validated by the Transportation Research Board in their TRB Circular 469 entitled, "Environmental Research Needs in Transportation") will subsequently be used as a basic backbone for the development of an INDOT long-range plan:

- Aesthetics and Visual Quality
- Air Quality
- Cultural Resources
- Energy Conservation, Alternative Fuels, and Climactic Change
- Environmental Review Processes
- Hazardous Materials Transportation
- Hazardous Waste
- Noise
- Operations and Maintenance
- Social and Economic Impacts
- Water Quality and Hydrology
- Wetlands
- Wildlife and Ecosystems

## GEOTECHNICAL

The following problem areas were identified based on the improvement goals that INDOT would like to achieve.

### Better Predictions

- role of soil fabric
  - how to describe anisotropy
  - effects of construction methods and traffic
  - how to include in analysis
- deep foundations
  - CPT improvement for better soil profiling
  - Lateral loads in multi-layer soils
  - Requirements for sockets into rock
- Scour
- seismic effects on soil behavior, not just liquefaction
- for jointless bridges
  - what soil movements will occur, and where
  - what movement is tolerable
- non-ideal soils - clayey sands, lightly cemented soils
- how do they behave
- use of performance data to determine causes of misprediction

## **GEOTECHNICAL (CONTINUED)**

### **Better Performance**

- subgrades
  - guidelines for remediating wet subgrades, including geosynthetics
  - long-term effectiveness of remediation, including drains
  - removing subgrade water
  - simplifying resilient modulus determination
- culverts
  - re-examination of specifications to mitigate settlements
  - flexible culverts requirements for replacement of multiple-opening boxes
- retaining devices
  - guidelines on when to use what type
- deep foundations
  - evaluate effects of coatings used to reduce dragdown
- landslides
  - categorization and guidelines for remedial measures and implementation
- expansive materials
  - how to eliminate expansion of sulfate-rich soils and combustion of by-products

### **Innovations**

- analysis
  - limit states design applied to slopes, walls, and embankments
  - risk analysis approach to stability of underground cavities
  - newer models for predicting deformations
- use of waste materials
  - shredded tires
  - ceramic materials
  - water sludge
  - study of corrosion caused by them
- modifying agents to improve behavior of soil deposits, e.g., injection into peat
- post-seismic inspection of foundation integrity
- evaluating performance of geotechnical instrumentation and design parameters therefrom
- soil freezing for deep cuts

## **INTERMODAL/PLANNING/FINANCING**

- Statewide travel demand forecasting
  - How variation in travel time affects model results
  - How best to develop and update trip tables for trucks and personal vehicles
  - Use of advanced technologies (e.g., remote sensing) in improving models
- Land use and travel – INDOT's role
  - Urban sprawl and megastores
  - Land use patterns that accommodate travel patterns
- Alternative sources of financing
  - Innovative financing

## **INTERMODAL/PLANNING/FINANCING (CONTINUED)**

- Alternatives to fuel tax
- Uses of new technologies for collecting user fees
- Mobility options in rural areas
  - Life-cycle and travel patterns
  - Alternatives to traditional public transit service
- Partnership for mobility management
- Freight movement in and through Indiana
  - Trucks on highways
  - Port-rail-highway relationships
- Integration of management systems
  - Congestion management
  - Safety management
- High-speed rail feasibility
  - Right-of-way acquisition/upgrade and cost
  - Competing modes and projected ridership
  - Other factors
- Effective use of new technologies in public transit
  - "Menu" of possible capabilities
  - Cost estimation procedure
- Non-motorized transportation
- Incorporating bicycle facilities (commuter and recreational) into design and renovation
- Pedestrian crossings at major intersections

## **PAVEMENT/MATERIALS**

- Use of pavement reinforcement grid on resurface projects
- PG binder grade selection for Superpave mixes in Indiana (are our PG binders stiff enough to resist permanent deformation?)
- Ignition oven testing of hot mix asphalt (HMA) containing dolomite aggregate
- Establishment of data needs for use with the new AASHTO 2002 design method
- Continued validation of the Superpave PG binder specifications
- Life-cycle cost study of Indiana Pavements
- Fine-tuning of Superpave system
  - The significant changes in the  $N_{des}$  table;
  - Termination of compaction at  $N_{des}$  rather than  $N_{max}$
  - Effect of changes in  $G_{mm}$  initial criteria;
  - Effect of change in STOA procedure;
  - Evaluation of the proposed new method of measuring CAA;
  - Evaluation of new VFA specification which would allow for high percentages of natural sand for low volume facilities;
  - Effect of changes in the dust proportion criteria;
  - Effect of new LTPP low temperature algorithm for binder selection;
  - Evaluation of proposed changes in the binder specification for modified binders on testing, selection, availability, and cost of binder selection;

## **PAVEMENT/MATERIALS (CONTINUED)**

- Precision of all Superpave specification items (a specification cannot be enforced without an understanding of precision).
- Early-Age Pavement Cracking/Deterioration
  - Shrinkage Cracking/Creep Relaxation Micro-Crack Development and Coalescence
  - Mixture Optimization for INDOT materials
    - Limiting the Amount of Cement
    - Specifying Different Aggregate Limits
    - Can Self-Desiccation Limit Freeze-Thaw Damage
  - Curling/Moisture/Thermal Profiles
    - APT heating and cooling capabilities
    - Curling modeling and simulation accounting for:
      - Soil Structure Interaction
      - Creep Compliance and its Relation with Moisture Content
- Determining age of cutting joints
- Quantification of surface texture and cracking patterns using computer image processing
  - Smoothness/friction
  - Winter traction
    - Noise
- Development of noise-mitigating pavement surfaces
  - Porous asphalt pavements
  - Porous PCC pavements
  - Tinning patterns
  - Mixtures with modified stiffness
  - Modified (lightweight and porous) bases
- Developing Methods to Assess New Materials and Repair Materials
  - Admixture Compatibility
  - Manufactures' Claims
    - Electro-chemical incompatibility with existing concrete, cracking
- High Strength/High Performance Concrete
- Developing Appropriate Accelerated Tests for Performance Knowledge to combine with PRS ideas
- Blended Cements, Supplementary Materials, and Environmentally Friendly Concrete
- HPC mix design for long-lasting (60-yr+) pavement
- Certification of ready-mix plants
- Self-Compacting Concrete for Bridge Piers and Abutments
- Ultra-Thin White Topping
  - Improving Processing Procedures for Accelerated Placing and Improved Material Performance
- Developing Non-Destructive Monitoring Techniques
  - Impedance Spectroscopy, TDR, Ultrasonics
  - Maturity/Links to Typical Property Development
  - Internal Damage/Reinforcing Steel Corrosion
  - Consolidation, Material Acceptance, Material Property Development, Flaw Detection
  - Developing Links to Long-Term Behavior and Performance Based Specifications, Condition Assessment, Monitoring of Practices and Performance
- Assessing the Corrosion/Deterioration of RC Concrete Elements Under Sustained Loading  
Limiting Crack Width to Improve the Performance of Concrete Pavements and Bridge Decks

## **PAVEMENT/MATERIALS (CONTINUED)**

- Determining the Relationship between Crack Width, Permeability, Freeze-Thaw, and Deterioration Reducing Crack Width with Short Fiber Reinforcement
- Assessing Impact of Short Fibers on Improved Durability
- Service-Life Modeling Fundamentals
- Fiber Reinforces Reinforcement
  - COTE mismatch and damage (especially with external bonding)
  - Improved Bond Slip, Bond/Debond, and Confinement Modeling
- Improving the Material/Structural Energy Dissipation Properties Through the Use of FRP Jacketing and Fiber Reinforcement (Joint thrust area with structures)
  - Characteristic Behavior
  - Long-Term Durability
- Durability of FRP Materials

## **STRUCTURES/HYDRAULICS**

### *Structural I - Inspection, Materials, Durability*

- Corrosion effects on structural elements. This includes deterioration of piles, substructure elements with backfill material, and section loss on structural beams and girders.
- Deck overlays to develop long life (25+ years). The use microsilica concrete for deck protection. The cost and effectiveness of microsilica concrete should be explored.
- Examine the use of no steel reinforcement in bridge decks. This concept could either involve the use fiberglass instead of steel or no reinforcement whatsoever.
- Cathodic protection to prohibit or minimize bridge deck deterioration. Acid rain and normal deicing salts combined with traffic wear has negative effect on bridges that can be reduced by cathodic protection
- Consider the use of stainless steel reinforcement in bridge decks to prolong the useful life of the reinforcement and the deck. The high initial cost may be offset by no need for early replacement of the deck steel.
- Non-destructive methods to evaluate insitu concrete strength. This type of information may be helpful in development of an accurate bridge rating.
- Post tensioning of the bridge deck may help extend the useful life of the deck by lowering the stresses and helping to distribute the vehicle loads. This study could possibly be conducted in conjunction with applications of high-performance concrete.
- Alternate types of precast bulb-tee cross-sections considered. Initial cost may be high, but it will be reduced if use is increased. Consider the implications of modifying the section for high-performance concrete. Also, consider the use of precast substructure elements that are post-tensioned together.
- Health management technologies to manage bridge condition data collection and evaluation. Toronto has this ongoing.
- Fatigue strength of sign structures. This effort would involve evaluation methods for both the structural members as well as the foundation anchor bolts. Recommendations for important inspection features during routine inspection of these structures.
- The design, durability and effectiveness of precast elements for soundwall systems. The toll road has a project ongoing at the time. Soil conditions, which influence the placement of these elements, will be considered.

## **STRUCTURES/HYDRAULICS (CONTINUED)**

- Inspection provisions to evaluate the downdraft (40-50%) load on piles.
- Contracts and delivery systems for bridge design competitions. This concept, which is used often in Europe and occasionally in the USA, can be used to produce innovative bridge designs. Develop criteria to foster and properly implement this design procedure.
- Design and construction considerations for temporary structures. Protection for column and substructure elements shall be considered.
- Life/cycle cost considerations. This would include an evaluation of various materials from the standpoint of durability, inspectability, and overall serviceability.
- An examination of the most economical types of substructure. Attempt to collect existing data to classify this effect. Consider the impact of ASD vs. LRFD on the design of foundation elements.
- Clearance values and impact effects on low bridge structures.
- Implementation of high-performance steel with controlled deflections. Consider the vibration/frequency issues; Ontario has conducted a number of bridge vibration studies.
- Dynamic performance and associated characteristics of bridge structures.

### *Structural II – Seismic Risk and Design Methods*

- Consider an increase in the number of critical regions beyond the 3 counties presently recognized by AASHTO. Identify critical routes for emergency management within the critical regions. Also, consider the connectivity of the critical routes with those of other adjoining states.
- In Category B for bridges, how do the highways hold up? Consider methods to evaluate regions where gasoline pipelines and water sewage lines cross the bridge structure.
- Economic recovery after a major earthquake. DARBA (Southern Indiana) developed plan for how to plan for recovery. Consider INDOT interactions with this group.
- Seismic resistance of integral abutment structures. Also, consider the conversion of existing bridges to integral abutment structures. Can invoke a more stringent design for bridges in a designated seismic route.
- Cable restrainer devices. “Alternate methods for bridge retrofit”. Lead isolation bearings. Design could be to prevent collapse versus keeping the bridge operational. Included is an evaluation of various bridge damping devices.
- ASD vs. LRFD. The design manual needs to be passed before a new code is adopted. Dual designs should be developed for both LFD and LRFD. Implementation of the new code will need to allow time for questions to be answered as the new code is being used. Literature search could be used to evaluate how widely LRFD is being implemented around the US.
- Advanced composites for seismic risk. Ohio bridge built box structure.
- Pile strength/performance. Post-seismic inspection and evaluation methods. Install rebar for wave monitoring. Develop procedures that can be used to inspect and evaluate the piles.
- Computer software development. Who really pays for software development? Analysis/design packages. INDOT doesn’t necessarily control what consultants are using from a design standpoint.
- Performance measurements related to design. Performance-related versus performance requirements. Liability issues related to this type of design could be significant.
- Training of new staff – innovation of design techniques CALTRANS – new engineers trained for 1<sup>st</sup> 6 months. Mention of multi-media instructional tools to assist in the training. Short course (workshops are possible vehicles for instruction).

## **STRUCTURES/HYDRAULICS (CONTINUED)**

### *Hydraulics I – Scour Related Topics*

- Scour monitoring at bridges and abutments.
- This nationally recognized important topic is currently being studied in Indiana as a JTRP project. Problems with protecting the instrumentation deserve further attention.
- Design and Construction of debris deflectors.
- In many bridges in Indiana, collection of debris has been a serious problem. Removal of debris is expensive. Laboratory studies may be needed to design debris deflectors. Field studies are needed to validate laboratory findings.
- Add-ons to HEC-RAS.
- (a) offset bridge openings (b) multiple bridges (c) sloping decks and vertical curves
- ability to keep non-horizontal road profile data from trial to trial.
- These improvements to HEC-RAS would be useful for INDOT engineers.
- Scour Risk evaluation.
- Recent work by Stein et al. (1999), supported by FHWA, would enable prioritizing scour vulnerable bridges. Comparison of results by this method with the current INDOT list would be useful.
- Channel realignments to reduce debris in streams. A preliminary study is suggested.
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### *Hydraulics II – Hydrology*

- Regionalization of Indiana watersheds for flood flow predictions.
- Regionalization is the first step in developing flood flow prediction equations. It is not a simple problem, but must be addressed to develop valid flood flow equations.
- Development of flood flow prediction equations for small Indiana watersheds.
- The present equations give flood flow values with large variances. Additional data, which have become available over the past 20 years must be used to develop better flood flow equations.
- Re-examination of bridge opening capacity of old bridges for the latest flood flow predictions.
- Recently developed software such as WSPRO and HEC-RAS are to be used for determining the adequacy of bridge opening capacity of old bridges. If these old bridges pose dangers of being overtopped, then they must be recommended for corrective measures.
- Culvert management.
- A study of culverts with problems such as settlement and erosion is recommended. If these are numerous, then a culvert management scheme may have to be developed.

### *Hydraulics III – Geotechnical Related Topics*

- Performance of culverts on softer soils. Re-examination of culvert specifications for mitigation of movements.
- Design of flexible culverts --- validation of design concepts proposed by Prof. G.A. Leonards.
- Re-examination of flexible culvert requirements for possible replacement of multiple-opening rigid culverts.

## TRAFFIC/ITS/SAFETY

- Virtual weigh station: Impact of OS/OW vehicles on infrastructure, data analysis, development of dynamic enforcement tools.
- ITS Laboratory: Evaluation of left turn loop count detectors vs. 4<sup>th</sup> loop; cost effective remote telemetry switching devices (lighting, messages, beepers); signal infrastructure evaluation and specification revision (detector housings, fiber optic cables/panels, disconnect hangers, etc.).
- Algorithm for travel times through work zones, deployed in conjunction with message signs and HAR. Measure the amount of diversion in interstate construction zones.
- Performance based acceptance of pavement markings. QA, retroreflectivity for signs. Should "Diamond Grade" be used for overhead signs.
- Internet identification of hazardous locations.
- Evaluation of signal preferentiality (use of all red flash).
- Improvement in railroad grade crossing safety technologies warrants for constant warning time devices, train counting technology, procedures for interconnecting new advanced warning devices with new traffic controller preemption features.
- How to measure effectiveness of improving safety, criteria on how decisions are made on making funds available for safety projects.
- Reconciling AASHTO design speeds vs. MUTCD and operational speed limits.
- Identification and development of risk management polices for safety related design decisions.
- Planning procedure for estimating impact on adjacent network during workzone construction.
- Evaluation of electronic speed enforcement equipment. Real time notification/display.
- Study on rotary/round-about/traffic circles (must be coordinated with INDOT's strategic plan to build one of these)
- Using imaging technology to evaluate highway safety (conflict analysis).
- Counting devices reliability (portables) with respect to weather conditions like: (i) temperature, (ii) tube spacing, (iii) classification vis axle counting, (iv) different manufacturers, (v) speed, (vi) accuracy, (vii) arrival time.
- Revisit warrant procedures used by INDOT, particularly for actuated LT signals.
- Tailored "Ramp Metering Requirements" for use with ITS systems in future. NTCIP compliance.

## SAC REVIEW PROCESS

The SAC began preliminary review of the individual focus group reports in January 2000. The primary focus of the review was the applicability of the proposed research to INDOT's needs, how well the individual research areas were investigated, as well as looking for potential overlap and consolidation of research needs. Several meetings were held with both the focus group facilitators and with those INDOT individuals who are requesting the research as well as implementing the results to clarify and quantify each group's proposed final list of recommended research priorities. A series of reviews and revisions was undertaken and as a result of this extensive analysis, many of the projects were redefined and some were reassigned to different groups. The following recommendations are subsequently made by the SAC for adoption as a long-range research plan for FY 2001-2003.

**CONSTRUCTION/SURVEYING**

	<b>Research Need</b>	<b>Length of Project</b>	<b>FY Funding Proposed</b>
1.	Modern Technologies for Design Data Collection	24 mos	2001
2.	Imaging and Locating Buried Utilities	24 mos	2001
3.	Lightweight Bridge Decks	18 mos	2001
4.	Automation of Pavement Marking Process	24 mos	2003
5.	Improvement of Safety in Construction Zone	24 mos	2002
6.	Automated Data Acquisition/Machine Control	12 mos	2003
7.	Trenchless Technologies for Utility Construction	18 mos	2001
8.	Information Technology Initiative	24 mos	2002

**ENVIRONMENTAL**

	<b>Research Need</b>	<b>Length of Project</b>	<b>FY Funding Proposed</b>
1.	Constructed Wetlands for INDOT Rest Stop Wastewater Treatment: Proof of Concept Research Investigation	36 mos	2001
2.	Constructed Wetland Systems for Wastewater Management	36 mos	2002
3.	Hydrology of Natural and Constructed Wetlands (Phase 1 & 2)	36 mos	2001 & 2002
4.	Remediation of Soils and Ground Water Contaminated by Aromatic and Chlorinated Hydrocarbons and Metals (Phase 1 and 2)	36 mos	2002 & 2003
5.	Remediation and Stabilization of Soils Contaminated by Lead Resulting from the Removal of Paint from Bridges	36 mos	2001
6.	Use of Vegetation in the Stabilization, Reclamation, and Remediation of Impacted INDOT Soils	24 mos	2002
7.	Wastewater Toxicity Testing of Wash Water from Deicing Trucks	24 mos	2002
8.	District Environmental Coordinator Checklist Development	18 mos	2001
9.	Traffic Noise Mitigation Using ITS Techniques and Technologies	24 mos	2003
10.	Traffic Management Strategies to Reduce Vehicular Emissions (Phase 1 and 2) (36 mos) FY2002 & 2003	36 mos	2002 & 2003

**GEOTECHNICAL**

	<b>Research Need</b>	<b>Length of Project</b>	<b>FY Funding Proposed</b>
1.	The Problem of Wet Subgrades	30 mos	2001
2.	Requirements for Pile or Pier Sockets Into Rock	36 mos	2002
3.	A Study of the Influence of Fabric on Strength and Deformation of Clay Soils	36 mos	2003
4.	Limit States Design of Slopes and Retaining Structures	36 mos	2002
5.	Stabilization and Improvement of Soils with Considerable Organic Content	36 mos	2001
6.	Evaluation of Performance of INDOT Geotechnical Instrumentation	20 mos	2001
7.	Mitigating the Effects of Expansive Behavior of Chemically Treated Soils	30 mos	2003
8.	Implementation - A Study of Subsurface Cavity-Related Subsidence	24 mos	2003
9.	Synthesis - Preventive Measures for Landslides	18 mos	2001
10.	Synthesis - Soil Freezing for Deep Cuts)	18 mos	2002
11.	Synthesis - Performance Improvements for Approach-Slab Embankment	18 mos	2001
12.	Synthesis - Load Response of Non-Ideal Soils	18 mos	2002
13.	Synthesis - Guidelines and Specifications for Additional Waste Materials	18 mos	2001
14.	Synthesis - Guidelines for Use of Types of Retaining Devices	18 mos	2001

**INTERMODAL/PLANNING/FINANCING**

	<b>Research Need</b>	<b>Length of Project</b>	<b>FY Funding Proposed</b>
1.	Best Practices of Innovative Financing Techniques	18 mos	2001
2.	Updating and Improving VMT Estimation Methods	21 mos	2001
3.	Minimizing Truck/Car Conflicts on Highways	18 mos	2001
4.	Improved Resource Allocation Across the Management Systems	24 mos	2003
5.	Alternative Land Use Patterns to Minimize Congestion Phases 1 & 2	36 mos	2001 & 2003
6.	Impacts of Mobility Options for Older Drivers and Non-Drivers	18 mos	2002
7.	An Investigation of Pricing and Other Methods to promote Non-Highway Modes for Freight Transportation	18 mos	2003
8.	Weigh-In-Motion Data Checking and Imputation	18 mos	2001
9.	Use of GIS in Building a Statewide Environmental Database and Environmental Management	18 mos	2002
10.	Life-Cycle Cost Analysis for Pavements and Bridges in Indiana	36 mos	2002

## PAVEMENT AND MATERIALS

	<b>Research Need</b>	<b>Length of Project</b>	<b>FY Funding Proposed</b>
1.	HMA Pavement Performance and Durability	24 mos	2002
2.	Polymer Modification: Is It Cost Effective and at What Temperature?	30 mos	2001
3.	High Stiffness Hot Mix Asphalt	24 mos	2002
4.	Developing/Refining Rapid Non-Destructive Testing Techniques for Material Acceptance and Assessment of Early-Age Property Development (Phase I and II)	36 mos	2001 & 2003
5.	Interaction Between Micro-Cracking, Cracking, and Reduced Durability in Concrete: Developing Methods for Considering Cumulative Damage in Life-Cycle Modeling	36 mos	2001
6.	Comparisons of Various INDOT Testing Methods and Procedures to Obtain Bituminous and Concrete Mix Properties	24 mos	2002
7.	Investigation of Long-Term Durability in Rapid Set Cement-Based Materials	24 mos	2003
8.	Effect of Pozzolans and Type D Admixtures on the Setting Time, Bleeding, Curing, and Surface Quality of Concrete Pavement	30 mos	2002
9.	Mid-Slab Cracking	12 mos	2001
10.	Development of a Rapid Set Cement-Based Material Composition for Patching and Repair	18 mos	2002
11.	Technical Issues Related to the Use of Fly Ash and Slag During the Late-Fall Construction Season	24 mos	2001
12.	QC/QA Procedures for Indiana and Materials and Procedures for QC/QA Core Filling	24 mos	2003
13.	Concrete Mixtures with Inclusions to Improve the Sound Absorbing Capacity of Pavement	24 mos	2003
14.	Performance Graded Binder Selection in Indiana	18 mos	2003

## STRUCTURES AND HYDRAULICS

	<b>Research Need</b>	<b>Length of Project</b>	<b>FY Funding Proposed</b>
1.	Regionalization of Indiana Watersheds for Flood Flow Predictions	36 mos	2001
2.	Simplified Wheel Load Distribution for Use in LRFD Design	30 mos	2001
3.	Floating Debris at Bridge Piers: Problems and Approaches	36 mos	2001
4.	Training of New Staff on Effective Design and Inspection Procedures	30 mos	2002
5.	Modifications to HEC-RAS for Enhanced Usability for Hydraulic Design of Bridges	36 mos	2002
6.	Lifecycle Cost Considerations for Performance-Related Specifications of Concrete Bridge Decks	36 mos	2002
7.	Load Monitoring and Associated Effects of Extra-Heavy Trucks on Bridge Members	32 mos	2003
8.	Fatigue Strength and Evaluation of Sign Structures	30 mos	2003
9.	Implementation of Full-Width Precast Bridge Panels	36 mos	2003
10.	Scour Monitoring of Bridge Piers in Indiana	24 mos	2003
11.	Health Management Technologies to Evaluate Bridge Condition	48 mos	2001

**TRAFFIC/ITS/SAFETY**

	<b>Research Need</b>	<b>Length of Project</b>	<b>FY Funding Proposed</b>
1.	Virtual Weigh Station	12 mos	2001
2.	ITS Laboratory	36 mos	2002
3.	Algorithm for Estimating Travel Time Through Work Zones	24 mos	2003
4.	Sign and Pavement Marking Management Program	12 mos	2001
5.	Internet-Aided Evaluation of Highway Safety	24 mos	2001
6.	All Red Flash Preferentiality at Traffic Signals	18 mos	2002
7.	Evaluation Safety Enforcement on Changing Drivers' Behaviors	12 mos	2001
8.	Hazard Elimination Program	12 mos	2001
9.	Reconciling Speed Limits with Design Speeds	18 mos	2002
10.	Development of Risk Management Policies: Synthesis Study	18 mos	2002
11.	Planning Procedures for Estimating Impact on Adjacent Network During Construction	28 mos	2003
12.	Operational Analysis of Multilane Roundabouts	24 mos	2003
13.	Using Imaging Technology to Evaluate Highway Safety	24 mos	2002
14.	Counting Device Selection and Reliability: Synthesis Study	12 mos	2001
15.	Revised Warrants for Installation of Left Turn Indications on Traffic Signals	24 mos	2003